ABSTRACTS

INTERNATIONAL CONFERENCE

On

Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security

November 05th-09th, 2019
NASC Complex, New Delhi, India

A Joint International Conference of

SOIL CONSERVATION SOCIETY OF INDIA

ISCO International Soil Conservation Organization

WASWAC

Soil Conservation Society of India (SCSI)
World Association of Soil and Water Conservation (WASWAC)
International Soil Conservation Organization (ISCO)

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Soil Conservation Society of India, New Delhi, India

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International Union of Soil Sciences

ESSC European Society for Soil Conservation

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Preface

Soil and Water Conservation and management are prerequisite for sustainable agriculture. It is important to conserve and properly manage the natural resources and improve economic viability of farming to meet food and livelihood security. Proper management of land, water, biodiversity and climate resources is the need of the hour. There is a strong need to increase agricultural production towards achieving the goals of livelihood security on sustainable basis as well as reduce the productivity gap between marginal and favoured areas. A strong infrastructure has to be built which can deliver optimally under climate variability and change. Soil and Water Conservation and Irrigation are important aspects of land use and rural development in these regions. Participation of the stakeholders at various levels is absolutely necessary. Proper management of soil, water, animal, plant and human resources is essential to aim for rural development, mitigating climate change effect, enhancing farmers' income and achieving the future targets on sustainable basis.

The 4^{th} International Conference of SCSI jointly organized by WASWAC, ISCO and SCSI on "Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security" during November 5-9, 2019, hosted by the Soil Conservation Society of India, New Delhi and co-sponsored by the Indian Council of Agricultural Research (ICAR), DST-SERB, NABARD, ICSSR, NBA, NRAA, CSIR and ISRO and supported by IUSS and ESSC. This book includes the Abstracts of the papers contributed by experienced professionals, researchers and academicians from different countries and are categorized into the broad themes of the conference. The editors are grateful to Prof. Li Rui, Prof. Samir A El-Swaify, Prof. Miodrag Zlatic and members of the technical committee of the conference for their efforts, support and cooperation.

This abstract book will prove to be an important knowledge bank and tool in the hands of policy makers, students, researchers, scientists and field level workers for better management options for management of the natural resources to attain sustainable farming vis-à-vis mitigating climate change effect.

Suraj Bhan and Sanjay Arora

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SESSION-I

Soil Degradation Assessment and Remediation

Preliminary Progress on Global Soil Erosion Assessment

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Currently many scientists and agencies are working to perform global soil erosion assessments at various scales. Here we would like to introduce the preliminary progress of the Project (Global Soil Erosion Assessment) implemented by a joint group of scientists from China and Europe. In the past 2 years the project was mainly concentrated on the driving factors of global soil erosion. We selected the newest available datasets and suitable methods to calculate and extract the soil erosion factors. In order to get better data of soil conservation practices and more realistic soil erosion assessment, the sampling survey based on high resolution Remote Sensing images and field checking was conducted. Integrated the data (natural factors and practices of soil conservation), water erosion rate is calculated at each sampling unit based on the Chinese Soil Loss Equation (CSLE). This method has been tested in the Pan Third Pole area and the results are satisfying suitable for erosion assessment at regional scale.

Key words: Global soil erosion assessment, Erosion factors, sampling survey, high resolution, water erosion

Strategies, Lessons and Experiences on the Sustainable Soil Management

Miodrag D. Zlatic

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Land degradation is the global problem from the beginning of mankind. The loss and degradation of land resources need to be seen in the context of policy, socio-economic conditions and the environment. The impact on agriculture, forestry and food production, as well as on the ecological and protective functions of natural and managed ecosystems is universally recognised. To meet these challenges, new and innovative approaches are required. This includes close cooperation with governments, civil society and international and national organisations to ensure a broadly acceptable and efficient implementation, as well as the necessary additional financial, institutional and human resource support. Sustainable management of land resources implies the application of participation methods, including the world methods such as: The Ecosystem Approach, CBNRM (Community Based Natural Resources Management), WOCAT (World Overview of Conservation Approaches and Technologies), DPSIR Approach. In this respect paper takes into account description some of the mentioned methods with some examples and lessons learned.

Key words: Land degradation, ecological functions, sustainable management

Management of Soil Resources for Sustained Production

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Soil, water and bioclimates, an integral part of land, greatly influence the productivity of plants and animals. Moreover, suitable agro-interventions have their own impact on production of targeted farming system. Although India has successfully achieved self-sufficiency in food production and came out from the clutch of ship-to-mouth situation owing to coordinated efforts of breeder, fertilizers industries and planner (bringing large area under irrigation). Later on, it is realized that gain in production could not sustain owing to various factors including non-judicious use of resources, weather observation (climate change) and economic consideration by stakeholders. Now, India has nearly 120.72 million degraded lands due to climate and anthropogenically induced degradation and thus, productivity and nutritional security are at crossroad.

Sustainable production deals both short and long term goal for providing the needs of today and tomorrow. It combines the economic consideration and ecological restoration. These issues can be addressed by scientifically managed soil heath. We have wisdom, ways and means in terms of doable technologies but it needs proper coordination and awareness at every level.

Key words: Bioclimate, degraded lands, climate, doable technologies

Soil Conservation Measures in Hot Arid Region of India to Control Wind Erosion

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Wind erosion is a major land degradation process in the arid and semi-arid regions of the world. It affects about 41% land area in the world and about 13.5 per cent in India. Removal of soil particles by wind is very active in the Indian Thar Desert and poses severe multifaceted problems. Loss of nutrient-rich particles from agricultural fields, suspension of fine particles in air, and deposition of eroded soil particles on railway tracks, roads, and irrigation canals etc are major wind erosion related problems in the region. During severe dust storm events, the suspended particles may get transported by air over hundreds of kilometers and form a blanket of dust haze over the Indo-Gangetic plains and surrounding area. Prevailing weather and terrain conditions of this desert are also very conducive to wind erosion. Among climatic factors, wind speed plays a vital role and if it exceeds the threshold of 5 m s^{-1} at 0.3 m height from ground surface it initiates wind erosion. Among terrain properties, soil aggregate distribution, surface roughness, soil moisture and vegetation cover are important factors influencing wind erosion. Minute soil particles (<60 mm) blown by wind are one of the major causes of particle air pollution and causes serious health hazard to people and animals dwelling in the desert region, especially to children, sensitive persons and old animals. Combating wind erosion in the vast desert requires prioritization of regions according to the severity of problem. In this context the measurement of wind erosion in different land use sites of the desert is essential for the validation of process-based wind erosion model and its application in the mapping of wind erosion prone regions. Eroded soil particles initially carried out by wind are deposited at distant places thus affecting the source area by depleting its soil fertility and creating environmental hazards in deposited areas. Sometimes, the deposition of nutrient enriched eroded soil particles in places away from the source region increased the fertility. Computed soil loss from field measurements revealed annual soil loss rate of 12.2 t ha^{-1} in under moderate category of wind erosion whereas it was as high as 83.3 t ha^{-1} under very severe category. However, under slight category of wind erosion, annual soil loss rate has been observed as 1.3 t ha^{-1}. There are main five factors affecting the wind erosion process, which are climatic factor, soil erodibility factor, roughness factor, field length factor and vegetative factor. Considering these causative factors different control measures have been formulated, which mainly aim either to decrease the erosive energy of wind or to decrease the erodibility of soil by altering the surface soil characteristics or surface cover or roughness. Among different control measures, well-anchored surface vegetative cover is the most applicable method to control wind erosion, which may be achieved through maintaining permanent grass cover in rangelands. Tree shelterbelt is also a suitable option to control wind erosion in those places of desert where water resource is available for its initial establishment.

Key words: Dust storm, wind erosion, shelter belt, vegetative cover

Gully Development and Erosion Environment Evaluation in a Small Watershed Located in the Transitional Area from Plateau to Plain in Northern China

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As part of the ecotone between agriculture and animal husbandry, the transitional area from plateau to plain in northern China is a fragile zone of ecological environment, as erosion caused by water and wind are both serious. After two decades treatment, the wind erosion has been controlled effectively. However, the water erosion is still non negligible, which could be reflected by the rapid development of gullies. To provide reference for present erosion situation and for future treatment, remote sensing images from satellite, orthoimage from unmanned aerial vehicle, and on-site survey and measurement have been all introduced to make clear the development of an active gully in a small watershed. The current distribution of the main gully and its branches were obtained, the related parameters including length, width, depth, density of gullies were measured, the relationship between gullies density and slope gradient/length were analyzed, the speed of expansion of the main gully was calculated, and the main influence factors to accelerate the gully's development were summarized. This study provided substantial contribution on water induced severe erosion in a traditional area experiencing serious wind erosion. This work was supported by the National Key Research and Development Program [grant number 2016YFC0500802].

Key words: Gully development, Transitional area from plateau to plain, Orthoimage, Water erosion

Corrosion Mechanical Properties of Topsoil in 4 Different Vegetation Communities

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In this paper, the surface soil (0-5cm) of four different vegetation communities in the poplar and caragana mixed forest, pure forest of poplar, evergreen coniferous forest and pure forest of caragana were studied, and the effects of soil moisture content on their mechanical properties were analyzed. The results showed that within the range of the tested surface soil moisture content from 2.5% to 12.5%, four different vegetation types and bare ground showed an increasing trend of shear strength and cohesive force of the surface soil with the increase of soil moisture content, indicating that the increase of soil moisture content in a certain range played an active role in improving soil surface erosion resistance. The values of shear strength and cohesive force of the four types of vegetation communities were significantly greater than the values of bare land, which indicated that the forest and grass measures of soil and water conservation promoted the improvement of surface soil structure, thus improving the anti-erosion ability of the surface soil. In the range of water content between 2.5% and 12.5%, there is no obvious change rule with the increase of water content. The shear strength and cohesive strength of the topsoil under the mixture forest of lime + poplar were the greatest. On the other hand, it also shows the advantages of creating mixed forests in the forest and grass measures of soil and water conservation.

Key words: Topsoil, Shear strength, Cohesion, Internal friction angle, Soil moisture

Preliminary Study on Soil and Water Loss and its Control Measures in Tibet

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Tibet is located in the Qinghai-Tibet Plateau and the third pole of the earth. Its ecological environment is fragile and soil erosion is serious. The types of soil erosion involved include freeze-thaw erosion, hydraulic erosion, wind erosion, gravity erosion and man-made erosion. According to the survey data, the scope of soil erosion accounts for more than 30.0% of the total land area in the region. Affected by global warming and human activities, grassland degradation, land desertification, soil erosion and frequent natural disasters directly affect regional socio-economic and livelihood improvement. Based on a large number of field surveys, remote sensing and a series of studies, the present situation of soil erosion in Tibet was evaluated, and the main influencing factors of regional soil erosion and the influence of soil erosion on land resources were analyzed. This paper puts forward a new model of soil erosion prevention and control, which takes ecological environment protection as the core, River Basin comprehensive planning as the means, comprehensive ecological restoration and environmental control projects in zoning, natural restoration of forest, shrub and grass, and supervision of soil and water conservation as the main technical means.

Key words: Global warming, ecological restoration, river basin, soil erosion

Study on the Change of Soil Erosion and its Influencing Mechanism in the Loess Plateau of the Middle Reaches of the Yellow River in Different Periods since the Middle of the 20th Century

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The annual sediment transport in the Yellow River is the expression carrier for soil erosion on the Loess Plateau, with an average of 1.6 billion t/year in the natural state. As of 2015, the comprehensive management measures for soil and water conservation in the middle reaches of the Yellow River reached 260,000 km^2, and the degree of governance exceeded 62%. The annual sediment transport volume of the Yellow River has not exceeded 500 million t/year in more than ten years, and the minimum year is less than 100 million t/year. The statistical analysis of the sediment transport volume of the Yellow River in 1954-2015 was conducted in three periods. The results show that: Before the 1960s, the effect of soil and water conservation on the sediment transport of the Yellow River was not obvious; during the period from 1967 to 1987, the effect of soil and water conservation on reducing the amount of sediment transported in the Yellow River was significant; From 1988 to 2015, only a factor of "water and soil conservation degree" can "interpret" the change of the annual sediment transport volume of the Yellow River by nearly 80%; When the degree of soil and water conservation is more than 55%, the annual sediment transport calculated by the regression model is less than 200 million t/year; In recent years, the amount of sediment reduction by the soil and water conservation to the Yellow River has exceeded 1 billion t/year; with a confidence of 80%, the annual sediment load of the Yellow River is less than 500 million t/year.

Key words: Yellow river, Loess plateau, Annual sediment transport, Soil and water conservation, Sand reduction

Soil Erosion and Sedimentation Research in Selected Countries

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Since the end of the Second World War, approximately 12 million ha of the world's agricultural land have been eroded, 10.5% of fertile land has been destroyed, and 35% of the Earth has been affected by desertification. These problems are the result of serious soil erosion, land degradation, reduced soil fertility, environmental degradation, and sedimentation of rivers. The erosion and sedimentation problems have affected industrial and agricultural water conservation, and development. To deal with the challenges of soil erosion and sedimentation, the strong support of science and technology is needed. New technologies are emerging constantly in this field owing to the advancement and development of new theories in the field of soil erosion and sedimentation science. In order to obtain a better understanding of the state of soil erosion and sedimentation research at the global scale, special research of scientific and technologies on soil erosion were conducted in this paper. 13 countries were chosen, namely China, Egypt, India, Iran, the Democratic People's Republic of Korea, Nepal, Russia, France, Germany, Japan, the Republic of Korea, the United Kingdom, and for a comprehensive evaluation and systematic analysis of the latest research progress on soil erosion and sedimentation. This research has done the following research subjects: Cutting-edge research on soil erosion and sedimentation in representative developing and developed countries; Evaluation of soil erosion and sedimentation research in different countries; Comprehensive analysis of soil erosion and sedimentation in typical countries. The research indicated that the world's countries face different types of soil erosion and sedimentation, and the severity of the hazards and the amount differ greatly. Overall, water erosion is more severe in India, China, Iran, Nepal, Russia, and the USA. Wind erosion is more serious in Egypt, Iran, China, and the USA, while countries such as the United Kingdom, Germany, France, Japan, and the Republic of Korea have relatively light soil erosion. The countries with more serious sedimentation problems include China, Nepal, Iran, India, Russia, Egypt, and the USA. Countries with less severe sedimentation issues are the United Kingdom, France, Germany, Japan, and the Republic of Korea. The selected typical developed countries have completed controlling their major rivers and currently have a strong emphasis on ecology, landscape, beautifying the river, and protecting the small rivers and streams. The selected typical developing countries are still in the stage of river development and management and have started to attach importance to the protection of the river's ecology. Countries such as the USA, Russia, France, Germany, and the United Kingdom have an in-depth basic research system, and China and India have more research results in applied research.

Key words: Soil erosion, Sedimentation, Statistical research, Selected countries

Causes Analysis and Control Technologies of Soil and Water Loss of Economic Forestland in Northern Earth-rock Mountainous Areas, China

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Soil erosion under the chestnut forests of Yanshan mountains is characterized by strong concealment and serious erosion. In October 9-20, 2016, we adopted field survey method to investigate in detail contiguous chestnut forests in Changfu village, Hebei province, China. The factors that affect soil erosion under chestnut forests were analyzed. Disorderly reclamation in large and cultivation on steep slope are primary causes of soil erosion, while chestnut trees grow on the outer edge of a level ditch and chestnut leaves gather little raindrops into larges were main reasons for gully erosion and splash erosion on a slope. At the same time, the reasons that soil and water conservation measures are lag behind and disrepair are: (1) chestnut forest managers are decreasing and aging; (2) tools that used for repair level ditch are backward. The existing measures of soil and water conservation include wood brace, level ditch, moss-covered, grass-covered, agro-forest intercropped. We suggested that grass-covered and agro-forest intercropped are the promising direction of production and management for chinese chestnut forest. Finally, suggestions for control soil erosion under chestnut forests are given from watershed and slope scales respectively, hoping to arouse enough attention of researchers and policymakers and give this problem timely study.

Key words: Chestnut forest, Disorderly reclamation, Steep slope planting, Soil erosion under chestnut forests, Control measures

Preparation of Erosion Susceptibility Map of Dhaman Khadi Sub-Watershed in Eastern Gujarat

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Soil degradation is a strong driver of climate change through its current and anticipated effects on land use and management. Among the major causes of soil degradation in India, water erosion is considered to be the most severe one which covers almost 68.39% of the affected area resulting into the annual soil loss of about 5.3 billion tons through erosion (Maji *et al.*, 2010). An attempt has been made to model land degradation in term of water erosion of selected Dhaman Khadi sub-watershed (7710.64 ha.) in Eastern Gujarat, India through Revised Universal Soil Loss Equation using ArcGIS interface. The average erosivity of 30 years (1986-2015) annual rainfall using standard formula was estimated to be 480.63 MJ mm ha^{-1} hr^{-1} per year. The erodibility factor K was computed as 0.236 and 0.177 mt.hr MJ^{-1} mm^{-1} per unit R respectively for clay loam and clay soils using modified formula. 20 m Digital Elevation Model was prepared from Toposheet No. F43N10 by using 'Topo to Raster' interpolation method. The slope length factor L was derived from DEM using Unit Stream Power Erosion and Deposition (USPED) Model. The raster layers of slope steepness factor for slope having < 9% and ≥9% was prepared separately to form final slope steepness factor map. Cover management factor map was derived based on cropping pattern for the various land cover categories of the study area. The standard conservation practice factor values for cross-sloped agricultural lands were assigned to the at-tribute table of the intersected map of LU/LC and slope maps to prepare the P factor map. Average gross soil erosion was minimum for evergreen forest while maximum for wasteland without scrub. Highest area covered by agri-cultural land (i.e. 41.54) of Dhaman Khadi sub-watershed having 33.28 tons/ha/yr gross soil erosion needs immedi-ate treatment to prevent land degradation. Soil loss tolerance limit of study area was used to derive erosion susceptibility map in order to identify the priority of conservation programs. As all the factors of RUSLE was estimated precisely at sub-watershed level, the study could help for rapid and reliable planning of watershed development pro-grams in combination with the use of RS and GIS technology.

Key words: ArcGIS interface, Erosion susceptibility map, Sub-watershed

Improved Interrill Erosion Prediction by Considering the Impact of the Near-surface Hydraulic Gradient

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The mechanism of the interrill erosion process is still unclear under complex conditions. Spatio-temporal variations of the near-surface hydraulic gradient are a common occurrence; however, few attempts have been made to characterize the near-surface hydraulic gradient for erosion prediction. Therefore, the objective of this study is to determine the influence of exogenic erosional forces (rainfall, overland flow, and seepage) on interrill erosion processes by considering the impact of the near-surface hydraulic gradient. Five near-surface hydraulic gradients (70% of field capacity, field capacity, saturated, artesian seepage at 20 cm and 40 cm of the hydrostatic pressure head) were applied in clay loam soil at two representative slope gradients of 8.75% and 17.63% under three rainfall intensities of 30, 60, and 90 mm h^{-1}. The results showed that the near-surface hydraulic gradient was the dominant factor in the interrill erosion process in addition to rainfall intensity (I), runoff (Q), and slope gradient (S). There was a significant improvement in the prediction accuracy of the interrill erosion rate when the factor of near-surface hydraulic gradient was introduced into the interrill erosion prediction equation based on the Water Erosion Prediction Project (WEPP) concept (R^2=0.92, Nash-Sutcliffe simulation efficiency (NSE)=0.92). The R^2 and NSE values were 22.36% to 210.00% higher than those of existing empirical equations (main parameters: I, I&S, I&Q, I&S&Q). The correlation matrix results indicated that the flow velocity was a key hydraulic parameter for predicting the interrill erosion rate. The interrill erosion rate was predicted well by a simple power function of the flow velocity (R^2=0.88, NSE=0.88), although this relationship lacks clear physical meaning. We also found that the interrill erosion rate increased as a power function with the runoff depth, rainfall intensity, hydrostatic pressure head and slope gradient (R^2=0.88, NSE=0.88). Considering the integrated effect of the exogenic erosional dynamics on the interrill erosion, a power function that included the physical description of the hydrodynamic parameters, rainfall intensity and hydrostatic pressure head was used to predict the interrill erosion rate ($R^2 \geq 0.85$, $NSE \geq 0.86$). The results of this research provide new insights into developing process-based and mechanistic models for interrill erosion processes.

Key words: Near-surface hydraulic gradient, Interrill erosion, Model, Hydraulic parameters, Hydrodynamic parameters

Effect of Gypsum, Crop Residue Mulch and Manure on Resource Conservation and Soybean Productivity in Table Land of Chambal Ravines

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Table lands are agricultural productive lands adjoining ravine belts and one such typical example is found near Chambal ravines of south eastern Rajasthan. Field experiment was conducted with various combinations of amendments like farm yard manure, crop residue mulch, gypsum and recommended dose of fertilizers laid out in random block design was carried out in table lands of IISWC, Research farm, Kota. Various combinations of treatments were Control (without fertilizers and amendments); Recommended Dose of Fertilizer (RDF) for soybean; RDF + FYM; RDF + Mulches; RDF + Gypsum; RDF+ Gypsum + FYM; RDF+ Gypsum + Mulches; RDF + Gypsum + Mulches + FYM. Results showed that application of amendments like gypsum along with crop residue reduced soil loss and runoff in all treatments. Gypsum application significantly reduced (20%) soil loss and runoff in all the treated plots thereby increasing water infiltration. Compared to FYM, addition of crop residues as mulch to the tune of 3t/ha was more effective in decreasing runoff and soil loss under soybean. Highest nutrient and soil loss was recorded in control plots without any amendments. Among the various nutrients, potassium loss was higher compared to nitrogen and phosphorus. Significant increase in soybean yield was observed where gypsum, crop residue mulch and FYM were applied. Combination of amendments like gypsum, crop residue mulch and FYM improved soil moisture content by 10 percent over control plots Application of amendments improved soil carbon, nutrient status and soil properties thereby enhancing crop productivity.

Key words: Farm yard manure, crop residue mulch, gypsum, soybean yield, soil carbon

Study of Soil and Water Conservation Measures in Chilkadabetta-1 Microwatershed in Chamarajanagar District in Karnataka, India

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The land resource inventory of Chilkadabetta-1 microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and the physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. The present study covers an area of 476 ha in Chilkadabetta-1 microwatershed in Chamarajanagar district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 734 mm. Ten soil series were identified in the microwatershed and mapped into 28 mapping units. The soils are shallow to moderately shallow (61%) in depth, loamy texture (52%), very gravelly (52%), low to very low (73%) in available water capacity and very gently to strongly slopping lands. The soil erosion from each management unit was estimated and a soil erosion map prepared. An area of about 169 ha (35%) is found under moderate erosion and 70 ha (15%) is severe erosion. Current land use map was prepared using both satellite imagery and field mapping. From the master soil map, several interpretative maps like soil depth, soil texture, soil gravelliness, soil slope, drainage characteristics and available water capacity were generated using GIS. These interpretative maps were used for preparing soil conservation and drainage line treatment plans. The conservation practices recommended are trench cum bunding in 74% area and terracing in 20% area across the slope. The drainage line treatments recommended are dugout ponds, diversion drains across the slope, *nala* bunds/percolation tank, drop spillway, brushwood check dam, loose boulder check dam and vegetative measures such as grasses (*Cynodon dactylon*, *Digitaria, Dicanthium etc*), trees (Neem, Pongamia, Bage, Ficus, Honne, Teak, Muthuga, Jamun, Tare, Custard apple etc) and shrubs (*Ipomea cornea*, *Vitex nigundo*, Agave, Bamboo etc). These conservation measures reduce the peak rate and volume of runoff, erosion, improve the moisture regimes in and around gullied areas and help to store water for supplemental irrigation and also help to build shallow water table through increased ground water recharge and environmental management.

Key words: Soil and water conservation, Land resource inventory, Soil erosion, Drainage line treatment

Effect of Straw Incorporation into Cultivated layer of Farmland on Surface Runoff Process under Heavy Rainfall Events

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Returning crop straw to the field can increase soil fertility and reduce air pollution caused by straw burning. Under heavy rainfall conditions, wheat straw incorporation can influence soil infiltration and surface runoff. This study uses laboratory experiments to examine the effects of mixing wheat straws, produced by combine during harvest, with soil materials on rainfall runoff process of cultivated loess slope. The experiments involved three rainfall intensities (80, 120, 160 mm/h), three slope gradients (10, 15, 20 °) and four straw application rates (0, 2, 4, 8 t/ha), with three replications. The total rainfall was 100 mm per event. The runoff rate process was recorded by sampling the runoff volumes during a given period of time of 20 s, at a time interval of 3 min. The experimental data show that with the increase of straw rate, the runoff time was prolonged by 31%, 75% and 102%, the cumulative runoff decreased by 0.79%, 8.49% and 13.61%, compared with that of the control group (0 t/ha straw incorporation). With the increase of rainfall intensity and slope gradient, the runoff time became shorter and the surface runoff rate increased. At the slope gradient of 10°, the cumulative runoff under 160 mm/h rainfall increased by 52.69% compared to that under 80 mm/h rainfall. Under the slope gradient of 20°, the cumulative runoff under 160 mm/h rainfall increased by 23.46% compared to that under 80 mm/h rainfall. In conclusion, the return of wheat straw to the field can delay the rainfall runoff time and reduce surface runoff to significantly increase soil water storage. Returning straw to the field is of great significance for increasing rainwater utilization and controlling soil erosion. This study can provide basic data for soil and water conservation research.

Key words: Cultivated loess slope, Straw incorporation, Flow time, Runoff, Rainfall simulation

Assessment of Runoff and Soil Loss under Different Grassland System in Sloping Land

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Soil erosion due to water is the major factor responsible for degradation of land resources and is a serious threat to cater to global population growth with increased and sustainable agricultural production. An experiment was conducted to evaluate the effect of five different grass planting systems namely Kudzu vine, Bajranapier, Hybrid napier, Love grass and Lemon grass on runoff and soil loss compared with control treatment at experimental site. The relationship among precipitation, vegetation and erosion are important factors for determining soil loss and runoff management under different grassland systems. The field experiment of runoff plot in sloping land was divided into six sub-plots of 10 m × 10 m. The runoff and soil loss got significantly reduced under the different grass systems as compared with control treatment. The effective rainfall (runoff) and soil loss with annual rainfall of 1000 mm and land slope of 43% under different grassland plantation systems were 55-66% and 15-26 t/ha/yr, respectively. Among the different grass systems, love grass and hybrid napier were found to be most effective in controlling runoff and soil loss. The average runoff generated through the love grass and hybrid napier was only 57.29% and 55.78% and the soil loss measured was 14.85 and 16.12 t/ha/yr, respectively. The biomass yield of different grassland systems were 47, 52, 58, 75 and 50 t/ha for Kudzu vine, Bajranapier, Hybrid napier, Love grass and Lemon grass, respectively. Among the different grass systems, love grass was found to be most effective in controlling runoff, soil loss and for highest biomass production. The result showed that the different grassland systems effectively regulate runoff and sediment compared to fallow land conditions.

Key words: Soil loss, Runoff, Grassland, Biomass

Effect of Plant Root and Shoot Charateristics on Runoff and Sediment Yield under Simulated Rainfall Conditions

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Soil and water are two important natural resources and the basic needs for agricultural production. So soil and water should be given first priority from the conservation point of view and appropriate methods should be used to ensure their sustainability and future availability. So in this aspect, an attempt is to be done to reduce soil and water losses. Vegetation plays a vital role to conserve soil and water. In this study, the laboratory experiments were performed to evaluate the effect of plant roots and shoots characteristics on runoff and sediment outflow under concentrated flow and rainfall simulated conditions. Two treatments are to be used (i) Bare plat and (ii) Napier grass. Napier grass was planted in the flume, which is to be put under different rainfall intensity and land slope. Before each experiment shoot part was clipped off at the soil surface and observed the effects of roots and shoots characteristics on runoff and sediment outflow at different stages under different hydrologic and land slope conditions. The results highlighted that the as increase in root density and shoot density runoff and sediment outflow is to be reduced.

Key words: Napier grass, rainfall intensity, hydrologic and land slope conditions, runoff, sediment

New Assessment of Erosive Soil Losses on Arable Land of the European Russia

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An assessment of erosion losses of arable soils was carried out using a calculation method using geo-information technologies on a scale of 1: 500,000 for the first time, for the territory of the European Russia. The total area of plowed land, where erosion calculations were made, was 650,000 km^2. The calculations were carried out for the conditions of bare arable lands and taking into account the soil-protective coefficients of agricultural crops. The mathematical modeling was used for assess of soil erosion. This model was methodically developed in the research laboratory of soil erosion and channel processes at Moscow State University, which is based on USLE model and model of State Hydrological Institute of Russian Federation.

A new values of soil erosion losses for the period 1965-2015 were obtained, presented on the thematic map of 1: 500000 scale, during of the research. Erosional soil losses on average for the European Russia are 11 t / ha per year under conditions of bare arable land and 3.3 t / ha per year, taking into account the soil-protective coefficients of agricultural crops. The rate of soil erosion in the arable land of the European Russia is decreasing in the direction from the taiga-forest to the steppe landscape zone. The strip of the maximum erosion of the soils of the west-east sub-latitudinal strike, confined to the subzone of mixed and deciduous forests with a very high tillage, is clearly distinguishedon the map. Also, intensive soil loss is observed in the foothills of the North Caucasus and in the west of the territory under study. The data obtained were verified using a similar technique, but using data of a 1: 50,000 scale on test sites. The performed test suggests that the values of the arable soil loss were obtained for the entire territory of the European Russia on a scale of 1: 500,000 are on average quite comparable with the results of calculations in key areas provided with more detailed data for the calculations of erosion. The map of soil erosion losses for the study territory was also compared with a similar map of soil erosion compiled by the same calculation method for the territory of Western Europe. The magnitude of erosion losses for Western Europe varies on average from 2.46 to 2.76 t / ha per year. These values are very close to our results (3.3 t / ha per year). The average annual soil loss calculated by the staff of the research laboratory of soil erosion and channel processes at Moscow State University in 1980 for the territory of European Russia is on average 4.7 t / ha per year. Therefore, it can be argued about a significant reduction in soil losses on the European territory of Russia over the past decades.

Key words: European territory of Russia, Soil water erosion, Modeling, Mapping of soil erosion

Rainfall Erosion of Partially-Thawed Slope of Organic Soil of Qinghai-Tibet Plateau

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Serious soil erosion caused by snowmelt and rainfall on partially thawed soil slope in high altitude cold region threatens the ecological environment.This study simulated the impervious permafrost under the thawed surface layer at the early thawing stage of frozen soil in the cold region, with saturated surface soil to resultin severe soil erosion under rainfall impacts. Laboratory experiments were made under the combination of four slope gradients (5°, 10°, 15°, 20°), three rainfall intensities (30, 60, 90 L/min), and three thawed depths (1, 2, 10 cm) to quantify the rainfall erosion relationship on partial thawed soil slope. Simulations were done on a flume of 8 m long. The functional relationship between sediment concentration and slope length, under impacts of rainfall intensity and thawed soil depth, was quantified by using experimental data. The results show that when thawed soil depth is 1 cm and the slope gradient is greater than 10°, the sediment concentration in runoff water flow decreases with the increase of rainfall intensity for the reason that the shallow thawed depth limits sediment supply. In the case of low rainfall intensity (30 mm/h), the soil infiltration increased with the thawed soil depth to lead to decrease of surface runoff. The sediment concentration decreased with the lower surface runoff, that is, the sediment concentration decreased with the increase of thawed depth. Heavy rainfall intensity (60, 90 L/min) produced higher erosion energy, but the shallow thawed depth restrictedthe rill development to result in limited sediment yield. The deeper thawed depth reduced the influence of limited sediment supply caused by the frozen soil layer, to produce more erosion and higher sediment concentration in runoff water. This study helps better understanding of rainfall erosion mechanism of thawed soil slope on Qinghai-Tibet plateau.

Key words: Rainfall, Rill, Thawed depth, Runoff sediment concentration

Long Term Impact of Soil and Water Conservation Measures on Physical, Chemical and Biological Properties of Laterite Soils of West Coast of India

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A study was carried out to investigate the long term (16 years) impact of soil and water conservation measures on soil physical, chemical and biological properties under mango cultivation in laterite soil on 19% sloping land. The experiment was conducted in the research farm of ICAR-CCARI, Goa. The experiment consisted of four treatments namely continuous contour trench + *Vetiveria zizanoides* (CCT+VB), staggered contour trench + *vetiveria zizanoides* (SCT+VB), *vetiveria zizanoides* (VB) and control treatment. Soil samples from three depths *viz.* 0-30 cm, 30-60 cm and 60-90 cm were collected from different treatments for analysis. Lower bulk density (1.10 Mg m^{-3}) and higher available soil water (12.19%) and hydraulic conductivity (8.43 cm/h) were found under CCT+VB treatment as compared to control at 0-30 cm depth. Similarly, at 30-60 cm depth lower bulk density (1.09 Mg m^{-3}) and higher hydraulic conductivity (9.73 cm/h) were found under CCT+VB, whereas higher available soil water (12.35%) was under VB treatment. Highest available nitrogen, available potassium and organic carbon of 104.4 mg kg^{-1}, 83.74 mg kg^{-1} and 2.02%, respectively were found under CCT+VB treatmentat 0-30 cm depth. At 30-60 cm depth highest available nitrogen of 72.72 mg kg^{-1} was found under VB treatment as compared to the initial values of 36.12 mg kg^{-1}, whereas highest potassium and organic carbon of 67.08 mg kg^{-1} and 1.39%, respectively were under CCT+VB treatment. The dehydrogenase activity under CCT+VB and SCT+VB were 26.71 and 48.19 μg TPF g^{-1} soil day^{-1}as compared to 12.01 μg TPF g^{-1} soil day^{-1} under control treatment. Phosphatase activity of 615.23 and 494.21 μg p-PNP g^{-1} soil day^{-1} was found under CCT+VB and SCT+VB, respectively and it was 482.07 μg p-PNP g^{-1} soil day^{-1} under control treatment at 0-30 cm depth. Similarly, at 30-60 cm depth dehydrogenase activity in CCT+VB and SCT+VB were 12.57 and 21.93 μg TPF g^{-1} soil day^{-1} respectively as compared to control (8.40 μg TPF g^{-1} soil day^{-1}). Phosphatase activity in CCT+VB was 466.87 μg p-PNP g^{-1} soil day^{-1} and 418.87 μg p-PNP g^{-1} soil day^{-1} under control treatment. The analysis of soil samples of 60-90 cm depth revealed no significant effect on soil properties. The overall analysis revealed that the physical, chemical and biological properties of the soils improved at 0-30 cm and 30-60 cm depths under the long term influence of soil and water conservation measures. The order of soil and water conservation measures in improving the soil properties was CCT+VB > SCT+VB > VB > Control. The most effective treatment was CCT+VB, which is a suitable soil and water conservation measure in laterite soils on sloping lands ranging from 11-25% for improving the soil properties.

Key words: Soil and water conservation, Soil properties, Laterite soil, Soil biological activity, Available soil water

Agriculture Resource Inventory a subset of Natural Resource Inventory

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This paper discusses the process of creating India focussed Agriculture Resource Inventory (ARI) by Lennon Agri-tech Pvt. Ltd (FarmGuide) which is a subset of natural resources inventory. This is an attempt to create a database contributing to empirical decision making system in the country, reflecting the realities of each farm on the geo-referenced format, suitable to the diverse geographical character of India. ARI combines the human and natural aspect of agriculture, sum up of farming pattern and land management systems based on farm field-specific information. The paper explains the challenges faced in the process and the approach adopted to overcome the same. Each farm has been given separate identity through Image Processing and all relevant factors for agriculture sustainability are attached with individual farm using deep learning and cloud-computing. The approach focuses on farm-level ecosystem for inventory development which amongst other primary variables may include farm size and distribution, sowing and harvesting window, the soil texture and composition, seeds and fertilizer distribution network, rain-fed and dry land areas, bank and warehouse connectivity, road-railway network and availability, mandi profiles and prices, and weather for the area. It also includes the attempt to deduce farm rating, land classification, crop-detection and remote sensing based cropping frequency from the primary set. Satellite images are being used as the base for the agriculture resource inventory, being stitched and cut into square tiles which will have annotated data about the location (latitude, longitude) and date. Tile Service serves the images based on location and date ranges and Administrative Location Service maps the various administrative units (such as villages, districts, etc.) to location. At FarmGuide, agricultural farms spread on the area of 21 Lakh square Kms is identified and segmented. Various technical breakthroughs in this exercise will be discussed in paper. Ganganagar district was the base district to test the accuracy of the Machine Learning (ML) tools, 95% accuracy was achieved in regions around Ganganagar however, it is between 70-80% for the rest of the country. Convolutional Neural Network (CNN) based ML tools are sufficient for farm segmentation and identification, also instead of a generic model, a regional model is a better choice for a diverse country like India. Connectivity matrix is used for crop identification through which the similarity in cropping pattern near rural areas and very random patterns near the urban area, is observed. It recognizes our crop identification technical capabilities and also, recognizes the orientation of people around urban areas to grow horticulture/perishable crops. ARI will help policymakers to access the real-time data contributing to the decision making process based on the realities of each individual farms thus helping them to differentiate between two farms wherever required.

Key words: Agriculture Resource Inventory, Image Processing, Crop Detection

Research on the Source of Sediment Using ^{137}Cs Tracing Method —A case study for the YANGOU Watershed, Jiangxi, China

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As an artificial radionuclide, ^{137}Cs were a by-product of atmospheric thermal nuclear testing in the 1950s and 1970s, with a half-life of 30.17 years. ^{137}Cs tracer method used to study soil erosion is the only one that has only emerged in recent decades, which has a bit of time-saving, labor-saving, reliable and efficient, and has been greatly popularized in soil erosion research.

The source of sediment has always been an important part of soil erosion research. To clarify the source of sediment will help to carry out targeted soil erosion control later in life.

Based on the contrast analysis of the upper soil sample in different location of slope land, forest and grassland, reservoir sedimentation in YANGOU Basin. The source of sediment was analyzed by using hybrid model. The results showed : The sediment in the watershed came from the sloping cropland mainly, about 61.73% of the total amount sediment in the watershed.

Key words: Radionuclide, thermal nuclear testing, sediment, soil erosion

Land Use Classification of Micro Watersheds near Dediapada in Narmada District using Remote Sensing and GIS

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Land use classification is essential for evaluating the hydrological response of the watershed. The assessment of the changes in the land use pattern in the last decade is essential for watershed planners and hydrologists. The land use changes are useful for water resource planning and management which in turn helps environmental conservation, economic development and livelihoods. In this study all the micro watersheds in the 5D1A6 watershed of Narmada district were classified based on land use and land cover. The ground truth data was carefully obtained and it was used in conjunction with the "Remap" software to obtain the land use classification. Landsat satellite imageries (TM) were acquired from United States Geological Survey (USGS) for the study. The land use system was divided into five classes namely agriculture, forest, barren land, built up and water body. The present study exhibited the land use/ land cover changes from 2011 to 2018 of all the micro watersheds in the 5D1A6 watershed of Narmada district in Gujarat. The changes in the land use were suitably recorded using remote sensing, GIS and ground truth data.

Key words: GIS, Land use classification, Remap software, Remote sensing

The Influence of Meteorological Conditions in Winter Period on the Soil Erodibility and Wind Erosion Vulnerability

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A factor contributing to wind erosion on heavy soils is the course of meteorological conditions. In the winter period have effect mainly soil moisture, freezing and thawing of soil surface and in spring perioddry soil surface and intense air flow. An impact of these events can cause erosion episodes even on fine textured heavy soils (clay, loam).

During winter, water and frost are subject to aggregation and disaggregation with a positive influence on the soil structure. In some cases, the course of weather in winter can contribute to the breakdown of aggregates and the formation of the structure prone to erosion. Due to the pressure of freezing of the soil water and subsequent spillage, the soil aggregates are broken down into erodible fractions that can cause an erosion event evoked by the effect of wind flow. For the analysis of the erodibility of heavy soils due to meteorological conditions in the winter period, the soil types of Fluvisols and Phaeosols were selected in the localities of South Moravia (Czech Rep.), vulnerable to wind erosion. Soil samples were withdrawn from the soil surface, on fields with or without vegetation (winter wheat), in five autumn / spring seasons. The air-dried soil samples were subjected to aggregate analysis. To determine the non-erodible fraction, a sieve with a mesh size of 2 mm was used. Climate data on soil surface temperature and soil moisture status were obtained from the closest hydrometeorological station. From these data, the number and duration of freeze (-2 ° C) / thaw (+ 0 ° C) periods were also determined, as well as information on the number of soil conditions promoting soil aggregate destruction (soil surface wet or covered with melting snow). The results show significant influence of the vegetation cover (lower increase of soil erodibility). The higher the number of freeze-thaw (F / T) periods, the higher the amount of the erodible fraction; the effects increase with higher number of soil conditions with a wet surface.

Key words: Wind erosion, Aggregate stability, Freezing and thawing, Soil erodibility

Estimation of Runoff using Rational Method from the Characterized Micro-watersheds in the Navsari Agricultural University Campus

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The estimation of runoff is important for the hydrologists as well as watershed planners for management of water resources. The conservation structures to be adopted are decided mainly on the basis of the amount of runoff to be handled which is an integral part of the hydrologic design of a structure. Therefore, in this study, an attempt was made to assess the amount of runoff generated in the micro watersheds in the campus. The runoff from all the four micro watersheds of the campus was determined using rational formula. As the runoff coefficient depends on the land use cover, the changes in the land use pattern were identified and runoff was estimated accordingly. The weighted runoff coefficient was determined taking into consideration the land use patterns. Five classes were included in land use cover namely built up area, water body, vegetation, crop field and open field. The intensity of rainfall was obtained from the intensity duration frequency equation developed for this region whereas the time of concentration was determined using Kirpich's formula. The data of land use, area and other dimensions were obtained by remote sensing as well by ground truthing. The runoff from the micro-watersheds in the campus was obtained based on rainfall of 10-year recurrence interval.

Key words: Rational method, Runoff, Time of concentration, Watershed

Transport of Matters Evoked with Erosion in a Small Agricultural Catchment

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Harmful impacts of water erosion processes belong among the serious widespread problems of current environment conservation and maintaining of sustainable development of human population. Disturbance of soil surface, loss of soil particles and nutrients evokes reduction of soil fertility but, on the other side (among others), it negatively influences siltation of water bodies and surface water quality. Erosion events have been studied in a small agricultural catchment Nµmèický stream in the Czech Republic since 2005. The experimental catchment (3 km^2) is situated in a hilly area north from Brno. There runs continual gauging of outflows and precipitations in the profile with a Thomson´s weir. Samples of surface water are taken with an automatic sampler during extreme rainfall-runoff events. Concentrations of insoluble matters, phosphorus and nitrogen are analysed in them. Erosion symptoms on the arable land (ridges, accumulation) are also studied and state of land use and vegetation cover are registered. Content of the nutrients (mentioned above) is monitored in soils and sediments in stream and on the bottom of reservoir closing the experimental catchment. The results enable to evaluate siltation velocity in the reservoir and to investigate nutrients transport in the catchment. From the year of the reservoir construction (2012), the bottom sediment has risen of 0.6 mm/year on the average. Total nitrogen and likewise phosphorus concentration in the bottom sediment appears to be nearly twice higher than in soils. The study is supported by the Ministry of Agriculture CR, in the frame of research projects RO0219 and QK1910282.

Key words: Erosion, Arable land, Water quality, Sediment, Phosphorus, Nitrogen, Reservoir

Soil Erosion Estimation using Universal Soil Loss Equation and Geographic Information Systems of Yarehalli Micro-watershed in Channagiri Taluk Davanagere District, Karnataka

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Understanding the relationship between land attributes and soil erosion processes is very important as the resource conservation and developmental programmes are being taken up increasingly on watershed basis. Soil erosion is a serious problem arising from agricultural intensification, land degradation and other anthropogenic activities. To have any development activity especially for soil and water conservation measures, watershed management plays a vital role in conserving natural resources. Soil loss is a very serious problem which effects environment as it threatens agriculture and also surroundings. This research integrates the USLE within a Geographic Information System (GIS) environment to investigate the spatial distribution of annual soil loss potential in the watershed. The five major input parameters used in the study are rainfall erosivity factor (R), Length slope factor (LS), soil erodability factor (K), vegetation cover factor (C) and erosion control factor (P). The rainfall erosivity factor has been determined from annual rainfall data of the study area. The soil survey data was used to develop the soil erodability factor and DEM of study area was used to generate topographic factor (LS). The value of cover management factor and support practice factor were obtained from land use land cover map. After generation of input parameters, analysis was performed for estimation of soil erosion using USLE equation. The quantitative soil loss (t/ha/year) ranges were estimated and classified the watershed into different levels of soil erosion severity and also soil erosion index map was developed. The watershed is classified according to National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) into different erosion classes such as nil (e0), slight (e1), moderate (e2), sever (e3) and very sever (e4).

Key words: Soil erosion, Soil erodability, Geographical information system, Topographic factor

Conservation Practices for Checking Soil Erosion and Improving Crop Productivity under Jhum Cultivation in North Eastern Hill Region of India

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Soil health/fertility is the most crucial factor in deciding the agricultural productivity. Majority of the fields in the North Eastern Hill Region (NEHR) of India are situated across the hilly slopes. Nearly 0.88 m ha area in NEHR is under *Jhum* cultivation. Soil erosion is the most serious problem on hills due to steep slopes. Soil loss from cultivated slopes is quite high, particularly during first two to three years of cultivation. Keeping this in view, the present investigation was carried out with several conservation practices in *jhum* fields to address the soil erosion problems and improving crop productivity. Recharge pits were dug and filled with stone rubbles and charcoal to retain rain water for checking soil erosion and increasing groundwater recharge so that winter vegetables can be produced during lean period from *jhum* fields. Conservation measure like wood logs, bunding across the slopes, and strip cropping practices were also included in this investigation. The unburnt wood logs and bamboo were placed across the slope at alternate interval with a distance of 1-2 m in between each wood long and bamboo. Leguminous crops like soyabean and groundnut were grown as strip crops. A normal *jhum* field without any conservation measures was treated as control plot. The investigation revealed that with the adoption of these conservation practices, soil erosion can be checked effectively, and soil moisture along with soil organic carbon content can also be increased significantly as compared to control *jhum* plot. Further, the productivity of different crops during *kharif* season can also be increased in comparison to the farmers practice reflected by control *jhum* plot.

Key words*:* Juhm cultivation, Soil erosion, Crop productivity, Conservation practices, NEH Region

Determination of Soil Erodibility Index for Ri-Bhoi District of Meghalaya

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In the Revised Universal Soil Loss Equation (RUSLE), erodibility accounts for the influence of soil properties on soil loss during storm events in upland areas, which are represented by the soil erodibility factor (K). K-factor values were best obtained from long-term direct measurements on natural runoff plots; however, in the absence of field tests, these values can be estimated using relationships based on physico-chemical soil properties. Soil erosion by water is a major concern in Meghalaya, and the application of models such as Universal Soil Loss Equation (USLE) or RUSLE is limited due to the lack of information about erodibility factors. The K factors once determined are generally given in nomograph or map form so that the values can be picked up easily for estimating soil erosion. The present study was therefore planned to determine the erodibility factor of Ri-bhoi district of Meghalaya based on soil's physico-chemical properties and to prepare the erodibility map on GIS platform. The objectives of the study were to determine the soil erodibility index for Ri-Bhoi district of Meghalaya and to prepare the erodibility Index map for estimation of soil erosion.

Ri-bhoi district has primarily four dominant land uses *viz.* agriculture, *jhum*, forestry and wasteland apart from the built-up areas. Hundred sampling points were taken according to the land uses, taking 25 sampling points for each land use, and the exact locations of the sampling points were recorded with GPS. The sampling points were than plotted on the map of Ri-bhoi in the GIS. The K factor for each of the sampling points have been determined and recorded. In agriculture land use system (LUS) K factor values were observed in the range of 0.08 - 0.41 with an average of 0.24, *jhum* LUS 0.08 - 0.42 with an average of 0.19, forest LUS 0.09 - 0.40 with an average of 0.22, in waste land 0.10 - 0.34 with an average value of 0.22 and final map of soil erodibility was generated using Geographical Information System (GIS) tools for the spatial representation of the soil erodibility in the study area. Arc-GIS was used to interpolate the data.

Keywords: K factor, RUSLE, GIS, soil erodibility index map, Ri-Bhoi district, Meghalaya

Influence of Lime on Soil Physico-Chemical Properties in Acid Soils of Upper Brahmaputra Valley Zone of Assam

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Liming is one of the most important and feasible management practices used to ameliorate soil acidity. Further, nitrification process although restricted in acid soils can be improved by liming. A study was carried out to investigate the "Influence of lime on soil physico-chemical properties in acid soils of upper Brahmaputra valley zone of Assam". The soils varied widely in texture (sandy loam to Silty clay loam), clay content (19.98-34.73%), pH (H_2O) (4.47-5.22), pH (KCl) (3.99-4.68), OC (0.58-1.06%), CEC (6.07-9.17 meq.100g^{-1}) exhibiting strongly acidic to moderately acidic nature. The effect of $CaCO_3$ on soil physico-chemical properties showed a significant variation with lime dose. Soil pH, EC, CEC, exchangeable basic cations, base saturation and available phosphorus of four soils increased with increasing doses of applied lime. But gradual increase in the availability of nutrient content with the increase of lime dose upto a certain dose and remains same or decreases the availability. The application of increasing doses of lime increased the OC till 1.2 gm $CaCO_3$ per100gm soil and thereafter decreased gradually. While, soil available nitrogen content increased with increasing dose of lime till 1.35 gm $CaCO_3$ per 100gm and thereafter decreased gradually with increased doses of lime.

Key words: Lime, dose, nutrients, physico-chemical properties

Extent, Causes and Restoration of Land Degradation

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In the recent past years, Land degradation exists as a major environmental problem due to unrelenting human pressure and incompatible land utilization in India as well as around the world.It emerged as a serious threat affectingmore than 1.5 billion people over the world as a result 12 million hectares of landdegrading every year. The extent of land degradation in arable and non - arable land is around 120.7 Mha i.e. 36.7% in India. Such lands are being degraded by natural and anthropogenic activities. The main causes of land degradation are erosion, salinization, acidification, overgrazing, climate change, pollution, deforestation as well as increased humanpopulation. Degraded land alters the physical, chemical and biological properties of soil which affects ecological balance and productivity of the land, mainly agriculture. Reforestation is one of the key steps for the restoration of degraded land. Therefore, during reforestation, biotic and abiotic stress tolerant species; survival of morphological traits during unfavourable conditions; soil type and its moisture retention ability etc., should always be focussed. The degraded top soil layers are very necessary to restore to meet the food demands, reducing soil and water pollution, minimizing intensive cultivation, balancing ecosystem, increasing agricultural and economic growth of the nation.

Key words*:* Land degradation, Restoration, Causes, Deforestation

GIS Aided Identification of Arsenic Vulnerable Zones for Possible Mitigation using Biochar in Rice Ecosystem of Central Brahmaputra Valley Zone of Assam, India

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Arsenic laden ground water is a newly emerging concern in Assam, showing its value above the permissible level. The average contribution to total arsenic intake from drinking water is found to be 13%, whereas from cooked rice it is 56%, thus making it clear that rice contributed most to the daily arsenic intake. Plentiful quantity of arsenic laden underground water is being used to irrigate summer paddy during dry spell. Long term use of such water may further aggravate this problem through high arsenic uptake in rice grain and enter into the food chain from cooked rice. Recent reports revealed that rice grains contain arsenic upto 2 mg kg^{-1} grain which is considered to be above the desirable limit (1.0 mg kg^{-1} grain) Therefore, technologically acceptable and economically viable management options to reduce arsenic loading in rice is the major challenge. Using Geographic Information System (GIS) in identifying arsenic vulnerable risk zones and finding the possible technology to reduce its translocation from arsenic laden irrigation water to paddy soil and to rice plant with its distribution in roots, straw and more particularly in rice grain can be considered as an important aspect in this regard. In the present study, ground water Arsenic status of Nagaon district of Assam, which is situated in the Central Brahmaputra Valley Zone, was evaluated to find out the Arsenic vulnerable zones using GIS. A field experiment was laid-out at *Sologuri* village in Nagaon district based on the high arsenic level in groundwater as depicted from GIS-aided arsenic map taking three *summer* rice varieties *viz*. Naveen, Abhishek and Sahbhagi to develop a low cost less arsenic loading technology. Biochar made up of two different sources of locally available bio-wastes *viz*. rice straw and *toria* stover under slow pyrolysis were used as strong adsorbent and applijed in 3 graded doses in specified irrigation channel to reduce root, straw and grain arsenic content in rice plant. The roots of the rice plants, irrespective of sources and levels of application of biochar, accumulated the highest amount of Arsenic followed by straw and rice (unhusked) grains. Thus the present observation obviously indicated an accumulation of As in the rice grain that would enter into the food chain. Application of biochars at 1 to 2 percent levels (weight by weight), irrespective of sources, reduced the root, straw and grain arsenic content. The significant reduction in the bioavailability of Arsenic suggests that biochar application may have potential for remediating contaminated soils and thus can be an excellent adsorbent for the removal of aqueous Arsenic.

Key words: GIS, Arsenic, ground water

Photocatalytic Activity of Methylene Blue Using Zinc Nanoparticles Synthesized from *Eucalyptus lanceolatus* Leaf Extract

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In recent years, the contamination of surface and ground water has increased due to population growth. The main sources of soil contaminations are organic dyes used in various food, leather, textile and other industries. Green synthesis of Zinc oxide nanoparticles were prepared using *Eucalyptus lanceolatus* leaf extract and zinc acetate dihydrate. It was utilized as a photocatalyst for the degradation of Methylene blue. The catalyst was characterized by UV (UV-visible spectrum), FT-IR, X-ray diffraction and scanning electron microscopy (SEM). Surface plasmon resonance confirmed the formation of ZnONPs with a maximum absorbance (λ_{max}) of 400 nm. The zeta potential was found to be –15.41 mV. X-ray diffraction studies confirmed the crystalline nature of the nanoparticles indicating particle size within the range provided by scanning electron microscopy data. These nanoparticles were used for photocatalytic degradation of methylene blue dye under solar light irradiation.The factors affecting the photocatalytic degradation efficiency, including irradiation time, loading catalyst doses,initial concentration of Methylene and pH variability were investigated. The results obtained showed that the photocatalytic degradation efficiency was increased with both the decrease of the initial methylene concentration and the increase of the catalyst doses. The maximum percent ofphotocatalytic degradation was obtained at 5ppm of methylene blue dye concentration at pH 4, irradiation time of 160 min and loading catalyst dose of 50mg L^{-1} Under these conditions, the photocatalytic degradation percentage of methylene blue was more than 96%.

Key words: *Eucalyptus lanceolatus*, ZnONPs, Photocatalytic activity, Dye degradation, Sunlight

S-oxidisers: An Alternative Approach for Sodicity Reclamation

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Soil sodicity is an environmental stress adversely affect the plant growth and agricultural production. Appropriate reclamation technology is advocated to reduce the harmful impact of soil sodicity and alkalinity Sodicity is frequently managed by application of gypsum. However, the current demand of these amendments in allied sectors has necessitated inventing the potentiality of refinery byproduct elemental S-formulation to combat sodicity/and reducing pH. Elemental S is insoluble in water and its oxidation is mediated by *Thiobacillus thiooxidans,* in some ambient condition. Considering this in view, a total of 215 S oxidizers morphotypes were isolated on thiosulfate medium from the soils with variable sodicity and high pH, S-rich dump sites and water collectedfrom hot-water springs. Among them, 15 isolates were selected on the basis of better pH reduction ability in S-broth containingbromocresol purple and agar medium by changing the colour of the media from purple to colourless. The S-oxidising bacterial isolates obtained from the soil of Mumbai coastal area reduced the pH up to 3.98-4.50 from the initial pH (8.0) within 11 days of incubation. Additionally, a maximum amount of SO_4^{2-} of 58.7 ppm was produced during the growth of S-oxidizer in elemental S-broth. Moreover, the selected cultures were found compatible with each other. Therefore, an effective use of these isolates either individually or as a consortia could be a boon for developing suitable reclamation technology to combat sodicity in near future.

Key words: Sodicity, Elemental S-formulation, Thiosulfate medium, Hot-water spring, S-oxidizers and consortia

Ephemeral Gully Erosion a Serious Problem of Soil Degradation in the Czech Republic

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Water erosion is a serious degradation process in Czech Republic, currently threatening more than half of agricultural acreage. Surface runoff resulting in the formation of ephemeral gullies (EGs) can contribute significantly to total soil loss in agricultural areas. Identification and mapping of potential paths of concentrated surface runoff (PCR) from blocks of arable land throughout the Czech Republic was carried out for the Ministry of Agriculture. The project was based on modelling accumulation of flow from drainage areas contributing to potential PCR, interpretation of terrain character, and visual interpretation of an orthophoto map, on the relevant physical blocks of Land Parcel Identification System. The output includes a database of structured items describing the location and character of individual identified and mapped PCR. More than 33 000 PCR were identified, with a total length of nearly 12 000 km. The South Moravia Region was selected as a case study area - mainly for its natural conditions and high risk of soil degradation. A set of data, collected in a maize-growing area, especially on deep loess soils in the South Moravia Region, was used to analyse the morphological characteristics of EGs. The relationship was confirmed between ephemeral gully length and the size of its contributing drainage area. It is also important that the closest relationship was confirmed between the length of the gully and its calculated volume. Dependence was sought on the data of detailed measured and evaluated EG. These results will become the basis for finding a predictive relationship and quantification of EGs erosion. Locating EGs and predicting their length is crucial for estimating sediment load and planning conservation strategiesincluding agroforestry conservation systems for the soil protection and restoration of landscape functions.

Key words: Ephemeral gully, Soil degradation, Soil erosion, Concentrated surface runoff

Evaluation of Buffer Lime Requirement Determination Methods for Acid Soils of Jorhat District of Assam

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Liming is one of the most important and feasible management practices used to ameliorate soil acidity. Generally lime requirement (LR) for acidic soils are determined by buffer pH method because of their ease of implementation, simplicity and rapidity. The SMP buffer test is used to determine lime requirement for Assam soils. Though this method is proven to work for Assam soils, it uses p-nitrophenol, which is very hazardous substance. Now-a-days soil-testing laboratories are under increasing pressure to reduce hazardous waste. So goal of this study was to evaluate a buffer as alternatives to the SMP buffer in determining the LR for Jorhat soils. In this study four composite soil samples from different soil series of Jorhat district having pH range 4.4 to 5.2 were collected and incubated with different doses of $CaCO_3$ for a period of thirty days to determine lime required (LR) to attain different target pHs (6.0, 6.4 and 6.8). These LR were then regressed with the different buffer pH (BpH) of four buffer solutions [(1) Shoemaker, McLean, and Pratt buffer (SMP), (2) Sikora-II buffer, (3) Mehlich buffer, and (4) Modified Mehlich buffer] to obtain calibration equations. The LR value evaluated from Soil $CaCO_3$ moist incubation (SCMI) method ranged from 1.69 - 5.55 tonnes $CaCO_3$ ha^{-1} for four soils. The vegetable growing soil of Jorhat series (J_{ser}^1) and Mariani series (M_{ser}) exhibited highest and lowest LR values respectively. The change of BpH was highest in Mariani series (M_{ser}) and lowest in Jorhat series(J_{ser}^1) for all five buffers. The highest percent variation between soil BpH and original BpH was observed for SMP buffer (25.10%) followed by Sikora-II (19.90%), Mehlich buffer (9.50%) and Modified Mehlich buffer (8.40%). Among the different buffer lime requirement methods tested, all the buffer methods of LR has shown higher buffer pH variability. But, almost similar lime rate values with that of SCMI was found in four buffer methods except SMP buffer. Further, Sikora-II based on the stated parameters may be considered as an alternative to present SMP buffer lime requirement method. These findings may overcome the use of hazardous chemicals used for recommending lime rate during Soil Health Card (SHC) preparation as mandated by Govt. of India.

Key words: Buffer, pH, Lime, SCMI, Lime requirement, Acid soil

Prediction of Runoff and Sediment Yield from Watersheds of Chambal Basin, India

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Assessment and inventory on soil erosion and sedimentation is essential for formulation of effective soil conservation plans of a watershed for sustainable development. Site specific quantitative estimation of sediment yield is necessary for designing and implementing appropriate soil and water conservation measures and also to mitigate the ill effects of sedimentation. Water erosion and sedimentation processes are influenced by a multitude of factors and occur at different intensities across the landscape which makes the monitoring and assessment a complex and cumbersome task with considerable uncertainty. The study aims to develop a simple method of sediment yield estimation from watershed using soil, land use and topographical characteristics. The study area lies between longitudes $74^0 45'$ to $75^0 50'$ E and latitudes $23^0 30'$ to $25^0 10'$ N, over the states of Madhya Pradesh and Rajasthan. The data set have been subjected to principal component analysis and multiple linear and non linear regression analysis. The relative importance of factors to sediment yield (in 0-1 scale) followed the order Rainfall (0.40) > catchment area (0.30) > slope (0.12) > silt percentage (0.11) > land use factor (0.055) > bulk density (0.005) > clay (0.0042) > hydraulic conductivity (0.006) > sand percentage (0.0097). Non-linear regression equations for runoff and sediment yield estimation are:

Runoff = $0.0051 \times A^{0.806} \times P^{1.231} \times Lu^{0.911} \times Sl^{0.176}$ (N= 30, R^2= 0.66)

Sediment yield = $0.806 \times 10^{-7} \times A^{1.11} \times P^{0.534} \times Lu^{0.602} \times Sl^{0.055}$ (N= 30, R^2= 0.54)

where, A = Catchment area and P = Annual rainfall, Lu= land use factor, Sl= slope

This prediction of sediment yield will be helpful in order to adopt the suitable conservation measures in the watershed area for minimising the sediment load in the reservoir and also to increase the life of structures.

Key words: Sediment yield estimation, principal component analysis, multiple linear, non linear regression, land use

Productivity, Water use Efficiency, Splash Loss and Economics of Sorghum (*Sorghum bicolor* L.) based Intercropping System under Rainfed Condition

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The field experiment was conducted during Kharif season of 2016 at Soil Conservation and Water Management Farm of C.S.Azad Univ. of Agril. & Tech., Kanpur. To adjudge suitable row ratio of Sorghum + Green Gram, Sorghum + black gram, Sorghum + Soybean in sorghum based intercropping system under rainfed condition. The treatment comprises 10 cropping systems, T_1 (Sorghum sole), T_2 (Green gram sole), T_3 (Black gram sole), T_4 (Soybean sole), T_5 (Sorghum + Green gram, 2:1), T_6 (Sorghum + Black gram, 2:1), T_7 (Sorghum + Soybean, 2:1), T_8 (Sorghum + Green gram, 3:1), T_9 (Sorghum + Black gram, 3:1) and T_{10} (Sorghum + Soybean, 3:1), with 3 replications in Randomized Block Design. Recommended dose of fertilizer was applied as per row adjusted. The results revealed that among different cropping system, sorghum equivalent yield of 30.09 q/ha, earned maximum net return Benefit: Cost ration i.e. Rs. 33,106.00 and 1:2:19 during the experimentation over other cropping systems under test.

Key words: Row ratio, soybean, green gram, sorghum, cropping system, B:C ratio

Rapid Detailed Spatial Soil Erosion Mapping and Risk Assessment in Shivalik Hills, Punjab

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Assessment of soil erosion risk is important for evaluating the soil loss dynamics in area. The present study was conducted in Geographic Information System (GIS) domain by using a framework of Erosion Risk Weightage Index (ERWI) model developed by Soil and Land Use Survey of India, Ministry of Agriculture and Farmers Welfare, Government of India.

This model comprises of the soil and land attributes acquired through rapid detailed soils mapping as input and provide a rapid scientific, landscape-based framework for assessment of erosion risks. The process involves development of image analysis map using IKONOS data with Cartosat- Digital Elevation Map (DEM) downloaded from BHUVAN. The mapping of soil and land parameters governing soil susceptibility to erosion was done using High Resolution Satellite data at 1:5 K scale.

The model principally based on Runoff Potential Weightage values assigned on the basis of relative assessed runoff generated from the area covered by landscape based unit. The Runoff Potential Weightage as derived from set of soil, land and climate attributes used to spatially prioritize the entire study area into five soil erosion risk categories. The particle inertia factor K is taken as 0.50. This study confirms that out of total 225506 ha area, the area under very high erosion risk and high erosion risk is about 43322 ha and 37440 ha, respectively. Detailed spatial mapping thus prepared will be helpful in planning appropriate field level conservation measures to prevent the soil erosion and further degradation of land.

Key words: Erosion risk, Weightage, Geographic Information System, Particle inertia

SESSION-II

Water Resource Conservation and Management

Concept of Zero Ground Water Exploitation – Potential and Challenges

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Groundwater in India is a critical resource for most of the major user sectors namely industry, agriculture and domestic. With the growth in pollution and industrialization, dependency on ground water is increasing resulting in unsustainable levels of exploitation. If current trends continue, in 20 years about 60 percent of India's aquifers will be in a critical condition says a World Bank report. This will have serious implications for the sustainability of agriculture, long-term food security, livelihoods, and economic growth of the country. There is an urgent need to change the status quo. More than 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater. Urban residents increasingly rely on groundwater due to unreliable and inadequate municipal water supplies.

The sub-surface reservoirs can store substantial quantity of water. The alluvial plains of Bihar have potential aquifers with ample source of water for recharge, but are witnessing accelerated groundwater draft over the last couple of decades. Despite being the land of rivers, more than 80% of irrigation demand in Eastern India are met mainly by groundwater resources due to easy availability and unreliable and insufficient surface water irrigation network. This unsustainable use of groundwater becomes even more challenging due to (a) increasing demand from a burgeoning population and industrialization which leads to a risk of insufficient supply, and (b) poorly understood effects of climate driven changes in water cycle such as increase in temperature and change in rainfall pattern that could affect the groundwater recharge rates.

The concept of zero ground water exploitation means a zone where ground water pumped is replenished with natural and artificial recharge. This will involve estimation of ground water pumped, domestic, industrial and agricultural use, estimation of natural recharge and therefore deficit/over exploitation. Once this is known the deficit can be met by three pronged strategy: improve the efficiency in each sector to reduce use, replace use of ground water by recycled treated/ filtered waste water and artificial recharge. A preliminary study at RPCAU Campus, Pusa has shown that total annual exploitation of ground water is 228 ha-m out of which about 100 ha-m is used for domestic and 128 ha-m for agricultural purposes. Natural recharge has been estimated to be about 110 ha-m leaving a deficit of 118 ha-m for artificial recharge.

The ground water recharge cum drainage unit developed at RPCAU, Pusa is one of such examples of artificial recharge method. This structure can very well be used for recharging ground water through runoff water at a rate of about 6.5 liter per second with Solid Removal Efficiency of about 81 percent. The annual ground water recharge potential of this structure varies between 1.5 - 2.0 ha-m. Ground Water Recharge of the 2nd aquifer is one of the viable options and it can be successfully recharged. Further studies are underway for utilization of waste water and reduction in water use by increasing efficiency.

Key words: Groundwater recharge, natural recharge, insufficient surface water irrigation network

Recent Trends in Agricultural Water Management for Climate Smart Agriculture

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Of all the planet's renewable resources, water has a unique place. It is essential for sustaining all forms of life, food production, economic development, and for general well being. Under the changing climate, water resources need to be preserved, optimally utilized and its quality maintained within acceptable limits. Innovative technologies, including the improvements in the indigenous technologies, are needed to fully utilize limited water resources and to safeguard these resources against pollution.

The overall efficiency in most irrigation systems is low and in the range of 35 percent to 40 percent efficiency in surface water and 65-70 percent efficiency in ground water utilization. Being, major consumer of water, even a marginal improvement in the efficiency of water use in irrigation sector will result in saving of substantial quantity of water. It is essential to modernize the irrigation system for optimal use of water resources by economizing water consumption per unit yield of agricultural produce. This involves not merely improvement of engineering parameters e.g. lining of canals / improvement of structures / providing additional field channels but also application of a complex combination of field disciplines (agronomic / management / field measurement and hydro-sociological aspects) to the irrigated agriculture sector. Different modern and innovative approaches may be adopted in i) water conservation, ii) water harvesting and storage, iii) land preparation, iv) water conveyance network, v) water application and vi) automation.

Indian Prime Minister's dream of conveying irrigation water to each holding may be achieved by laying elaborate network of water courses by employing system engineering models like Minimum Spanning Tree Model. Since many farmers are averse to spare their land in water courses, underground pipeline distribution system is preferred and should be encouraged. It will also help in minimizing conveyance losses (approximately 20%), besides saving 5 to 7% precious land, used for laying watercourses. Modern efficient water application methods like surge irrigation for surface and drip and sprinkler under pressurized conditions need to be employed on large scale. Automation and use of computer models may also help in ensuring water security in changing climatic situations.

Another way through which we can improve freshwater availability is by recycle and reuse of water. Use of water of lesser quality, such as reclaimed wastewater, for agriculture is an attractive option. This will also help in conserving better quality waters for potable uses. Currently, recycling of water is not practiced on a large scale in India and there is considerable scope and need to incentivize the use of this alternative. This article presents different alternative technological solutions proposed by different researchers in agricultural water management under changing climatic conditions.

Key words: Water management, Climate change, Water productivity

Integrated Irrigation Management for Higher Water Productivity of Rice-Wheat System in Northwest India

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The rice-wheat system, the mainstay of the region's agriculture, has accounted for over 80 per cent of the gross cultivated area. Coupled with high productivity, the cropping system has not only improved the economy of the farmers, but also contributed towards the central pool to ensure the nation's food security. But at the same time, this phenomenal growth over the years has over-stressed the water resources, as reflected by the alarming fall in groundwater levels. The average fall in the water table rose from 0.18 m $year^{-1}$ in 1982-87 to 0.74 m $year^{-1}$ in 2004-05 in the state of Punjab. The enactment of the Preservation of Subsoil Water Acts in Punjab and Haryana (that banned transplanting of rice before June 10) has arrested this depletion of groundwater resources to some extent. As a consequence, the average decline in the water table during 2013-18 was recorded to be 0.37 m $year^{-1}$ in the state. Strategies need to be developed to improve water use efficiency in rice-wheat system through the use of novel irrigation technologies. The irrigation management strategies need to be devised and tested to avoid deficits at critical plant growth stage that will impact adversely on yield and impose deficits when they will reduce shoot growth but not impact adversely on yield and may enhance harvest index and/or crop quality.

Crop scheduling to take advantage of periods with low evaporation demand (e.g. delayed transplanting of rice) holds promise in real saving of irrigation water. Synchronizing water application with crop demand so as to avoid over-irrigation. It can best be achieved by identifying water-sensitive growth stages in relation to prevailing weather conditions. The use of tensiometers for successful irrigation to rice in Punjab has ample scope to be studied for other crops. It has dual benefit of considering soil type as well as climatic demand while indicating when to irrigate. Deficit irrigation, which involves less water supplied to the crop than would be needed for achieving maximum crop production, needs to be worked out for different wheat-based cropping systems. Because of the usually curvilinear shape of the crop-water production function, maximum crop water productivity would be achieved at a water supply that is lower than need for maximum yield. Partial root zone drying irrigation (furrow irrigation) needs to be rescheduled for various crops in the cropping system, based on applied water dynamics in different soils.

The development of irrigation schedules for crops grown with resource conservation techniques (RCTs) is a pre-requisite for improving their water productivity. Growing crops with RCTs alters the micro-climate of the field and hence the water balance. This requires re-working the water balance components of different crops grown with RCTs. The use of isotope signals in the soil-plant system to characterize depth and extent of water extraction by crops need to be studied. In addition this technique can go a long way in delineating pathways of applied water movement so as to manage it efficiently.

Key words: Groundwater, crop water productivity, water balance

Reliability and Implementation of Automated Wireless Sensor for Irrigation System

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In an era of increasing population and decreasing rainfall, requirement for food security and natural resource management has increased to an extend where old practices like agriculture and irrigation are often drawn to question for innovation and modernization with development in science and technology. The irrigation practices could be defined as a methodology for storing and managing water resources for cultivating crops at right time with right amount of water.With growth of humanity, this old practice has also transformed from an era bullocks to water pumps and now further to complex automated system of sensors and actuators. Present, irrigation system are driven through actuators like solenoid valves, water pumps and sensors like water flow meter, ph meter, electrical conductivity meter etc for ensuring a higher water productivity and minimal water wastage for a subjected field. These irrigation practices are often optimized through scheduling, where soil stress for any field is reduced through scheduled delivery of water thus giving ideal condition for plants to grow and absorb nutrients from soil, for instance in case of corn crop, through a stage germination to initial stage moisture content of soil should be maintain upto 50%, and in middle stage to final stage i.e flowering and fruiting stage of crop moisture content of soil should be maintained at 75% for ensuring high yield and maximum fruiting. Through above stated scenario,requirement of crop changes every time as per change climatic conditions, temperature, stages etc and therefore there is a need continues attention for maintaining highly productive, farmers are generally required to keep crop check through revisiting field to get a real time status of crop. Thus an automated irrigation system is a requirement of modern day farmer for monitoring and maintain an amicable condition in their field through a cooperative use of modern day smart sensors and smart actuator. Presently, crop conditions could be measured with parameters like electrical conductivity, pH, permittivity and temperature etc. The soil moisture content could be measured through electrical conductivity with a means of capacitive and resistive sensor and further a relation could be derived between changing conductivity and water content of soil. This moisture based sensor could act as part of remote sensing wireless system through which information could be use for real time analysis and controlling actuators, therefore controlling irrigation. Such real time water requirement analysis could further be used in estimating the annual water requirement of any field with similar crops.

Key words: Sensor, Actuator, Irrigation, Water productivity, Electrical conductivity

Revival of Village Ponds in Bihar with Common Sense based Scientific Interventions

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The village ponds in various parts of India in a state of disrepair and neglect were once a lifeline of the rural hydrology, but with the advent of modern irrigation infrastructure and more reliable and clean drinking water sources, they are being neglected. We conducted field surveys and disscusion with local people of the villages to understand the water bodies, ponds and wells that are still existing. There is a realisation that these boides are still being used for irrigation and accumulation of water in ponds from different streams plays an important role. Several ponds occur in the villages and they are fed by channels / *ahars* carrying water from the seasonal rivers in the rainy season. *Ahars* make a network of village ponds and feed these ponds with water in a series. The cultivated as well as built up area along with permanent fallows in these villages serve as catchment for rainwater to accumulate in the ponds. A detailed study through exploratory surveys, focused group discussions and scientific investigations was conducted in *Kolakhurd* village of Bhagalpur. Several factors that may be held responsible for the decline of village ponds were identified during the exploratory surveys and have been addressed through common sense based scientific interventions. The profile characteristics of the selected ponds suggest that the pond bottoms can be very safely dug out by another 5 ft or so without any danger of increasing the seepage losses. The infiltration rate is likely to decrease further with pond deepening because of the compact clay dominating the lower profile. The steady state infiltration rate of the pond bottom was measured using double ring infiltrometer and was found to average 1.5 to 2.5 cm day^{-1}. Regular monitoring of the pond water quality (before drying) indicated that the water quality was safe for use in agriculture and animal husbandry. Treatment of the catchment by planting of perennial grasses in the inlet channel, closing of the multiple inlet channels and directing the inflow through a single regulated inlet channel, installation of a sluice gate on the targeted inlet to prevent backflow of water from the pond, installation of a piped outlet with ball valve to regulate out-flow from the pond for irrigating the command area, deepening of the pond for increasing the storage capacity, shaping of the pond embankment and planting of perennial grasses and fruit trees for stabilization of the pond embankment have helped in making the pond in a better shape. Further interventions such as initiation of a user group for better utilization of pond water and upkeep of pond and keeping a track of the in season water availability by monitoring of the rainfall and water level in the pond on a weekly basis have strengthened the approach. Further educational and training activities with the user group and other stakeholders of the adopted pond in the village are envisaged.

Key words: Rainwater harvesting, Water table, Groundwater recharge, Conjunctive use

Baseline Studies and Irrigation Innovations for Higher Water Productivity of Medium Irrigations Projects of Telangana Sate of Southern India

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Water is one of the most important inputs for sustainable and profitable agriculture. The prevailing water use efficiency of irrigation projects is in the range of 30 to 40% which could be enhanced to about 60% through systemic improvement. There is immense scope for improving irrigation efficiency & saving the huge volume of water for additional irrigation/other beneficial use. Due emphasis is required to be laid on both efficiency in use of water through appropriate demand side management and on the efficiency of created facilities for utilization of water. Keeping these considerations in view, baseline studies for improving water use efficiency of 5 medium irrigation projects namely Sathnala, Vattivagu, Musi, Pedavagu and Taliperu of Telangana State of Southern India was conducted during 2015-2019 under the externally funded project from National Water Mission, Government of India. The main objective of the study is assessing the water use efficiency of medium irrigation project and identification of measures for improving the efficacy of created facilities. The overall water use efficiency of the medium irrigation projects were worked out based on reservoir filling efficiency, conveyance efficiency, on farm application efficiency, drainage efficiency, project water use efficiency, irrigation potential created and utilized. These efficiencies were worked out based on the field experimentation and the data collected from primary and secondary sources. The reservoir filling efficiency of the projects varies from 85-100%. The conveyance efficiency of the canal networks varies from 60-96%. The lining of canal networks and proper maintenance of canals has significantly increased the conveyance efficiencies upto 96%. The water saving technologies such as alternate wetting and drying, direct seeded rice cultivation, rotational supply of irrigation water and micro irrigation techniques has significantly increased the on farm efficiency in these project commands. These technologies need to be upscaled for increasing the water use efficiency, productivity and equity in the canal command areas.

Key words: Medium irrigation projects, Water use efficiency, On-farm efficiency, Water saving technologies

The Hydrodynamic Mechanism of Rainfall Runoff from Loess Slope Mixed with Straw

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The hydrodynamics of rainfall runoff are important factors that affect soil erosion and migration and diffusion of chemical pollutants. As a soil amendment, straw incorporated into the cultivated soil layer may affect rainfall and runoff on slopy farmland. Laboratory experiments were conducted with four straw incorporation rates (0, 2, 4, and 8 t/ha), four rainfall intensities (40, 80, 120, and 160 mm/h), three slope gradients (10, 15, and 20°) to study the hydrodynamic dispersion coefficient, at three slope lengths (5, 6, and 7 m), by using the analytical solution of electrolyte transport under pulse boundary condition. The results show that the hydrodynamic dispersion coefficient is significantly reduced by the influence of straw incorporation. Under all experimental conditions, the rainfall runoff was laminar flow. Re and Fr decreased with the increase of incorporation rate. Compared with the control, straw incorporation caused more tortuous runoff path, resulting in weakened runoff turbulence. The slope roughness increased due to the increase of straw incorporation, causes increase in friction force, f, significantly as compared with the control group. The increase of rainfall intensity and slope gradient increased the driving force at slopy farmland. With or without straw incorporation, Re and Fr decreased with rainfall intensity, slope gradients and slope length, and f increased with rainfall intensity, slope gradients and slope length. However, the changes of Re, Fr and f with the above-mentioned factors were larger than those of the control group and increased with the increase of straw incorporation rate. Straw mixing into soil can significantly reduce the runoff force at slopy farmland, resulting in reduced erosion. The implementation of straw incorporation into the field is of great significance for the treatment of arable land degradation caused by soil erosion.

Key words: Straw mulch rate, Slope farmland, Rainfall intensity, Hydrodynamics, Hydrodynamic dispersion coefficient

Alternate Use of Freshwater at Early Growth Stage and Saline Canal Water at Reproductive Stage Can Minimize the Yield Loss of Maize under Coastal Saline Region of Bangladesh

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Bangladesh is a small country, but with the world 8th largest populated country in the world. The government of Bangladesh has already taken an initiative for crop intensification in the southern coastal saline region by using the improved technology as well as management practices. While, cropping intensification should not be done easily due to the scarcity of fresh irrigation water and since canal water are naturally saline. An experiment was carried out in consecutive two rabi seasons (2015-16 and 2016-17) in coastal region of Bangladesh to find outa suitable irrigation scheduling for maize cultivation in saline coastal region of Bangladesh. Treatments were six levels of irrigation such as:1. Two irrigation (T_1): first at 45 days after sowing (DAS) (vegetative stage) and second at tasseling stage(75 DAS) with fresh water; 2. Three irrigation ($T_{2)}$: first at vegetative, second at tasseling and third at grain filling (105 DAS) stages with fresh water; 3. Two Irrigation (T_3): first at vegetative stage with fresh water and second at tasseling stage with saline canal water; 4. Three irrigation (T_4): first at vegetative stage with fresh water, second at tasseling and third at grain filling stages with saline canal water; 5. Two irrigation (T_5): first at vegetative and second at tasseling stages with saline canal water and 6. Three irrigation (T_6): first at vegetative, second at tasseling and third at grain filling stages with saline canal water) were set. Two different sources of water were used for irrigation: (i) relatively fresh groundwater (with salinity of 1.10-2.23 dS m^{-1}), (ii) moderately saline canal water (with salinity of 4.18-9.74 dS m^{-1}). Irrigation water was applied to bring the soil moisture content on the root zone to field capacity considering the effective root zone depth.Results showed application of three irrigationwith fresh water (T_2) resulted in the maximum grain yield of maize,while the poorest was recorded withT_3 or T_6. Considering on the both years yield advantages, treatment $T_{4\,(}$three irrigation: first at vegetative stage with fresh water + second at tasseling and third at grain filling stages with saline canal water) produced the maximum yield, followed by T_1, T_3, T_6 and T_5. In case of water productivity, treatment T_1found the best, followed by T_3, while $T_6$was the lowest. It may be concluded that moderately saline canal water can be used for irrigating maize under water scarce coastal regionof Bangladesh. However, conjunctive use of freshwater at early sensitive stage combined with saline canal water at a later stage can minimize yield loss of maize, instead of reducing the number of irrigation events.

Key words: Salinity management, Maize, Irrigation, Conjunctive use, Bangladesh

Effects of Automatic Drip Irrigation on Yield and Water Productivity in Banana

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Water scarcity is one of the major factors affecting the productivity of banana. Drip irrigation (DI) has been found as a water saving technique in banana cultivation. Further, sensor-based automated DI which has been considered as a smart and real time water application technique might increase the water savings and enhance yield of banana. With this hypothesis, a field experiment was conducted to study the performance of automated DI in banana (cv. Grand Naine) at Bhubaneswar, Odisha during 2016–2017. Five automated DI schedules: (i) soil water sensor based irrigation and timer based irrigation (ii) at 80% crop evapotranspiration (ET_c) at 1 hr interval 3 times daily (iii) at 80% ET_c at 2 hr interval 2 times daily (iv) at 60% crop ET_c at 1 hr interval 3 times daily (iv) at 60% crop ET_c at 2 hr interval 2 times daily were compared with manually operated DI in the crop. The highest vegetative growth of plants (plant height, canopy diameter, stem girth) was observed with manually operated DI. However, sensor-based DI produced 15% higher fruit yield with 20% water saving, resulting in 40% higher water productivity (yield per unit quantity of water) compared with manually operated DI (water used, 820 mm; yield, 60.5 t ha^{-1}; water productivity, 6.2 kg m^{-3}) in the crop. The fruit qualities (total soluble solids and acidity) of sensor-based irrigated plants were superior to manually irrigated plants. The volumetric soil water content under manual DI was marginally higher (11–15%) than that under sensor-based DI (21.2–24.8%). The soil available nutrients (N, P and K) and leaf nutrients content of the plants followed the similar trend of soil water content under different treatments. The yield forecasting based on leaf-N, leaf-K, leaf water content and radiation interception using 'Principal component analysis' performed well with reasonably accuracy ($R^2 = 0.82$). Overall, these results reveal that soil water sensor-based automated DI is a productive and water saving technique which may be adopted in banana cultivation in eastern India and anywhere else with similar agro-climates of the study site.

Key words: Automatic drip irrigation, Water saving, Banana, Fruit yield, Fruit quality

Enhancing Water Use Efficiency through Improved Microbial Jute Retting Technique

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Conventional practice of jute retting requires a very high (1:20) ratio of jute plant: water for proper retting. Retting is properly carried out in slow moving soft water which is not available to more than 90% jute growers of India. In absence of that, farming community ret their harvest in stagnant water utilizing rain or underground water following conventional practice of retting. The resultant fibre from conventional retting is not of good quality and cannot be utilized for high valued diversified uses; hence farmers get less value for their product. In the improved jute retting method developed by ICAR-CRIJAF, a microbial formulation consisting of three very efficient pectinolytic retting bacterial strains of *Bacillus pumilus* is used for proper retting of jute in 1:5 ratio of jute: water. The retting duration is reduced by 6 to 7 days in improved method of retting compared to conventional practice.It will help the farming community to utilize the same retting water for 2 to 3 times in a retting season, which otherwise is not feasible in conventional retting. The fibre recovery is also higher by 8 to 10% because of lesser duration and recovery of full fibre compared to conventional retting. The fibre obtained from the improved method of retting is of very good quality, which is increased by at least 2 grades from conventionally produced jute fibre and can be utilized for diversified uses because of improvement in colour, strength, lustre and reduction in root content in fibre. The net income of jute farmers was found increased by more than Rs.10,000/ha following the improved method of microbial retting over conventionalretting.This improved retting technology has been adopted by National Jute Board under Ministry of Textiles, Govt. of India and used by more than 3 lakh jute and mesta farmers of Assam, Bihar, Odisha, Meghalaya, West Bengal and Andhra Pradesh during last four years (2015 to 2018) under Jute-ICARE (Jute- Improved cultivation and advanced retting exercise) project.This potential technology can be used in larger scale to meet the demand of quality jute fibre by jute industries and also to increase the net income of resource poor jute farmers with very little initial input.

Key words: Jute retting, Water use efficiency, Microbial formulation, Fibre quality

Soil Wetting Pattern and Water-Front Advance Study under Subsurface Drip Irrigation in Vertisol

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An experiment was undertaken to study the spatial and temporal soil moisture distribution pattern and wetting front advance under subsurface drip irrigation (SDI) in vertisol for given depth and spacing of lateral lineat the Precision Farming Development Centre (PFDC) of ICAR-Central Institute of Agricultural Engineering, Bhopal in central India, during summer season of 2018.Non pressure-compensating emitters with a working interval ranging from 50 to 400 kPa with 4L/h flow rate imbedded in laterals were placed at 15 cm depth from bed surface. Calculated irrigation statistical uniformitywas high during both cases (0.93 at the beginning of the experiment and 0.89 at the end).Vertical cuts were made in the soil both along and across the laterals for visually observation of soil water front movement with time in vertical and horizontal direction in completely dry soil and comparatively wet soil.Because black cotton soil offers substantial resistance in the process of downward flow. For this reason, vertically downward diffusion was relatively small, but compared to lateral movement vertical movement was fast and relatively uniform.SURFER 10 windows software was used for developing moisture content lines.Thus, the results of this study will be helpful for a better understanding of the geometry of wetting zone i.e. depth and radius of wetting zone at different irrigation duration for crop selection, system design, operation and management of system.

Key words: Subsurface drip irrigation, SURFER, Water front, Wetting pattern

Integrated Rainwater Resource Management (iRaM) Model for Coastal South Gujarat

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South Gujarat region had ample water availability but water shortage is being experienced during summer and water logging during monsoon. Also, due to large scale industrialization of south Gujarat, problems of air and water pollution have arisen which have become more complex because of over exploitation of natural resources 'ground water'. In many areas, due to continuous pumping of sweet water, sea water ingress has taken place and bores had become defunct as the water quality deteriorated drastically, due to which many cultivable farm land became uncultivable and are lying as waste land. The water quality had deteriorated to such an extent that neither it could be used for drinking purposes nor for irrigation of crop. High intensity rains occur during monsoon allowing very little opportunity time for the water to infiltrate into the aquifers. All the rainwater during monsoon directly goes as runoff ultimately reaching the sea. Also, where ponds exist, catchment areas are disappearing due to construction work and ponds no longer receive rain water. So, an attempt was made to conserve the "rain water" natural resource while evaluating the potential of raising fish in small pond through harvested rain water. From the study, it was inferred that rain water harvesting in small or big ponds not only replenished aquifers but also checked deteriorating water quality in addition to providing sweet water fish harvest for economic gain. For coastal south Gujarat it was suggested that approximately 10% area of the farm land may be allocated for a pond so as to store 2.5 m deep water, to harvest rain water / excess canal water.

Key words: Rain water, Runoff, Fish, Rainwater, Water resource management, etc.

Effect of Irrigation and Mulch Regime on Pigeonpea

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The field experiment was conducted at college farm, College of Agricultural Engineering and Technology, Navsari Agricultural University, Dediapada, during *rabi* season 2017-18. The experiment was laid out in randomized block design with four replications, keeping five treatments of T_1- Drip irrigation with 0.6 PEF, T_2 - Drip irrigation with 0.6 PEF, Drip + Black Plastic Mulch 50 μ with (56% coverage), T_3 - Drip irrigation with 0.6 PEF, Drip + sugarcane trash mulch @ 5 t/ha with (56% coverage), T_4 - surface irrigation IW/CPE: 1, 60 mm depth + sugarcane trash mulch @ 5 t/ha (56% coverage) and T_5 - surface irrigation IW/CPE: 1 (control) with 60 mm depth. Significantly higher yield attribute and biological yield was observed in the treatment 0.6 PEF through drip irrigation with sugarcane trash mulch @ 5 t/ha. Among mulch treatments, 0.6 PEF through drip irrigation with sugarcane trash mulch @ 5 t/ha was found to be significantly superior over other treatments with higher plant height at harvest (182.66 cm), leaf area index (0.88), stem girth (16.46 mm), root length (40.05 cm) and spread (27.38 cm), number of pods per plant (273.26), number of seed per plant (981.89), number of seed per pod (3.59), pod yield per plant (147.71 g), grain yield per plant (100.63) and 100 seed weight (11.20 g). The grain yield registered under treatment T_3 and T_4 were 80.66% and 50.87% which were higher than the grain yield under surface (control).

Key words: Drip irrigation, Biometric parameter, Mulching, Pigeonpea, Sugarcane mulch

Drainage Technologies for Enhancing Productivity of Temporary Waterlogged Vertisols in Central India

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Vertisols (clay soils) occupy over 320 mha (2.5%) of the global land area and are characterized by poor soil physical properties. In India, out of 6.74 mha salt affected lands, more than 1 mha severely waterlogged saline soils fall under each coastal and black cotton heavy soil (Vertisols) regions. Sub surface drainage (SSD), an effective technology practiced extensively for amelioration of waterlogged irrigated lands. The Bhopal region receives 1070 mm average annual rainfall with 48 rainy days. The soil of Bhopal region is classified as Vertisols having 51.0 - 54.7% clay content. High intensity of rainfall during monsoon season combined with poor physical properties of Vertisols lead to flooding, surface ponding and/or water logging, thus making them difficult for crop cultivation during Kharif season. In order to restore these degraded lands drainage becomes an essential measure.The paper presents the research findings of the conducted field studies on surface drainage (surface trenching and broad bed & furrow (BBFs) and SSD systems (pipe and mole drainage) for temporary water logged Vertisols of Madhya Pradesh.

Surface and SSD systems were designed and their effectiveness was evaluated through field studies for the crops sensitive to waterlogging (soybean, maize and pigeon pea). The surface drainage system comprising V shaped trenches of 300 mm deep installed at 20 m drain spacing resulted into 20.7 to 27.7% increase in the yields of pigeon pea, maize, soybean crops over the control (land without drainage). The broad bed and furrow (BBF) system of 150 mm depth and 1.50 m spacing increased 32% soybean crop yield over the control. The designed SSD system comprise corrugated perforated PVC pipe of 72/80mm diameter with geotextile filter laid at 20 m spacing and 1.0 m depth. The crop yield increased by 54%, 40% and 41% over the control for soybean, maize and pigeon pea crops respectively under SSD system. The SSD effect on subsequent chickpea & wheat crops *revealed* 11-14% increase in yield over control. Economic analysis revealed that soybean, maize and pigeon pea crops with surface drainage, SSD and control systems resulted in benefit-cost ratio of 1.35-1.77, 1.44 – 1.55 and 0.41-0.47 respectively with payback period of 6-7 years. The performance of mole drains of 84 mm size formed at 4 m drain spacing and at a depth of 600 mm with 60 m lateral length was evaluated for soybean crop. Mole drainage system resulted in about 60% increase in soybean grain yield over the control. The soybean grain yields increased by 70% under treatment comprising BBF coupled with mole drainage over the control. Studies indicated that mole drainage is observed to be a cheaper and viable alternate to costly pipe drainage system. The study revealed that both surface and SSD systems are technically feasible and economically viable for effective drainage of Vertisols.

Key words: Subsurface drainage, Mole drainage, Vertisols, BBFs

Study on Characteristics of Soil and Water Loss in the Yangtze River Basin and Benefits of Comprehensive Treatment

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On the basis of soil analysis and water loss actualities and basiccharacteristics of Yangtze River basin, the author first discusses the small watershed as a unit of mountain, water, land, forest, road of comprehensive control of soil and water conservation technique and method, and then analyzes the effects of the comprehensive control of soil and water conservation in Yangtze river basin. Accumulative total of soil and water loss in Yangtze river basin area has reached 390,000 square kilometers in nearly 30 years.Soil erosion area embarked on a historic transformation by reversing the increase ofthe soil loss area decreased from 622,200 square kilometers in the mid-80s to 530,700 square kilometers in 2013 (38.18%), The vegetationcoverage rate was observed up to 42.5%. In soil conservation regions, the intensity of soil loss decreased by 1-2 degrees.The livelihood condition of people engaged in agriculture in these regions haswith adequate food and clothing for 20 millionpopulation.

Key words: The Yangtze river basin, Soil and water loss, Regulation, Effects

Development and Evaluation of Solar Powered Micro Irrigation using Floating Submersible Pumpset in On Farm Reservoirs for Improving Water Productivity in Small Farm Holdings of Rainfed Areas

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GOI has implemented farm pond scheme on large scale in SAT regions through PMKSY to achieve more crop per drop of water in both agriculture and horticulture sectors. Such schemes can be successful with solar power integrated micro irrigation systems with respect to varying farm holding size. Farm pond or on farm reservoirs (OFR) is an option for managing drought in the rainfed areas during the long dry spells with the harvested surface runoff (SRO). SRO has silt load along with the water and it settles within the OFR after 10 -15 days. This silt load makes the MI systems use filtration equipment adding an extra expenditure to the small farmers. Moreover, silt load will affect the performance of MI system. Hence, it is necessary to develop a floating submersible pumpset for pumping water within the 1m depth from the water surface through MI system. A 0.5 hp DC submersible pump set having discharge of 70 l/min and 27m max head was installed in the OFR connected with micro irrigation system for irrigating 1 acre plot for investigating the water productivity in small holdings. Two solar panels of 250 watts each having dimension of 1.49 m^2 area were installed as power source to DC submersible pump set which is floating in water. The floating device was designed based on the buoyancy principle by inflating tube with 17kg/cm^2. The above system was used to evaluate the water productivity in horticulture crops like water melon, carrot, Tomato and Chillies during 2017-19. The crops were sown on raised beds of size 14x1m with daily irrigation scheduling in both kharif and rabi. Water melon was tried with treatments of plastic mulching and organic mulching (grass) at 5 t/ha and beds with no mulching. The results indicated that there was maximum water productivity of 5.6 kg/m^3 as compared to organic mulching (4.8 kg/m^3) and 2 kg/m^3 in no mulching beds in the water melon. The average water productivity with micro sprinklers was 3.11 kg/m^3 in carrot as compared to furrow irrigated of 1.9 kg/m^3. The water productivity of Tomato and Chillies was observed to be 20.8 kg/m^3 and 9.46 kg/m^3 respectively. The above system could be popularized in integration with OFR based IFS models with horticulture crops on small areas as a viable option in increasing productivity and profitability of small farmers in rainfed regions. The floating device was developed with low cost of Rs.1000/- per unit and can be effectively used to reduce silt load which increased efficiency and lifespan of the MI system.

Key words: Micro irrigation, solar power, OFR, Floating device, water productivity

Development of Expert System for Agricultural Water Management

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The crop water demand and appropriate time of irrigation is very crucial for proper growth, yield and success of the crop. Lack of awareness about crop water demand and suitable water management practices have resulted in crop failures. Improper agricultural water management has resulted in poor coverage of irrigated agriculture and low cropping intensity. In such a situation, expert decision guided agricultural water management decisions is the need of the hour. Therefore, an expert system for agricultural water management was developed to facilitate knowledge management on water management practices in agriculture, horticulture, aquaculture and animal husbandry practices. Expert systems are special computer software applications that work on the principle of if-then-else rules and facts.The information on various crops were collected and compiled in development of the expert system for the end users. The web page formats for various crops were developed in open access PHP language for better user friendliness and hosted on WampServer platform. The end-user can select an option from the given list to find out the detailed water management practices for the selected crop.

An android based mobile app of the expert system on agricultural water management was also prepared to catalogue water management practices in various crops. The mobile app contains mainly four modules such as i)Agriculture, ii)Horticulture, iii)Aquaculture and iv)Animal husbandry. The user can search the water management practices on crop basis.In agriculture module, options are created for cereals, pulses, oilseeds and commercial crops. In aquaculture module, the program has been created for displaying suitable water management interventions in different land type such as upland, medium land, low land and coastal. Based on the user land type selection, the aquaculture interventions are further classified as coldwater aquaculture, production of carp fry, production of carp fingerlings, grow out technology, catfish culture, freshwater prawn culture, ornamental fish culture, freshwater pearl culture, integrated rice-fish cultivation and shrimp culture.The benefit of an expert system is that it can offer better solution than a traditional method by using the knowledge stored in the database. The expert system on agricultural water management is expected to be useful for different stakeholders like farmers, extensionpersonnel, NGO and other officials.

Key words: Expert system, Agricultural water management, Database system, Mobile application

Application of CCME Water Quality Index for Assessment of Groundwater Contamination in Rural Environment of the Great Hungarian Plain

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As a result of the establishment of sewage networks in the last decadesin Hungary,the secondary public utility ratereduced to 14% by 2017.Investments have significant impactson the rural environment, primarily on groundwater resources. This study is aimed to evaluate the changes in hydrochemical properties of groundwater after construction of the sewage system in an eastern Hungarian settlement.Water samples were collected from 40 groundwater wells in the summer of 2013, 2017 and 2018. The groundwater quality was assessed by using the Canadian Council of Ministers of the Environmental Water Quality Index (CCME WQI) method. Following parameters were used for calculation: pH, EC, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, CODand Na. Statistical tests were performed using SPSS 12 software.

The results show strong groundwater contamination. According the CCME WQI in 2013,80% of the water samples were classified as *"marginal"* or *"poor"* and only 20% as *"fair"*,*"good"* or *"excellent"*.In 2017significant improvement in water quality can be observed. The percentage of *"marginal"* or *"poor"* water samples decreased to 55%, the percentage of*"fair"*,*"good"* or *"excellent"*water samples increased to 45%.Although in 2018 a slight decrease in water qualitywas measured,the the degree of contamination was still lower compared to the baseline in 2013. After construction of the sewage network, changes in the spatial distribution of pollution were observed.While in 2013 the middle of the settlement was the most contaminated area, in the years following the project significant positive changes were measured. In 2018 south-west and south-eastern parts of the village showed the highest contamination.

Based on the results, it can be concluded that the purification process is still ongoing. Groundwater purification is slowed down by the fact that there are still households that have not joined the sewer network, and that point sources such as latrines and manure heaps can still be found in several parts of the settlement. Further environmental measures are needed to eliminate these sources of pollution.

Key words: Water quality, sewage network, Environmental Water Quality Index

Single Auger Hole Method for Seepage Estimation of Canal Under Waterlogged Conditions

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Measurement of seepage from large canals by ponding is practically impossible due to continuous running and large widths of canals. Inflow-outflow method is not suitable for seepage measurement in short reaches of canals. Seepage meter technique may require large number of measurement to arrive at an average representative value. Analytical solutions are over simplified for estimation of canal seepage due to several assumptions which are rarely met in field. Estimation of saturated hydraulic conductivity and selection of a representative value is tedious task. It is difficult to incorporate large variations of saturated hydraulic conductivity within a short reach of canal for seepage estimation. Tracer technique may result in erroneous seepage value in the area where seepage is partially flowing to some drain. Empirical methods are specific to a canal only. Available methods of canal seepage estimation are having limitations either for its application in large canals or its use in designing subsurface drainage or bio-drainage belt for combating waterlogging. A Single Auger Hole Method is proposed for estimation of seepage from large canals under waterlogged situations. Canal seepage was estimated by calculating subsurface flow and subsurface storage with time along the canal. A sufficiently long period of canal closure was selected for measuring the canal seepage. Water table fluctuations in the observation well located in the adjoining fields were recorded on daily basis. The water level receded with time after canal closure and ranged 2.35-2.22 m below ground surface over a period of six days. Similarly water level rise in observation well after canal resumed supply ranged 2.19-2.70 m below ground surface. The equations were developed to describe fall and rise in water depth with time. Subsurface flow rates as a function of receding water table depths were worked out. Similarly a relationship between subsurface storage and time was developed once the canal supply was restored. For a rise in water table depth over a day the subsurface flow and subsurface storage were calculated and summed to get the seepage rate. The estimated subsurface flow rates ranged 1.422 to 211.355 m^3 /d and subsurface storage ranged 24.92 to 68.53 m^3 /d. The estimated seepage rates ranged 69.952-236.275 m^3 /d from a grid of 100 m x 100 m. The canal seepage was calculated to be 3622.21 m^3 /d per km of canal reach. Proposed method is simple and suitable for small and large reaches of canals simply by putting a series of shallow open observation wells. The method is suitable for the area where water table is shallow and shallow observation wells can be installed easily.

Key words: Auger hole, Canal seepage, Waterlogging, Sodic soils and Canal lining

Developing Relationship for Transforming Water Table Heights of Horizontal Subsurface Drainage of Flat Land to Sloping Conditions

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Reclamation and management of waterlogged lands with or without salt accumulation attained due focus with time. Subsurface horizontal drainage is widely accepted engineering measure to control water table and remove excessive salts from root zone. Most of the theories describe water table fluctuation in response to constant recharge for flat lands. Drainage theories for sloping aquifers need more attention at present. Boussinesq equation had been used for developing analytical solutions for horizontal as well as sloping land. The present study was conducted to understand the drainage pattern of sloping land using the drainage theory of horizontal subsurface drainage. An experiment was conducted over a Hele-Shaw model of length 1.84 m and height 0.56 m for 0, 0.026, 0.052 and 0.078% bed slopes. The spacing between plates was kept as 1.65 mm. Shell Tellus oil 72 was used as viscous fluid with density ranging from 475.000 to 2218.75 centipoise and corresponding bulk density range as 0.9480 to 0.9655 g cm^{-3} for a temperature range of 40 to 20^{o}C. A linear relationship between water table reduction factor and horizontal distance was observed. The variable error correction factor (δ) of and fixed error correction factor (Δ) as a function of bed slope (bs) was worked out to calculate total error correction factor (μ_{bs}) for changing steady state water table heights between the horizontal and sloping impervious barrier to the sloping conditions as below.

$$h^2 = \mu_{bs}\left[\frac{R}{K}(L-x)\right]$$
$$\mu_{bs} = \Delta + \delta.bs$$
$$\Delta = 0.1309503\, e^{-\frac{1}{2}\left[\frac{bs-0.051165299}{0.04417230}\right]^2}$$
$$\delta = -0.0008345388 + 0.0015150596\, bs - 0.040437544\, bs^2$$

Comparisons between predicted water table heights using analytical solution of Sewa Ram et al. (1987) and with proposed model were made with experimental heights. The proposed model predicted closer values of water table heights with root mean square deviation (RMSD) of 0.161744, 0.181304 and 0.166229 while analytical model could predict water table heights with RMSD of 0.824461, 1.039384 and 0.909310 against the slope of 0.078, 0.052 and 0.026%, respectively. The proposed model is easy to understand the flow problem of horizontal subsurface drainage in relation to the subsurface drainage of sloping lands.

Key words: Subsurface drainage, Sloping land, Hele–Shaw, Waterlogging, Salt accumulation

Comparison of Water Removal by Biodrainage Belt and Interceptor Drain

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Reclamation and management of waterlogged salt affected soils has become inevitable for the country like India for sustained increase in agricultural productivity with shrinking natural resources base for feeding the growing population. Irrigation is essential to sustain crop productivity. Large scale irrigation projects result in waterlogging and salt buildup with time. Major reasons for waterlogging in canal command are excessive seepage, over irrigation and insufficient natural and manmade drainage provisions. Interceptor drains have been tried to arrest the canal seepage for minimizing water logging and associated problem. Biodrainage is advocated for averting waterlogging and salt accumulation in the root zone. In the present study a comparison of interceptor drainage and biodrainage were done to see their efficacy. A eucalyptus biodrainage belt was established along the canal having 400 m length and 30 m width. Lysimeters were installed inside the biodrainage belt for measuring plant height and ET of eucalyptus. A simple mathematical model was developed to predict daily ET of eucalyptus as function of plant age using lysimetric data of ET and plant height. Water extraction by biodrainage belt was estimated for a period of 10 years. Annual canal seepage in affected reach was estimated as 528842 m^3. Seepage interceptions by interceptor drain were 28756.03, 30171.62 and 29289.66 m^3 for first, second and third year, respectively giving an annual average seepage interception rate of 29405 m^3/year. Single lateral interceptor drain with limited installation depth is unable to arrest canal seepage. Equivalent biodrainage lines for existing interceptor drain where calculated as 79.52, 31.77, 12.10, 6.05, 3.94, 3.10, 2.76, 2.63, 2.59 and 2.58 for first to ten years respectively. Interceptor drain can be replaced by three biodrainage lines at an age of six years of plantation. Additional biodrainage lines required for intercepting un-intercepted canal seepage by interceptor drain where calculated as 1351, 540, 206, 103, 67, 53, 47, 45, 44 and 43.7 from first year to tenth year, respectively. Annual seepage interceptions by biodrainage belt were calculated as 8106.12, 17136.59, 48103.25, 95841.25, 147649.93, 187568.57, 210611.7, 220946.24, 224640.45 and 225710.59 m^3 for consecutive 10 years. Existing biodrainage over an area of 1.2 ha was also not able to arrest the canal seepage even at the age of 10 years. Additional biodrainage lines required for intercepting un-intercepted canal seepage by biodrainage are 1408, 553, 198, 89, 51, 36, 30, 28, 27 and 27 from first year to tenth year, respectively.

Key words: Biodrainage, Canal seepage, Evapotranspiration, Plant height, Interceptor drain, Waterlogging

Effects of Long-term Saline Water Irrigation on Soil Water-stable Aggregates in Cotton Fields

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Saline water irrigation has been widely used for crop production in some areas where agriculture is short of water. However, irrigation with saline water can have negative impacts on the soil environment (e.g. increased salinity, reduced hydraulic conductivity) and these are well documented for soils in arid and semi-arid regions. To understand the impact of saline irrigation on soils in semi-humid region, a field study was conducted at North China Plain, where saline water effluent was used for irrigation for 10 years. The study evaluated the effects of long-term saline water irrigation with different salinity level on soil water-stable aggregates in cotton fields. Six groups of irrigation salinity levels were set up: 1 g/L (CK), 2 g/L (T1), 4 g/L (T2), 6 g/L (T3), 8 g/L (T4), 10 g/L (T5). The salinity of 0-30 cm soil layer and the content of >0.25 mm water-stable aggregates, mean weight diameter (MWD), geometric average diameter (GMD) and fractal dimension (D) were analyzed. The results showed that soil salinity increased with the increase of irrigation water salinity, and decreased with the increase of soil depth in the early growth stage of cotton. By contrast, the soil salinity decreased in each soil layer, and showed a decreasing trend with the increase of soil depth in the later growth stages. The content of >0.25 mm water-stable aggregates, MWD and GMD decreased with the increase of irrigation water salinity, while D increased with the increase of irrigation salinity. After the stabilization of growth period, the soil water-stable aggregates in cotton field were restored, and the number of large aggregates, MWD and GMD in the later growth period of cotton increased compared with the earlier growth period, and D decreased, with the recovery effect of 10-20 cm soil layer being the most remarkable. Comprehensive test results showed that saline water irrigation with <6 g/L made less salt accumulation, and had less damage to soil water-stable aggregates in cotton field.

Key words: Saline water irrigation, Soil salt, Soil water-stable aggregates, Stability index

Comparative Evaluation of Various Radiation and Mass-transfer based Reference Evapotranspiration Models

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The study found out the best alternative model for the estimation of evapotranspiration (ET0). Accurate estimation of actual reference evapotranspiration is a necessary step in water resource management. Recently, the FAO-56 Penman-Monteith model has been established as a standard for calculating reference evapotranspiration (ET0) which requires measurement of all climatological parameters vs. maximum and minimum air temperature, maximum and minimum relative humidity, solar radiation, and wind speed which may not be available in most of the meteorological stations. Still there are some limited weather data based ET0 models which estimate ET0 closely to Penman- Monteith (P-M) method for sub-tropic climatic condition. The present study is based on analysis of long term of 7 years (2008 to 2014) climatic data to calculate monthly reference evapotranspiration and compare the FAO-56 Penman monteith model with different ET0 models. Performance evaluation on the bases of different statistical Parameter based for Gwalior district of Madhya Pradesh. Hargreaves method and Pan Evaporation (E-Pan) method overestimated the values of ET0 when compared with FAO-56 Penman-Monteith method. On the basis of lowest value of RMSE, Jensen-Haise (J-H) method was found best alternative method to FAO-56 Penman-Monteith method for better estimates ET_0 in the study area.

Key words: Various limited data based ET0 models and Reference evapotranspiration, Statistical analysis

Development and Evaluation of Soil Moisture Sensor for an Automated Drip Irrigation System: An Approach for Water Smart Agriculture

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Resilient water management practices which aim at enhancing the efficiency and productivity of water are critical climate smart interventions. Recent irrigation technologies used sophisticated equipment to supply water to the root area of plants as per their needs. However, use of these sophisticated methods is not possible for all farmers. Therefore, when developing an automatic irrigation system, it needs to be designed so that it can be adapted by most farmers. Soil moisture sensors for irrigation control have been commercialized by big industry. However, limited research has been carried out to evaluate their precision in measuring the soil water content. This paper describes the performance of sensor used for irrigation scheduling with laterite and sandy loam soils. In the present study soil moisture sensor was evaluated, whichwas developed as low-cost soil moisture sensor based on electrical conductivity. Developed sensor was simple, precise, sensitive, light weight and cost effective. The data obtained from the calibration of sensor in different soils can be used for irrigation scheduling by setting upper and lower limits for irrigation control to increase the water use efficiency.

Laboratory test were conducted using circular containers (plastic pot) made up of polyvinylchloride (PVC) which is an insulator having diameter 22 cm and height 20 cm. The containers with drainage holes in the base were filled with soil. Soil moisture sensors were located along the centreline of each container to minimize any interaction between the sensor or container edge effects. Soil moisture sensor measures the conductivity between the electrodes, which is a function of soil moisture content. In the case of sandy loam soil, electrical conductivity varied from 9.0 to 5.8 mS/m at field capacity (17.64%) and varied between 6.2 to 4.9 mS/m at permanent wilting point of (10.78%.). For laterite soil electrical conductivity varied between from 15.1 to 15.5 mS/m at field capacity (19.57%) and 4.6 to 2.4 mS/m at permanent wilting point (7.46%).Overall data showed nearly constant trend in the relationship between the soil electrical conductivity and soil moisture content in all the trials but the calibration of sensors showed different soil conductivity value with respect to moisture content in different type's soils.This might be due to non-uniformity in soil texture and air gap between the soil and sensor.In some soils, cracks were easily formed which were responsible for the air gap between the soil and the sensor. So, it is important to calibrate the sensor in different types of major soils where soil moisture sensors are to be used. Also, care should be taken while fixing the sensors in the soil for measurement

Key words: Soil moisture sensor, irrigation automation and electrical conductivity

Impact of Groundwater Recharge from Rain Water Harvesting Structures in Hard Rock Areas of Odisha

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Importance of Groundwater recharge has been the major focuses in entire world considering the imbalance in groundwater withdrawal and water recharge to aquifer. Rain Water harvesting structures has been the best option in many parts especially in hard rock areas which contributes towards the groundwater recharge in an effective way. There is no generalized approach to decide location and size of the water storage structures in terms of quantitative amount of contribution towards groundwater recharge. Surface water bodies generally form localized recharge zones from which recharge can be estimated using surface water data. In this paper recharge from rain water harvesting structures were estimated through water balance approaches. Water balance study was conducted in Rain Water Harvesting Structures (RWHS) in Srirampur and Nachhipur villages under Bargharianala micro watershed, Daspalla block (Odisha). All inflow/outflow components of water balance model for different sizes of RWHS during 2017 and 2018 were quantified. It was observed that inflow during the year 2018 was from 1307 mm rainfall (2470.46m^3, 2175.05 m^3 and 1045.72 m^3 respectively) in 3 structures. Nearly 1962.47 m^3, 1227.90 m^3 and 474.41 m^3 of runoff was contributing to these structures, which accumulated 4432.93m^3, 3402.95 m^3 and 1520.11 m^{3}of storage water to the structures. This storage was contributing towards evaporation (3396.33m^3, 2990.21m^3, 1437.60m^3) and percolation/seepage losses (1077.30 m^3, 948.48 m^3 and 456 m^3). Outflow from these structures including pumped water were estimated at 9409.23 m^3, 6552.29 m^3, 3245.60 m^3 respectively. This showed that 4976.30 m^3 3149.34 m^3, 1725.49 m^{3}of water was contributing towards subsurface or recharge including storage in the structures. Subsurface flow of 0.63 m/month and recharge of 0.11m during monsoon (July to November) was contributing towards inflow to the structure in 0.75 ha m capacity structure. In case of 0.5 ha m capacity of structure, 0.47m/month as subsurface flow and 0.18 m of recharge during monsoon months was adding to the structure. In Rain Water Harvesting Structure with a recharge well, 0.38 m/month was contributing as subsurface flow and 0.153 m of recharge during monsoon months were inflow to the structures, with 1.69m of pumping from the structure. Hence recharge contribution from the structure was nearly 1.843m due to impact of recharge well. The impact of these structures is extended upto 300m areal extents covering the area of influence of 15 ha command area in hard rock areas of Odisha. Due to presence of the recharge structures water table depth in dug wells raises upto 1m during pre monsoon season.

Key words: Rain water harvesting structures, Groundwater recharge, water balance

Effect of Various Mulch Practices on Moisture Retention and Fruit Plant Establishment in Bundelkhand Region

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The Bundelkhand region with a geographical area of 7.07 M ha comprising six districts of Madhya Pradesh (Chhatarpur, Damoh, Datia,Panna, Sagar and Tikamgarh) and seven districts of Uttar Pradesh (Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Lalitpur and Mahoba) in central India is as one of the most deprived regions of the country. It is characterized with undulating terrain, scarce vegetation cover, hostile climate, lack of irrigation facilities and unfavorable edaphic conditions. The productivity of the soil in the region is low due to low water holding capacity, low fertility and limiting soil depth. More than 75% of total annual rainfall occurs during monsoon season (mid June to mid September) and remaining months face water scarce condition which becomes more adversible even for plant survival in the month of summer when the maximum temperature hover around 48°C. In such extreme type of climatic condition, application of various mulches may quite be useful in establishing fruit plantation of the region. A study was started in 2015-16 with three fruit species *viz*. pomegranate, custard apple and lemon and four mulch treatments *viz.* sunhemp mulch, stone mulch, plastic mulch and no mulch (control) in a randomized block design with three replications to see the effect of mulch treatments on moisture retention and fruit plant establishment. The plantation of fruit samplings was performed during rainy season, 2015 at 5×5 m spacing in 50×50 cm^2 pit. Plant growth parameters i.e. survival percent, plant height & collar diameter and periodic soil moisture were recorded. After three years of plantation, the survival percent of pomegranate and lemon were almost 100% irrespective of mulch treatments, whereas, that of custard apple plants was also as high as 90%. The data of plant growth parameters revealed that the mean maximum plant height 113 cm, 190 cm and 202 cm were in custard apple, pomegranate and lemon under sunhemp treatment, respectively, whereas the mean minimum plant height 81 cm, 154 and 166 cm were in custard apple, pomegranate and lemon, respectively under control. The soil moisture content was higher in the sunhemp treatment plantation of pomegranate and lemon, whereas the soil moisture was lowest in stone mulch treatment. The study showed that water availability to the plant was higher in case of sunhemp mulch treatment for longer duration. The initial results suggested that different mulch practice have favourably affected the plant growth and establishment in the region.

Key words: Bundelkhand region, Fruit plantation, Moisture content, Mulch, Plastic

Effectiveness of Recharge Filter for Ground Water Recharge Structure for Alluvial Plains of North Bihar

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The subsurface reservoirs are very attractive and technically feasible alternative for storing surplus monsoon runoff. The sub-surface reservoirs can store substantial quantity of water. Performance of a recharge filter designed at Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur was evaluated with different filter combinations. Performance of different filter combinations having different filter length/thickness has been studied in terms of Filtration Rate and Solid Removal Efficiency.

Altogether twenty one filter combinations were evaluated in lab and field condition. The highest filtration rate was observed for filter combination-3 consisting of Colour gravel (15 cm), Sand (15cm) and charcoal (15cm) having total filter length of 45 cm. When the similar comparison was made for 135 cm filter length the highest filtration rate was found for filter combination -3 (Colour Gravel (45cm) +Sand (45 cm) + Charcoal (45 cm)). The lowest filtration rate was observed for filter combination- 5 (Colour Gravel (45cm) +Sand (45 cm)+ Saw Dust (45cm)) for total filter thickness of 135 cm. The solid removal efficiency was found highest for filter combination -3 (Colour Gravel (45cm) + Sand (45 cm) + Charcoal (45 cm)). The higher retention capacity of saw dust, rice husk and activated charcoal has led to lower filtration rate. It was also found that the saw dust, rice husk and activated charcoal swelled after coming in contact of water and made more compact medium than the charcoal and coconut fiber which led to lower infiltration rate.

Filter combination-3 consisting of Colour Gravel (45cm), Sand (45 cm) and Charcoal (45 cm) and total filter length of 135cm was found most promising in terms of Filtration Rate and Solid Removal Efficiency. The Filtration Rate and Solid Removal Efficiency for filter combination 3 consisting of Colour Gravel (45cm), Sand (45 cm) and Charcoal (45 cm) were recorded to be 9342 lph and 77.5% respectively. Filter combination-4 (Colour Gravel + Sand + Rice Husk) and filter combination -5 (Colour Gravel + Sand + Saw Dust) were also found promising in terms of solid removal efficiency and lowering of turbidity level.

Key words: Filter, charcoal, colour gravel, saw dust, rice husk, sand

Efficacy of Drip Irrigation on Summer Sesame Grown in Narmada District of Gujarat

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The experiment was conducted to study the effect of different irrigation levels and different dripper discharge rates on sesame crop and to study the effect of irrigation on growth and quality parameters of sesame at the farm of College of Agricultural Engineering and Technology, Dediapada; during summer seasons (Feb. - May) of the years 2018 and 2019. A factorial randomized block design with four replications of the ten treatments consisting of drip irrigation levels, dripper discharge rates and control was adopted for the experiment. The drip irrigation levels selected in the experiment were 1) 0.5 PEF (Pan Evaporation Fraction), 2) 0.75 PEF and 3) 1.0 PEF and the dripper discharge levels selected in the study were 1) 2 LPH 2) 4 LPH and 3) 8 LPH. The irrigation level of 0.75 PEF and dripper discharge of 4 LPH recorded highest plant growth and yield attributes. The pooled data indicated that the irrigation level of 0.75 PEF (I_2) recorded the highest plant height (101.1 cm), 1000 seeds weight (4.12 gm), oil content of seed (40.11%), plant biomass (1985.72 kg/ha) and yield (1791 kg/ha). The pooled data indicated that the dripper discharge of 4 LPH (D_2) recorded the highest plant height (150.67 cm), oil content of seed (39.81%), plant biomass (1825.93 kg/ha) and yield (1484.5 kg/ha). The highest water use efficiency of 2.66 kg/ha mm was obtained in treatment I_1D_2 followed by water use efficiency of 2.61 kg/ha mm was obtained in I_2D_2 treatment. The treatment I_2D_2 recorded highest net return of Rs. 1,19,790 per ha and the treatment control recorded lowest net return Rs. 42,219 per ha.

Key words: Distribution uniformity, Drip irrigation system, Growth attributes, Irrigation scheduling, Sesame, Uniformity coefficient, Water use efficiency, Yield attributes

Status of Distance Learning Programmes in Water Sector Offered by IGNOU

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Water plays a pivotal role in agriculture sector. The share of water for agriculture sector is continuously deceasing due to higher demand for water in other sectors. The level of ground water is depleting continuously in many parts of the country and there is an urgent need for augmenting the groundwater resources through harvesting and recharging rainwater as well as proper utilisation of available resources for sustainability of agriculture. In order to create awareness and skillsamong the stakeholders, Indira Gandhi National Open University (IGNOU) has developed and is offering two programmes in this area *viz.* Certificate in Water Harvesting and Management (CWHM) and Diploma in Watershed Management (DWM). The CWHM programme is aimed at sensitizing and educating learners on efficient utilization of water resources; imparting knowledge, skills and expertise in various aspects of water harvesting techniques; and enabling learners to act as trainers and organizers at household and community levels for efficient water management in terms of its usage and for water conservation. The objectives of DWM programme is to develop competent human resource in the field of Watershed Management; impart basic knowledge and skills for water harvesting, conservation and utilization, soil erosion and its management, integrated farming systems including crop husbandry, animal husbandry, agro-forestry, fish farming, funding, monitoring, evaluation and capacity building of watershed programmes besides extension and communication skills for long term socio-economic development of the society.About 351 and 1272 leaners have enrolled for the CWHM and DWM programmes respectively during the last five years (2012-2017).This paper will throw light on the socio-economic profile and the success rate of the learners of the CWHM and DWM programmes.

Key words: Water, Distance learning, IGNOU, CWHM, DWM

Effect of In situ Rain Water Conservation Practices in Sorghum [*Sorghum bicolor* (L.) Moench] under Rainfed Condition

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An experiment was conducted during *kharif* season of 2013 and 2014 with the objective to find out the suitable mechanical and rain water conservation practice for higher productivity and profitability. The soil of the experimental field was sandy loam, having pH 7.8, organic carbon 0.30%, total nitrogen 0.03%, available phosphorus 16.00 kg ha^{-1} and available potassium 197.00 kg ha^{-1} initially before starting the experiment. Three treatments of mechanical practices i.e., shallow ploughing (SP), medium ploughing (MP) and deep ploughing (DP) and five rain water conservation practices, i.e., flat bed sowing (FB), inter row water harvesting (IRWH), inter paired row water harvesting (IPRWH), inter paired row water harvesting + organic residue mulch @ 4 t ha^{-1} (IRWH+ OM) and inter row micro *Jalkund*/scooping (IRMJ) were tested under split plot design with three replications. The sorghum variety selected for the experiment was Bundela. The maximum grain yield of sorghum was obtained 17.64 q ha^{-1} under deep ploughing and 19.19 q ha^{-1} under inter paired row water harvesting + organic residue mulch @ 4 t ha^{-1}. In economics of different treatments, the deep ploughing (Rs 9064 ha^{-1}) and inter paired row water harvesting + residue mulch @ 4 t ha^{-1} (Rs 11390 ha^{-1}) gave high net return. Deep ploughing (1.35) and inter paired row water harvesting + organic residue mulch @ 4 t ha^{-1} also brought out the maximum benefit:cost ratio (1.42). On the basis of experiment, the farmers may be advocated for the adoption of deep ploughing and inter paired row water harvesting + organic residue mulch @ 4 t ha^{-1} for good productivity & profitability and better moisture conservation in soil profile.

Key words: Inter paired row water harvesting, organic residue mulch, deep ploughing, productivity, profitability

Sensor Based Real Time Automatic Irrigation System

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Sensor based scheduling of irrigation reduces the loss of water and may apply the water as per requirement of the crop, which improves the water use efficiency of the irrigation systems. In this research, an Automatic Irrigation System (AIS) was developed to automate the micro irrigation systems. It consisted of raspberry pi as a controller, soil moisture sensors, LCD display and other accessories. The real time soil moisture content from the field was recorded by the dual probe conductance based soil moisture sensors. It was calibrated and the non-linear polynomial equation of degree 3 in terms of 'x' and 'y' was developed and the other values of corresponding moisture content were determined using interpolation. The python language was used for programming the controller which was used to control the solenoid valve and the motor. The field capacity and 50% depletion of available soil moisture content (AWC) were set as the upper and lower limits of the soil moisture for switching the motor to 'OFF' or 'ON', respectively. The developed system was tested on the cabbage crop. The crop yields and benefit-cost ratio for cabbage was compared with manual sprinkler irrigation for cabbage. It was found that, the moisture content under AIS was found varying in the range of 0-10% of soil moisture recorded using the gravimetric soil moisture content indicating better accuracy of the AIS in sensing the water content in the crop root zone. The total cost incurred for the design and development of the system for 1 hectare area was found to be Rs 16058. The benefit-cost ratio was 2.16 for manual irrigation, whereas for AIS it was 2.59. This indicates cost-effectiveness of the AIS.

Key words: Automatic Irrigation System, real time soil moisture content, crop yields, benefit-cost ratio

Predicting Soil Moisture under Indirect Subsurface Drip Irrigation for Contrasting Soils

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Drip irrigation has been proven to be an efficient and important technique to save water used in crop production. Indirect subsurface drip irrigation has an advantage of low running cost, and thus is used widely in arid regions such as Xinjiang province in China. Amongst all those controlling indirect subsurface drip irrigation, soil texture is one of the most important factors required to be carefully considered. In this study, a numerical investigation into the effects of various soils on soil moisture distribution during and after indirect subsurface drip irrigation was carried out using HYDRUS-2D. Three types of soil (sandy loam, silty clay loam and clay loam) with contrasting water holding capacity were selected for the study. The irrigation device had a permeable cylinder with a diameter of 7.5 cm and a height of 10.0 cm. The initial soil water potential before the irrigation was -100.0 m. The irrigation time was 3 h, and soil water content at the permeable boundaries was assumed to be at saturation during irrigation. The time-dependent wetting process in the soil domain in a 24 h period from the start of irrigation was simulated.

The simulated results showed that the influx flow rate was higher at the beginning of irrigation, and the rate remained fairly constant at later stages. The irrigated amount after 1 h irrigation for clay loam was 1175 cm^3, and was 1.65 and 2.62 times higher in silty clay loam and sandy loam, respectively. The corresponding values increased to 2375 cm^3, 1.90 and 3.13 times after 3 h irrigation. The wetting distance in both the vertical and radial directions increased more rapidly in the early stages than the later stages during the irrigation. For sandy loam the wetting distance in the vertical direction was 22.4 cm and 7.7 cm in the radial direction after 1 h irrigation, compared with 32.2 cm and 13.2 cm at the end of irrigation. On contrast, the wetting distance in both directions was only 16.0 cm and 4.1 cm after 1 h irrigation, and increased to 22.0 cm and 7.4 cm after 3 h irrigation for clay loam. It was also noted that the wetted soil volume was significantly increased after the end of irrigation due to soil water redistribution. The simulated vertical wetting distance was 37.8 cm, 28.8 cm and 24.6 cm for sandy loam, silty clay loam and clay loam 2 h after the end of irrigation, while radial wetting distance was 15.4 cm, 11.4 cm and 8.9 cm, respectively. Also, it was found that the expansion of soil wetting volume became greatly slower afterwards. The results found in this study could be practically useful in designing indirect subsurface drip irrigation for various soils in irrigated agriculture.

Key words: Agricultural water management, Indirect subsurface drip irrigation, HYDRUS-2D, Soil water simulation, Smart irrigation

Designing Rainwater Harvesting System for College and Hostel Buildings at Pantnagar, Uttarakhand

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Water, the most widely distributed substance on planet Earth, plays a vital role in sustaining the environment and other living things on earth. Global freshwater consumption rose more than twice the rate of population during the last decade. This indicates towards mismatch between the demand and supply of water for human consumption in future, if corrective measures are not taken up in time. According to UN estimates, if the present trend continues, two out of three persons on earth will live in water-stressed condition. In India, this crisis is already visible, contributing to enormous social, political and environmental costs that affect the economy and quality of life. In northern part of India also, water scarcity is fast approaching. Use of pumped underground water being used for household activities such as drinking, cooking, cleaning utensils, bathing, washing, sanitation etc and irrigation has put more pressure on underground water resource in the foothills of Uttarakhand Himalayas. Continued use of good quality tap water (pumped groundwater) for gardening, floor cleaning and toilet-flushing in college and hostel buildings will further worsen the situation. This situation calls for generation of alternative water resources by way of rainwater harvesting. Though *Tarai* region in Uttarakhand state receives good amount of rainfall, its temporal and spatial distribution and occasional dry spells during monsoon season and rest of the year make water harvesting system a necessity and vital task.

Keeping the above points in view, a study on rainwater harvesting was conducted at the college and hostel buildings of the College of Technology, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. The objectives of the study were: (a) to assess technical feasibility of rainwater harvesting through roof-top of buildings and surface runoff to meet the demands for drinking water, cooking, cleaning utensils, bathing, washing, sanitation and groundwater recharge; (b) to design rainwater harvesting system; and (c) cost estimation and feasibility assessment. The rainfall data of 55 years were used to determine the required storage. The optimum size of tank was decided on the basis of water budgeting of weekly rainfall data during monsoon season (June to September). The study revealed that one surface tank of 81 m^3 size for a hostel and four surface tank of 100 m^3 size for two college buildings would be required. The recharge pit would be constructed from brickwork, filled with course sand, gravels and boulders. The top of the pit would be covered with 15 mm crossed mild steel bars. The recharge pit would add about 66,000 m^3 of water per year to the groundwater resource.

Key words: Roof-top runoff, Water storage tank, Tarai region, Groundwater recharge

Prediction of Soil Water Content at Field Capacity using Artificial Intelligence-Based Machine Learning Approaches

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SWC_{FC} is an important hydraulic property of soil required in modelling of water and solute transport, biophysical model and for determining the suitable time and rate of irrigation water to be applied. Direct laboratory measurements of SWC_{FC} are labor intensive, time taking and expensive. In the present study, $SWC_{FC}$was predicted using AI (artificial intelligence) based machine learning tools such as Artificial Neural Networks (ANN) and Support Vector Machines (SVM).Total 120 data points were taken for the prediction of SWC_{FC}. These 120 data of sand, silt, clay,bulk density (BD) and organic carbon (OC) were divided into 4:1 ratio for training (calibration of model) and testing data (validation of model). These data were then used for prediction of SWC_{FC} using ANN and SVM models. These models were then evaluated for their performance using various parameters such as root mean square error (RMSE), mean absolute percent error (MAPE), Correlation (CR), and mean absolute error (MAE). Soil SWC_{FC} (output variable) was predicted using ANN and sand, silt, clay, BD and OC as input variables. The optimal number of hidden layers was selected using a trial-and-error process by changing the number of hidden neurons from 1 to 10. Among all the hidden layers in ANN, ANN with 4 number of hidden layers, were selected based on the RMSE, CR and MAPE values that were found to be 2.81,0.70 and 10.79, respectively, for training dataset and corresponding values for testing dataset were 4.55,0.47 and 19.84, respectively. To compare the performance of artificial neural network approach, another AI based machine learning approach SVM, was used for predicting SWC_{FC} values using similar input parameters. Various kernels were used to evaluate the performance of support vectors. Considering the least RMSE values and then the other criteria which showed improvement, the radial basis kernel function was selected as the best in case of SVM. Performance of ANN was better than SVM in prediction of SWC_{FC}. ANN can capture non-linear functions and performer better.

Key words: Artificial Neural Networks, soil hydraulic property, RMSE

Crop Water Requirement for Wheat under Different Conservation Practices in the Semi Arid Region of India

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There is an enormous pressure on water resources due to long spell of drought in most parts. Estimation of optimum water requirement for crop is essential for proper irrigation scheduling by providing the water that matches the crop evapotranspiration and water saving in an arid region for improving water productivity of the crop. Conservation agriculture practice is promoted for its natural resource saving practice and better use of scarce water resources. Keeping these in mind experiments were conducted during *Rabi* 2014-15 and 2015-16 at research farm of ICAR- Indian Agricultural research Institute, New Delhi to study crop water requirement for wheat under different conservation practices along with conventional practice using single crop coefficient, dual crop coefficient and water balance methods. The field experiment was carried out with seven treatments i.e. conventional tillage (CT), permanent narrow-bed without residue (PNB), permanent narrow-bed with residue (PNB+R), permanent broad-bed without residue (PBB), permanent broad-bed with residue (PBB+R), zero tilled flat bed without residue (ZT), zero tilled flat bed with residue (ZT+R) arranged in a randomized block design (RBD) with three replications. Adjusted single and dual crop coefficient values for semi-arid climate of Delhi were calculated with the help of FAO-56 method. The reference crop evapotranspiration ET_0, was estimated using FAO Penman–Monteith equation.

Results showed that estimated reference evapotranspiration and pan evaporation had good correlation at R^2 value of 0.89 for wheat crop. The adjusted value of single and basal crop coefficient had initially lower value, increase during development phase reached maximum during mid stage and then decline during late stage. Soil evaporation coefficient K_e was low except during irrigation and precipitation events. The value of crop evapotranspiration was found to be higher during mid season stage with respect to different treatments. The crop evapotranspiration (ET_c) and actual evapotranspiration (ET_a) were higher under CT, ZT and ZT+R treatments because they had flood irrigation. PNB, PNB+R, PBB and PBB+R had less value due to furrow irrigation. Water productivity had maximum values under PBB+R treatment and lowest value under conventional treatment. PBB+R treatment had 23-27% higher in wheat as compared to corresponding value in conventional treatment. Since dual crop coefficient method consider the effect of soil evaporation and crop transpiration both therefore the value calculated by it are more reliable as compared to single crop coefficient. Therefore dual crop coefficient method is useful for determine water stress in crop, daily evapotranspiration losses, water need of crop and for irrigation scheduling. Among all treatments, PBB+R showed better water productivity than other treatments. Thus, PBB+R management practice could be adopted by farmers for improving water productivity in semi-arid region of India.

Key words: Evapotranspiration, Crop coefficient, Wheat, FAO-Penman monteith equation

Effect of Water Management on Soil Nutrient Status of Nectarine (*Prunus persica* Batsch var. nucipersica)

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The present investigation was carried out at the experimental farm of Department of Soil Science & Water Management, YSPUHF, Nauni, Solan, Himachal Pradesh, during the years 2015 and 2016. Twelve treatment combinations comprising three types of mulches viz. unmulched control (M_o), grass mulch (G_m) and black plastic mulch (P_m); two irrigation levels i.e. Ir_o (Rainfed control) and Ir_1 (4 cm irrigation at 40% available moisture depletion) and two nutrient levels i.e. N_1 (100% of recommended dose of NPK) and N_2 (75% of recommended dose of NPK) were replicated four times in a randomized block design (factorial). Mulches significantly increased the OC contents over unmulched control and highest contents were recorded under Gm at 0-15 and 15-30 cm depths during 2015 (1.31 and 1.19%) and 2016 (1.70 and 1.43%). Among NPK levels, significantly higher OC at these depths being 1.31 and 1.15% in 2015 and 1.61 and 1.36% in 2016 were recorded in N_1 at respective depths. Significant effect of irrigation was observed in 2016 and highest OC were recorded under Ir_1 i.e. 1.59 and 1.34% at respective depths. Interaction between mulches and nutrient levels were significant and maximum OC (1.79%) was recorded under T_7 (Grass mulch+4 cm irrigation at 40% available moisture depletion level+100% of recommended dose of NPK) at 15-30 cm depth during 2016. Mulches, nutrient levels and their interaction exhibited significant effect on available NPK during both the years of study, whereas, irrigation exhibited significant results only during the second year of study. Among mulches, Pm recorded highest contents of N (363.7 and 328.6 kg ha^{-1}), P (45.3 and 36.7 kg $ha^{-1)}$ and K (361.7 and 342.1 kg ha^{-1}) at 0-15 and 15-30 cm depths, respectively followed by Gm and Mo during 2015. Similar trend was observed in 2016. Among NPK levels, N_1 recorded significantly higher available N (340.2 and 313.7 kg ha^{-1}), P (42.0 and 33.3 kg ha^{-1}) and K (352.5 and 335.1 kg ha^{-1}) at 0-15 and 15-30 cm depths, respectively, in 2015. In 2016, similar trend was observed. Among irrigation levels, maximum available N (368.2 and 337.3 kg ha^{-1}), P (53.2 and 41.1 kg ha^{-1}) and K (362.7 and 343.8 kg ha^{-1}) contents were found under Ir_1 at 0-15 and 15-30 cm depths, respectively, during 2016. Interaction between mulches, irrigation levels and nutrient levels were also significant and maximum N (369.9 and 333.9 kg ha^{-1}) was found under T_9, whereas, maximum P (48.8 and 38.2 kg ha^{-1}) and K (366.5 and 344.9 kg ha^{-1}) were found under T_{11} at 0-15 and 15-30 cm depths, respectively, during 2015. In 2016, highest N (398.2 and 372.4 kg ha^{-1}), P (66.0 and 53.0 kg ha^{-1}) and K (392.2 and 363.3 kg ha^{-1}) were found under T_{11}. Black plastic mulch with irrigation at 40% ASM and 100% of recommended dose of NPK recorded significantly higher contents of available N, P & K. Grass mulch was superior and saved 41.9 and 26.8% of irrigation water over unmulched control (M_0) and black plastic mulch (P_m), respectively.

Key words: Mulches, Irrigation, Nutrient status

Water Saving Technologies for Irrigated Plains of Jammu

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Realizing the importance of irrigation, greater emphasis has been laid on its development and large investments have been made since independence to develop irrigation facilities that resulted in continuous increase in irrigated area from 22.6 mha in 1951 to current level. The use efficiency of applied water through the major irrigation facilities developed is one-third. This has shifted the focus of researchers to modify or evolve water saving practices which are based on conservative and productivity approaches. Taking this into account, Water management Research Centre of SKUAST-Jammu under AICRP (Irrigation Water Management) has developed several water saving technologies in last five years *i.e.* 2013-2018 for irrigated plains of Jammu. The technologies based on optimization of canal system, geospatial approach, field based technologies like laser leveling, advanced technologies like sprinkler in potato and drip irrigation in tomato, aerobic rice cultivation and multiple water use based on raised and sunken bed technique have proved that water can be saved considerably and productivity of water and crop can be enhanced.

Key words: Optimization, Laser leveling, aerobic rice and raised sunken bed

Effect of Different Irrigation Methods and Schedules on Water Productivity of Wheat

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The present study entitled “Effect of different irrigation methods and schedules on water productivity of wheat” was carried out at Punjab Agricultural University, Ludhiana during rabi seasons of 2013-14 and 2014-15. The experiment was carried out in randomized block design with thirteen treatments to evaluate the effect of combinations of three irrigation methods (check basin, drip and sprinkler irrigation) and four irrigation schedules (CPE:IW 0.6, 0.8, 1.0 and 1.2) along with recommended surface irrigation (7.5 cm depth) as control on water productivity of wheat cultivation. The results showed that maximum water productivity was recorded in drip irrigation as compared to sprinkler and check basin methods during both the years. During 2013-14, water productivity of drip irrigated wheat (16.18 kg ha^{-1} mm^{-1}) was significantly higher than sprinkler irrigated wheat (14.59 kg ha^{-1} cm^{-1}) and check basin method (15.35 kg ha^{-1} mm^{-1}). During 2013-14, interaction effect for irrigation methods and schedules of irrigation was found significant for both irrigation water productivity (IWP) and water productivity (WP). Check-basin irrigation at 1.2 CPE:IW gave the highest WP (18.68 kg $mm^{-1}ha^{-1}$), closely followed by WP obtained at drip irrigation at 0.6 (16.98 kg $mm^{-1}ha^{-1}$).

Key words: Wheat, Micro-irrigation, Check-basin irrigation, Irrigation schedules, Water productivity

Influence of Varied Wastewater-Groundwater Irrigation Regimes on Nutrients and Heavy Metals Accumulation in Spike and Bulb of Tuberose (*Polianthes tuberosa* L.)

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An experiment was conducted to assess the nutrients and heavy metals accumulation in spike and bulb of tuberose (*Polianthes tuberosa* L. *cv.* Prajwal) under varied wastewater-groundwater irrigations regimes at WTC farm of ICAR-Indian Agricultural Research Institute, New Delhi during three consecutive seasons in the years 2013-16. The treatments comprised of wastewater irrigation schedules (0.6, 0.8, 1.0, 1.2 and 1.4 ID: CPE), conjunctive use of groundwater and municipal wastewater (at 1.0 ID: CPE) and only groundwater irrigations (at at 1.0 ID: CPE) were laid-out in randomized block design with three replication. Major nutrients (N, P, and K), micronutrients (Zn, Mn, Cu, Fe) and toxic heavy metals (Ni, Pb, Cd, Cr) concentration in spike and bulb parts of tuberose were analysed as per standard methods. Results indicated that significantly higher contents of macro nutrients (NPK), micronutrients (Zn, Mn, Cu, Fe) and toxic heavy metals (Ni, Pb, Cd, Cr) in both spike and bulb parts of tuberose were recorded under wastewater irrigations scheduled at 1.4 ID/CPE as compared to groundwater irrigation at 1.0 ID/CPE. Hence, irrigation with wastewater may enhanced uptake of nutrients and toxic heavy metals in tuberose due to their higher concentration in wastewater as compared to groundwater.

Key words: Heavy metals, ID/CPE, Irrigation, Nutrients, Tuberose, Wastewater

Conservation of Water through Pressurized Irrigation System in Rice-Wheat Cropping System: Scope and Limitations

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In fact both rice and wheat are the two most important cereal crops and staple food of millions of Asian people. Rice –wheat in irrigated agro-ecosystem of Indo-Gangetic region of India, which contributes about 32% to the national food basket. Over use of irrigation through tube well must be avoided, because an acute shortage of water is presently faced by the country peoples and has been visible everywhere in Indo-Gangetic plain (IGP) of India. In coming years even drinking water availability will be problematic. Thus, the study was under taken with the sole aim to know the workability of the system under different operating pressure of installed sprinkler system in rice –wheat cropping sequence. This production system is labour, water and energy –intensive and is becoming less profitable as these resources are becoming increasingly scare and costly. Keeping these views in aim a field experiment was conducted at ICAR-Central Soil Salinity Research Institute, Karnal (Haryana)-132001 during 2011-2015 on strategies of resource conservation and mini sprinkler irrigation on crop productivity under rice –wheat cropping system in reclaimed alkali environment. Three adopted resource conservation *vis-à-vis* conventional practices (Cv) were imposed viz.; direct seeded rice (DSR) with surface irrigation followed by wheat sowing in zero tillage with rice residue mulch; DSR with mini sprinkler irrigation system with wheat residue incorporation followed by zero tillage wheat with rice residue mulch and DSR with mini sprinkler irrigation system followed by zero tillage wheat with rice residue mulch. Zero tillage with 100% rice straw mulch produced highest wheat average grain yield (5.45 t ha^{-1}) under surface irrigation method followed by 5.26 t ha^{-1} in zero tillage with 100% rice straw mulch under mini sprinkler irrigation method. Mini sprinkler irrigation method in wheat saved irrigation water up to 34.61% more over surface irrigation method. Irrigation through mini sprinkler irrigation method saved electricity up to 8.15% with saving of 22.9% energy in comparison to conventional wheat sowing method. Nitrogen use efficiency in wheat crop under fertigation in mini sprinkler irrigation method was observed up to 72.3 Kg grain Kg^{-1} nitrogen, saved 50% nitrogen of recommended (150Kgha^{-1}) with 100% rice residue mulch. Maximum rice biological yield produced 13.08 t ha^{-1} in conventional transplanting rice followed by mini sprinkler irrigation method in DSR with minimum tillage (12.45 t ha^{-1}). Rice under DSR technique saved 57.73% of irrigation water in mini sprinkler irrigation method with water productivity 1.98kg m^{-3} which was 2.14 times higher than conventional rice transplanting (0.926 kg m^{-3}) after 5 years of experiment. However, in DSR with minimum tillage under surface irrigation method saved irrigation water up to 27.35% with water productivity of 1.24 kg m^{-3}. Irrigation through mini sprinkler irrigation method in DSR saved electricity up to 32.49% in comparison to conventional rice transplanting.

Key words: Rice, Wheat, Irrigation, Mulch, Nitrogen use efficiency, DSR, Zero tillage

Studies on Effect of Drip Irrigation System on Growth Parameters and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.) Under Raichur Agro-Climatic Conditions

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The field experiment was carried out to study the effect of drip irrigation system on growth parameters and yield of cluster bean under Raichur agro-climatic conditions. The experiment was laid out randomized complete block design The different drip irrigation levels included T_1 - 70 per cent ET, T_2 - 80 per cent ET, T_3 - 90 per cent ET, T_4 - 100 per cent ET and T_5 - furrow irrigation (control). The objective was to study the yield response for different irrigation levels of Cluster bean to compare the performance of growth parameters and yield of drip and furrow irrigation (70, 80, 90 and 100 per cent ET). The data revealed that 100 per cent ET level with drip irrigation produced superior values for plant height, number of branches per plant, leaf area index and days taken for fifty per cent flowering, number of pods per plant, length of pods, green pod yield per plant, green pod yield per plot, green pod yield per hectare. The highest yield of cluster bean 24.84 t ha^{-1} was obtained in 100 per cent ET level which was closely followed by 90 per cent ET level (22.24 t ha^{-1}) as compared with furrow irrigation.

Key words: Cluster bean, Drip irrigation, Water requirement, water use efficiency, Leaf area index

Selection of Water Harvesting Structures with Suitable Sites in Yarehalli Micro-watershed of Davanagere District Using GIS & RS Applications

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Integrated hydrology and land resource inventory will play an important role in suggesting suitable soil and water conservation structures. The study was carried out in Yarehalli micro-watershed, Channagiri Taluk of Davanagere district located at 13°59′6.67" to 14°0′50.4" North latitudes and from 75°51′44.07" to 75°53′24.7" East longitudes, covering an area of 761.2 ha. Out of total rainfall of 931.8 mm (2017), *kharif* rainfall accounted for 60.2%, Rabi rainfall 20.1% and summer rainfall 19.6%. Water is the most precious resource on the earth which is essential for the existence of life. Water Harvesting is the best technique that can be used effectively to trap the unutilized surface runoff and thereby increase the groundwater recharge. Water harvesting structures have to be located at places where runoff water is available in excess and conditions are favourable for enhanced infiltration. The objective of this study is to identify suitable sites for water harvesting structures as per the Integrated Mission for Sustainable Development (IMSD) guidelines. ArcGIS is used for the spatial analysis and the sites are located by overlaying thematic maps of land use, soil, slope, runoff potential, soil permeability and stream order. Runoff computation was made by Rainfall intensity-infiltration capacity method. The result shows that the 38 percent of the total area is ideal for constructing farm pond, 22 percent for checkdam and 2 percent for percolation pond. Locations of water harvesting structures are suggested by conducting meteorological and topographical analysis. However, for the practical implementation of these structures, viability of other considerations such as economy, social implications, practical feasibility etc. need to be considered.

Key words: Water harvesting structure, Runoff, Soil permeability, Stream order

Instantaneous Measurement of Soil Moisture for Scheduling Irrigation

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Irrigation scheduling determines the time and amount of water to apply. Irrigation events can be scheduled based on i) soil moisture content in plant root zone, ii) the amount of water lost by plant evapotranspiration (ET) and iii) plant response to water stress. Even though the basic criteria for scheduling irrigation on different crops are well defined and understood by the majority of farmers and irrigators, their field implementation, i.e., determining when to start and stop irrigation and how much water to apply, often remain a challenge due to a number of uncertainties related to crop, soil characteristics, climatic conditions and dynamics of water flow through the soil and uptake by the crop. At farmers level the decisions of when and how much to irrigate are based on their past experiences, or on physical assessment of soil and weather. To measure soil water content, we have several direct and indirect methods in hand. Direct methods involves physical collection of soil samples and oven drying to estimate soil water content in terms of weight or volume basis. However, these methods are accurate but lacks in applicability in timely scheduling of irrigation. Hence, these methods mainly used as reference. Indirect methods involve installation of soil moisture based sensors in soil profile. These sensors can be categorized as a). those measuring dielectric constant and b). measuring matric potential. The indirect methods commonly employ electrical properties of the soil (dielectric constant, acoustic impedance, capacitance, thermal conductivity and soil resistivity etc.), soil matric potential, magnetic resonance of the water molecules, infrared rays, and radioactive techniques such as neutron scattering, gamma attenuation and optical techniques to estimate the soil moisture status. These methods use sensors of different kinds to sense the wetness of soil, hence they provide opportunity for real time irrigation scheduling. Based on their measurement characteristics they are broadly classified as (i) Volumetric techniques (ii) Tensiometric techniques. Volumetric techniques estimates soil water content indirectly by measuring some variable in the soil profile in which the soil water content is to be estimated. Because of this these techniques are considered to be more useful for real time irrigation management decision. Various principles are used in these techniques on the basis of which they are broadly classified as:(i). Dielectric method and (ii) Neutron moderation method. Tensiometric types measures the soil matric potential. The commonly used are tensiometers, electric resistance sensors, thermal conductivity sensors and psychrometers. The major limitation with sensing technology is that they require proper selection and calibration as performance of soil moisture sensors is influenced by the change in soil types.

Key words: Scheduling of irrigation, soil moisture based sensors, dielectric, neutron, tensiometric

Pyrolysed Biomass Reduces the Adverse Effects of Saline Water Irrigation on Crop Yield and Soil Functions

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Persistent and continuous use of poor quality ground waters for irrigation by farmers in arid and semi-arid regions results in build-up of salts, lowering crop yields. In addition, decrease in biomass limits the carbon inputs into soil, thus reducing microbial activity and availability of plant essential nutrients. Although, beneficial effects of application of pyrolysed biomass in non-saline and non-sodic soils have been documented in many studies, information is still scarce on the impact of pyrolysed biomass when applied to soils irrigated with saline water. A field experiment was initiated at research farm, Punjab Agricultural University, Ludhiana, to study the effect of application of pyrolysed rice-residue biomass (PRB) on crop yield, soil C sequestration, availability of plant nutrients in soils irrigated with water of different levels of salinity [0 (SW_0), 5 (SW_5), 10 (SW_{10}), 15 (SW_{15}) dS m^{-1}] at four rates of PRB application [0 (PRB_0), 2 (PRB_2), 4 (PRB_4) and 8 (PRB_8) t ha^{-1}] in cotton-wheat system. Pyrolysed rice-residue biomass used for the experiment was prepared from rice residue using intermediate pyrolysis technique at temperature of around 450-500°C. PRB was applied before sowing cotton and its residual effect was evaluated during the next wheat crop. At different levels of saline water, application of PRB at increasing rates showed a beneficial effect on seed cotton (14-20%) and wheat yield (5-13%) than treatment with only saline water irrigation. Similarly, irrespective of the salinity of the applied irrigation water, pH, EC (electrical conductivity), bulk density of the soil decreased whereas, infiltration rate increased in plots with application of PRB. Furthermore, microbial activity and total C also showed a significant increase with addition of PRB at various salinity levels. The results of the study indicated that application of pyrolysed rice-residue biomass to soils irrigated with saline water can be an effective approach in reducing the adverse effects of salinity stress on agronomic yield and soil functions.

Key words: Salinity; rice-residue; pyrolysis; crop production; soil properties

Response of Irrigation and Nitrogen Level on Yield, Water Productivity and Profitability of Cluster Bean (*Cyamopsis tetragonoloba*)

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A field experiment entitled Response of irrigation and nitrogen level on yield, water productivity and profitability of Cluster bean (*Cyamopsis tetragonoloba*) was conducted at research farm, Agricultural research sub-station, Hanumangarh, a unit of Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif*, 2016. The Cluster bean variety RGC-1055 with seed rate of 16 kg ha^{-1} was planted using 3 levels of irrigation (100, 200 and 300 mm) and 4 level of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and analyzed in Split plot Design with three replication. Results showed that irrigationlevel at 200 mmgave significantly higher seed yield (1624 kg ha^{-1}), straw yield (3645 kg ha^{-1}),biological yield (5270 kg ha^{-1}), test weight (28.71 g), net returns (31179 Rs ha^{-1}) and B:C ratio (2.09) over 100 mm irrigation level. However, water productivity (0.29 kg m^{-3}) was highest at 100 mm irrigation level.The Nitrogen application rateat 40 kg ha^{-1} significantly improvedseed yield (1668 kg ha^{-1}), straw yield (3696 kg ha^{-1}), biological yield (5364 kg ha^{-1}), test weight (32.21 g), net returns (32273 Rs ha^{-1}), B:C ratio (2.12) and water productivity (0.27kg m^{-3}) over control (0 kg N ha^{-1}).

Key words: Irrigation, Nitrogen, Water productivity, Cluster bean

Influence of Sowing Time on Productivity and Thermal Utilization of Mustard (*Brassica juncea*) Varieties in Arid Region

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An experiment was conducted during four consecutive*rabi*seasonsduring 2013-14 to 2016-17to study the effect of weather variability on mustard crop at Agriculture Research Station, SKRAU, Bikaner, Rajasthan. Treatments include three date of sowing (10 October, 25 October and 9 November) in main plots, four varieties (RGN 48, Pusa Bold, Laxmi and Vasundhara) in sub plots and fertilizer levels (75% recommended dose of fertilizers and 100% recommended dose of fertilizers) in sub-sub plots. The experiment was laid out in double split plot design with three replications.The results revealed that days taken to physiological maturity and yield reduced significantly when crop was sown with delayed sowing (9th November). Though, Mustard crop sown on 10th October utilized more thermaltime and heat units but it remain at par with middle date of sowing (25th October). The grain yield was found maximum in the middle date of sowing (25 October) which was attributed to the comparatively optimum temperatures at the time of sowing of the crop. Further, delayed sowing resulted in reduced growing season of mustard crop and resulted in lower yield due to lesser thermal time taken in completing the life cycle. And also due to forced maturity because of higher temperature during reproductive phase and grain ripening stage of the crop. Heat use efficiency (HUE) was also found to be higher for earlier dates of sowing in comparison to late sown crops. Correlation studies indicated that lower night temperature during vegetative phase is favourable and higher day temperature during reproductive phase is not favourable for mustard yield.Out of four varieties, pusa bold produced maximum grain yield followed by RGN 48 which showed its suitability in the region. Application of 100% recommended dose of fertilizers resulted in greater yield of mustard in comparison to the lower dose of fertilizer application.Therefore, on the basis of three year experimentation, it may be concluded that middle date of sowing (25 October) should be adopted in comparison to early and delayed sowing of mustard and Pusa bold and RGN 48 can be better option with 100% recommended dose of fertilizers for the farmers of arid regions.

Key words: Sowing dates, Growing degree days, Heliothermal units, Photo-thermal unit and Heat use efficiency

Daily Reference Evapotranspiration Estimation using Artificial Neural Networks

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The study has been undertaken to develop and evaluate artificial neural network (ANN) for prediction of daily rainfall for monsoon season for Pantnagar area, Uttarakhand, India. The Pantnagar located between 29° N latitudes and 79.38° E longitude. The study area falls in district of Udham Singh Nagar (Uttarakhand), India. The area lies in Tarai belt located in the foothills of the Himalayas. Daily meteorological data required for the study were collected for the period 1st January to 31st December of years 2004-2013 from the meteorological observatory of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. This observatory is situated at crop research centre (CRC) of university. 17 different cases of data sets have been taken for ANN modeling. Various structures of the networks were trained for maximum iterations of 1000 for single and two hidden layers' network for prediction of evaporation in each model. Since there is no specific rule available to determine the best structure of the network, a trial-and-error procedure was used for the selection of the best network among various structures of the network. Two networks, one of single hidden layer and other one of two hidden layers were selected on the basis of minimum mean square error (MSE) and Akaike's information criterion (AIC) and higher correlation coefficient (CC) from each model.

Key words: Artificial neural network, Rainfall, Evaporation, Meteorological

Spring Water Management for Fulfill Drinking and Irrigation Requirement in North East, India

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Springs are the main water sources of the northeastern hilly region,the local communities are depending on these natural sourcesof water for drinking, irrigation, livestock feeding and other activities.In recent years, discharge of many Himalayan springs have been gradually decreasing and drying out due to climate change and unsustainable water management.To survive in this climate change scenario, it is of the utmost important need to adopt different spring water management practice such as harvesting water when it excess, use traditional or modern precise method. In the Himalayan region, local communities have established various in-situ spring water management, rainwater-harvesting systems based on the specific conditions of the location and named them accordingly. In almost every part of northeast India, the sources of water are believed to be as holy place. Due to the undulating topography in hilly regions, like steep slopes, water harvesting, and carrying water from a very distant point to house, field or workplace is a major challenge. To overcome these, they transport water by means of PVC pipes, traditional bamboo pipe, channels, etc. Those who can't afford to buy the PVC pipes are forced to queue at the nearer waster sources. In this region agriculture is largely rain-fed (about 90%), during winter or large dry-spells farmers generally face severe soil-moisture stress due to erraticdistribution of rainfall amount and intensity. Tribal farmers adopt the traditional bamboo drip irrigation systems to grow betel leaves, black pepper and around for over 200 years.Bamboo drip irrigation is based on gravity and the steep slopes facilitate in implementing it.

Key words: Springs, Tapping, Bamboo drip irrigation, Harvesting structure, Gravity-fed

Identification of Rainfall Probability Distribution for Navsari, Gujarat

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The probability distribution of rainfall is useful for estimating the rainfall which could be useful in making decisions related to planning and design of structures. The rainfall data of 35 years (1984-2018) of Navsari was used for assessing the probability distribution related to weekly, monthly and annual rainfall. The commonly used probability distributions in stochastic hydrology like Normal, Log-normal, Gamma, Gumbel and Weibull distributions were used in the study. The method of moments was used to determine the parameters of the distributions. The chi-square test was used as a goodness of fit test to obtain the best fit distribution. The rainfall at various probabilities and recurrence intervals were also obtained from best fitted probability distributions. It was concluded from the study that the best fit monthly distribution for Navsari for June and August were Weibull and lognormal distribution respectively while for July and September months, the best fit distribution was found to be Gumbel which is a type of extreme value distribution. The analysis of weekly rainfall revealed that most of the weekly data followed Gumbel distribution. The annual rainfall also followed Gumbel distribution as indicated by Chi-square test.

Key words: Chi-square, Goodness-of-fit test, Probability distribution, Rainfall, Recurrence interval

Water Harvesting in Kharif Fallow for Augmenting Ground Water Recharge

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Ground water extraction for irrigation, if not done properly, leads to declining water table below critical level. In Madhya Pradesh, out of 313 blocks, 25 blocks reached to over exploited category, 04 blocks are now in critical stage and 55 are in semi critical stage (MP Dynamic Ground Water Assessment, 2015). As per norms of CGWB, the areas where water level could not recovered upto 3 m depth after the monsoon season, will need artificial recharge. The solution lies in harvesting rainwater in farmers field which are kept or left fallow for one reason or another. Though, all these fields may not be good enough to recharge ground water like percolation tanks but shall transfer water well below at least @ 4 mm/day even in clayey soils. So, to decide which area is to be taken first in present study a method of identification of priority is proposed. Four basic criteria to decide the priority namely, amount of annual rainfall, the soil type, stage of ground water development and extent of kharif fallow. Each of these four category are into four sub classes and giving grades from A to D where A is top in that particular category. Thus an area which attains all four 'As' in all four category will have a score of '4' and qualifies as top priority area. Based on above methodology the rank table is prepared. There are five districts come under top priority which needs immediate action towards artificial ground water recharge. These districts are Indore, Mansaur, Ratlam, Sheopur and Ujjain. The spatial variability of priority areas is shown that Western Madhya Pradesh as a whole needs more attention for ground water recharge.

Key words: Kharif fallow, Groundwater recharge, Priority

Trend Analysis of Precipitation Data and its Utilization for Water Harvesting Strategies

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The precipitation data collected from KVK Shikohpur, Gurugram (Haryana) India was used for trend analysis. Geographically, this area is situated 28°22.3' N latitude and 76°59.345' E longitude. The climate of the area is characterized by a humid subtropical and semi-arid. The main occupation of farmers in this area is farming and its allied activities, *viz*., dairying, vegetable growing, bee keeping and goat rearing. The crops being cultivated are bajra, jowar, arhar, cluster bean, wheat, barley and mustard. The daily precipitation data of 8 years (2012-2019) was collected from rain gauge located in the KVK. In recent years, understanding and predicting climatic change and its variability have become the key issues for the research community working in the area of water harvesting and utilization. Understanding the rainfall variability is essential to optimally manage the scarce water resources that are under continuous stress due to the increasing water demands, increase in population and the economic development. This analysis investigates the temporal variability of precipitation and aims at understanding the annual variation, seasonal variation, number of rainy days, normal rainfall, deficit rainfall and excess rainfall in this region. The overall rainfall amount decreased during the study periods. The mean rainfall in this region is 592.1 mm per annum. The annual maximum rainfall was 838.4 mm in the year 2015 and minimum of 451.2 mm in the year 2014, respectively. Normally 80 percent of the total annual rainfall in this region accounts from June to September *i.e.* during monsoon season. July and August recorded the highest amount of rainfall. If we look at the rainy days per year, it was found that rainy days range from 25 to 34 days during the study period. The greater the number of rainy days, better will be the rainfall distribution and vice-versa. Having precise and standard information of rainfall pattern proves useful for preparing crop calendar, designing of different storage structures and also in managing and executing of irrigation strategies during drought spells.

Key words: Trend analysis, annual, daily and monthly rainfall

Impact of Fertigation on Soil Nutrient Dynamics in *Dalbergia sissoo* Tree Plantations

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Fertigation allows the controlled placement of nutrients reducing fertilizer losses through leaching and minimize groundwater pollution. In fertigation Nutrient Use Efficiency (NUE) could be as high as 90% compared to 40-60% in conventional method of fertilizer application. Standardizing nutrient management with micro-irrigation system would require consideration to be contributed to soil nutrient dynamics. A field trial was conducted in tree (*Dalbergia sissoo*) plantation of Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu, India. *Dalbergia sissoo* is one of the indigenous species with short rotation.The present study was conducted to standardize water and nutrient requirement for raising this tree species in High Density Plantation and to study the distribution of nutrients in soil sub-surface using SURFER software.Fertigation schedule consisted of humic acid and inorganic fertilizer. The experiment was laid out in split plot design comprised of main plot with irrigation treatment and sub plot with fertilizer levels. Fertigation schedule consisted of humic acid (62.5 litre ha^{-1}), inorganic fertilizer level of 150:100:100 kg N, P and K ha^{-1} (100% recommended dose) was applied in the form of urea, single super phosphate and muriate of potash and humic acid (62.5 litre ha^{-}1) + 75 :50:50 kg N, P and K ha^{-1} (75% recommended dose).Water requirement of the tree plantation was calculated using the pan evaporation (PE) data. The soil samples were collected at a radial distance of 30, 60 cm and 90 cm and at a depth of 0-30 and 30-60 cm. Soil nutrient dynamics was estimated by analyzing available nitrogen, phosphorus and potassium content of soil. SURFER 7 (Golden software) packages was used to show the contour and three dimensional view of nutrient distribution vertically and horizontally from the plant. The mobility of nutrient in soil depends on the quantity and kinds of fertilizers applied, form of nutrient ions, moisture content of the soil and other reacting ions present in soil solution. The available N decreased steadily with increase in distance from the tree horizontally at 30, 60 and 90 cm and vertically at 0-30 and 30-60 cm. At vertical depth of 0-30 cm the highest available N was registered. The available N, P and K contents decreased as the distance from the plant increased and were found to be the lowest at 90 cm lateral distance and at 30-60 cm vertical depth in sub surface soil. Nutrient distribution study revealed that irrigation level at 125% PE and fertigation @ 100% RDF (150:100:100 kg N,P and K ha^{-1}) recorded the highest soil N,P and K status at 30 cm lateral distance and horizontal depth of 0-30 cm.

Key words: Fertigation, Tree plantation, Nutrient dynamics, Humic acid, Fertilizer

Enhancement in Water Use Efficiency and Economic Feasibility of Reusable Plastic Bags Mulching Roll for Growing Rabi Onion under Drip System of Irrigation

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The cost of conventional black plastic is a constraint for small and marginal farmers under Badi cultivation. To address this issue, an experiment was conducted in the field lab of Department of Soil and Water Engineering, IGKV Raipur to study the enhancement in water use efficiency and economic feasibility of mulching roll prepared from reusable plastic materials for growing Rabi onion. Eight types of mulching conditions (Black plastic mulch-BPM, silver plastic mulch-SPM, reusable Wheat flour bag mulch-WFBM, reusable Rice bag mulch-RBM, reusable cement bag mulch-CBM, paddy straw mulch-PSM, soil mulch-SM and without mulch-WM (control)) having three replications in randomized block design (RBD) had been adopted. Irrigation was provided on the basis of Evapotranspiration of crop at 100% ET_c using modified Penman method. Maximum plant height, number of functional leaves per plant, polar diameter, equatorial diameter and maximum bulb yield was recorded in BPM in all the growth stage and minimum plant height, number of functional leaves per plant, polar diameter, equatorial diameter and minimum bulb yield of onion was recorded in WM condition as compare to other conditions. The maximum water use efficiency (1.13q $ha^{-1}mm^{-1}$) was found under BPM and the minimum water use efficiency (0.66q $ha^{-1}mm^{-1}$) was found under WM while the water use efficiency under SPM, WFBM, CBM, RBM, PSM and SM was found to be 1.11, 0.94, 0.90, 0.87, 0.78 and 0.72 q $ha^{-1}mm^{-1}$, respectively which is nearly 1.5 times the WM condition. Similarly, the benefit cost ratio was found maximum under BPM (2.28) and minimum under WM (1.71) while the benefit cost ration was found to be 2.26, 2.21, 2.12, 2.06, 1.98 and 1.86, respectively under SPM, WFBM,CBM, RBM, PSM and SM condition. On the basis of study it can be concluded that low cost mulching roll can be prepared from reusable plastic material and can be utilized as mulches for enhancing water use efficiency and benefit cost ratio particularly for small and marginal farmers under Badi cultivation.

Key words: Mulching Roll, Rabi onion, Reusable Wheat flour bag mulch, Reusable Rice bag mulch, Reusable cement bag mulch, Drip irrigation, Water use efficiency, Benefit cost ratio

Effect of Different Soil and Water Conservation Practices on Soil and Water Quality in the Adopted Village Ponds of North - Western Himalayas

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The water resource in the lower Shivalik region of Jammu is facing daunting challenges due to urbanization, industrialization and huge demand for agricultural activities. The potential for augmentation of water availability is limited, water tables are receding day by day and water quality issues have been increased. Mere 25% plain area is covered under different canal command areas, whereas 75% is rain fed spread over the span of ten districts of Jammu region. The study was conducted to assess the impact of water conservation modules onwater quality of four adopted ponds at village Merth, Sahar & Uttri of district Kathua respectively. The participatory rural appraisal report of each village has been formulated to understand location as well as present resource potential of the district. The adopted ponds have been redesigned in such a manner that most part of the runoff from adjoining rivulets should be trapped in these ponds. The conservation modules which were adopted for improving the water quality of ponds are Digital Elevation Model (DEM) mapping of watershed area, bunding, contour bunding, promoting terrace farming to reduce soil loss, diversion of sewage water, constructing channels to divert rain water into ponds & promoting rain water harvesting. Various water physico-chemical & biological parameters were assessed using standard procedures before and after adopting conservation modules. The water parameters which were assessed are pH, dissolved oxygen (DO), biological oxygen demand (BOD), electrical conductivity (EC), temperature, turbidity, total coli forms, nitrate & total dissolved solids (TDS). The overall Water Quality Index(WQI) value on the scale of 0-100 for the four adopted village ponds before adopting conservation module was 50.0 (Medium) for Merth first pond, 21.0 (Very Bad) for Merth second pond, 42.0 (Bad) for Sahar pond & 40.0 (Bad) for Uttri pond. After adopting conservation modules the WQI value of adopted village ponds was 78.0 (Good) for Merth first pond, 52.0 (Good) for Merth second pond, 74.0 (Good) for Sahar pond & 72.0 (Good) for Uttri pond. The study thus revealed that there is an improvement in water quality of adopted ponds and which can be further improved by sustaining these conservation modules. The trainings and awareness given to farmers & local residents of village also played an important role as they will help in participatory approach for the conservation of these ponds.

Key words: Water Quality Index, Digital Elevation Model. Conservation modules, ponds

Extreme Weather Associated Sediment Load and its Influences on Water Quality of Water Storage Reservoir in North Eastern China: A Case Study

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The water quality in a water storage reservoir is affected by a wide range of factors that come from natural environmental process and human activities. Ongoing climate change has been recently recognized playing significant role in influencing water quality in reservoir. The reality, however, is that how climate changes, especially extreme weather conditions, impact the water quality in reservoir remaining unclear. Here, we investigated the potential linkage between extreme weather conditions and water problem using Xinlicheng Reservoir as a case, which is located in the northeastern China. This reservoir is one of the two drinking water sources in Changchun, the capital city of Jilin Province. The algae blooms occurred in Xinlicheng reservoir led to stop water supplying in the summer of 2007. There was no algae problem recorded in this reservoir since it was constructed in 1965. Actually, water quality issues derived from algae bloom have rarely been occurred in the northeastern part in China due to the fact that these areas are high northern latitudes China. Few existing studies have reported the extreme weather associated sediment load and its influences on water quality of water storage reservoir in northeastern China to date. Here, we tracked the extreme weather conditions, especially the meteorological parameters perception and temperature in the summer time during the period (1997-2017). We found that the temperature and perception on June and July in 2007 showed a distinctive feature from the other years. The sediment load in the upper stream of Xinlicheng Reservoir was calculated by SWAT mode. The excessive nutrients input accompanied with runoff and sediment load likely explained the water quality degradation in Xinlicheng Reservoir in the summer of 2007. Taken together, increased land use, especially agriculture actives in the upper watershed, most likely intensify the water quality deterioration in reservoirs under extreme weather conditions.

Key words: SWAT mode, Extreme precipitation, Extreme temperature, Algae bloom

Effect of Moisture Conservation and Irrigation Scheduling on WUE and NUE of Linseed under Varying Fertility Levels

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The main reason for low yield of this dual purpose linseedis deficit of soil moisture and low nutrient application.Mulching has been advocated as an effective means for conserving soil moisture.Irrigation to linseed is mostly based on critical growth stages and the latest approach of scheduling irrigation is mostly through irrigation water depth, cumulative pan evaporation (IW: CPE) ratio has not yet been amply tried in almost all the regions of Uttar Pradesh. Therefore, it is important to compare the previous methods with the IW:CPE ratio approach of irrigation scheduling to identify the most suitable frequency, time and depth of irrigation for higher yield of linseed. This research investigation was carried out on Agricultural farm, Banaras Hindu University mainly implied to study the impact of moisture conserving techniques on water use efficiency and nutrient use efficiency viz. Nitrogen, Phosphorus, Potassium) of linseed crop. Use of mulching, scheduling irrigation and taking IW:CPE ratio significantly improved the WUE and use efficiency of nutrients (N, P, K) which determines the productivity of the crop along with some deduction in cost of cultivation.

Key words: Linseed, Water use efficiency, Nutrient use efficiency, moisture conservation, mulching

Crop Residue Mulch and Irrigation Regime Effects on Profile Moisture and Productivity of Zero-till Lady's Finger Grown in Sequence with Garden Pea

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In India, lady's finger (*Abelmoschus esculentus* L.) is grown extensively grown during *kharif* and summer season due to its high adaptability over a wide range of environmental conditions. However, it suffers from moisture stress due to hot-and-dry weather conditions in the summer season resulting in low yields. Optimised irrigation scheduling with various crop residues could be promising technology to minimise the water stress in lady's finger. Hence, a two year field experiment consisting of 16-treatment combination of 4-types of crop residue mulches (applied to preceding vegetable pea) and 4-irrigation schedules, viz., recommended irrigation, and irrigation at 30, 50 and 70% depletion of available soil moisture (DASM) was conducted in spring-summer season (March-June) of 2017 and 2018 at research farm of Division of Agronomy, ICAR-IARI, New Delhi to assess the productivity of zero-tilled lady's finger under different crop residues and irrigation regimes in sequence with garden pea. The yield of lady's finger was comparable between recommended irrigation and irrigation at 30% DASM. Delaying irrigation till 50% DASM reduced yield considerably and when irrigations were further delayed upto 70% DASM, the yield fell drastically (>60% reduction). Under frequent irrigations (recommended and 30% DASM), soybean and maize residue mulches were better but under stressed irrigation (50 and 70% DASM), paddy straw mulch was better. All mulches improved yield over no-mulch. Overall, it could be concluded that summer lady's finger may be irrigated at 30% DASM under adequate moisture availability and at 50% DASM with yield penalty under inadequate irrigation water availability. Use of mulches like soybean, maize and rice residues could further improve water productivity and yields.

Key words: Crop residue mulch, Irrigation regime, Lady's finger, Water saving, Zero-tillage

Water and Energy Conservation through SPV Linked Micro Irrigation System

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A Solar Photovoltaic (SPV) pump operated drip irrigation system has been designed and developed for growing crops in arid & semi arid region considering different design parameters like pumps size, water requirements, the diurnal variation in the discharge of solar radiation pressure of the pump due to change in irradiance and drippers. Solar radiation as a power source for irrigation is available at the site of application without the need of an elaborate distribution system. With decreasing availability of irrigation water and the low irrigation efficiencies (about 35%) in conventional methods of irrigation, alternative solutions need to be explored. Drip irrigation operated with solar systems has been promoted recently through various programs of ministries. Subsurface drip irrigation (SDI) is most advanced method of irrigation, which enables the application of the small amounts of water to the soil through the drippers placed below the soil surface. Therefore, a research was undertaken on potato (Solanum tuberosum) cv- Kufri chipsona-3 to study the effect of fertigation doses and depth of placement of drip laterals of SDI system during 2017-18 and 2018-2019. Laterals were placed at three depths (i) surface (ii) 15 cm soil depth and (iii) 30 cm soil depth. 30 cm spacing inline drip irrigation were used for irrigation. The bed of potato was prepared with row to row distance of 60 cm and plant to plant distance of 30 cm. The recommended doses of fertilizers for the potato crop was adopted i.e., 150 kg N, 100 kg P_2O_5 and 150 K_2O, out of which 30% fertilizer given as basal dose and 70% through drip fertigation. Weekly fertigation was given at three doses ie 100%, 80% & 60% RDF. Total amount of irrigation water was applied as 110.16mm and maximum yield of 51.33 t/ha in 100% RDF in weekly fertigation frequency by placing the lateral at 30 cm depth. Maximum water use efficiency was found in 100% RDF (301.56 kg/ha.mm).

Key words: Potato, Fertigation, Lateral placement, Nutrients NPK, Subsurface drip irrigation

Research on the Response of Peach Tree Root Soil to Drip Irrigation in Coastal Saline-alkali Land

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Peach is one of the main fruit varieties in Zhejiang province, Sourheast China. Besides selling fruits, peach blossom in spring and fresh fruit in autumn could attract many tourists to the countryside for sightseeing, fruit picking, experiencing and consumption. Peach planting has become an important measures for agricultural development, farmers' income increase promotion, ural area revitalization and vilige beautification.Traditionally, peach trees are planted and grown on sunny and well drained hills and slopes with weak acidic soils that are rich in organic matter and have a Ph value from about 5.2 to 6.8. The widely distributed coastal saline-alkali lands, which are eager to develop modern, ecological and sightseeing agriculture, had been generally considered unsuitable for the growth of peach trees. This study applied the Jiangdong irrigation experimental base located in the Qiantang river estuary area to carry out field experiments to observe the growth status of Da Guan $1^{\#}$ peach species in the saline-alkali land, and to study the response of the root active layer soil of peach tree to drip irrigation. Four years' observation showed that under certain cultivation and protection conditions, individual varieties of peach trees could grow well in saline-alkali land. The experiment of one irrigation season showed that after irrigation, a vertical and horizontal desalting zone was formed arround the active layer of root system. The salinity of the desalting area decreased obviously, soil conductivity decreased by 64%-88%. The concentration of SO_4^{2-} anion and CL^- anion decreased by 86% and 93%, respectively. Ca^{2+}, Na^+ and other metal cations decreased by about 23%, and HCO_4^- anion decreased by 8%. Soil quality and environment were improved obviously in the respect of the above index. Meanwhile, trace elements like effective iron, manganese and zinc, which are necessities to peach tree growing, were decreased by 11%, 21% and 8%, respectively. The loss of trace elements must be compensated by fertilization.

Key words: Peach tree, irrigation, coastal saline-alkali land, soil improvement

Interactive Effect of Irrigation and Nutrient Management on Yield and Water Use Efficiency of Cowpea

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In the age of over-exploitation of natural resources, proper conservation management practices should be adopted to make it to a sustainable and quality rich environment along with high income of the resource poor farmers in agriculture. In this context, proper utilization of water along with nutrient management are important aspects to make farming more beneficial. On this behalf, an field experiment was conducted during the summer season of March to July 2018, at the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to investigate the interactive effect of irrigation and various nutrients under Cowpea (Var- Rohan 1086) production. The experiment was laid out in split plot design having three main plot treatment (I_0 – CPE 60 mm, I_1- CPE 50 mm, I_2- CPE 40 mm) and five sub plot treatment [F_0 – Control, F_1 –Farm yard manure @ 2.5 t/ha, F_2 – Cow dung @ 10 t/ha, F_3 – Poultry manure @ 2t/ha, F_4 – Recommended Dose of Fertilizer (N-P-K : 12.5 – 25 - 12.5)] with three replications. Results showed that the yield is increased with each treatment, attaining the highest value of 13.62 q/ha in treatment I_2F_4 which is 81.6% more than control. The moisture use efficiency of the crop, was increased significantly by 52.99% in the treatment I_0F_2 over control. Though the best results were obtained in I_2F_4, in terms of benefit-cost ratio and from sustainable point of view treatment I_2F_2 was proven more beneficial than any other treatments.

Key words: Benefit-cost ratio, Cow pea, Integrated nutrient management, Water use efficiency

Water Saving Technologies for Increasing On Farm Water Use Efficiency in Irrigated Commands for Climate Smart Agriculture

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Rice is one of the most cultivated grain crops in India as well as the Asian countries and a staple diet of major part of India. Traditional methods of rice cultivation require large quantity of water. It is more laborious and requires higher doses of fertilizers which in turn create soil problems. With proper field management practices and irrigation methods rice cultivation would be profitable. With water scarcity in agriculture, there is a need to popularize the alternate methods of rice cultivation like Alternate wetting and drying as well as cultivation of paddy under drip and direct sowing of rice with water management. By keeping all the above aspects in view, a field experiment has been conducted at WALAMTARI, Himayatsagar, Rajendranagar to cultivate paddy with different water saving technologies in 2017-2018. It is observed that there is almost 25% reduction in water usage and approximately 15% improvement in yields.

Key words: Alternate wetting and drying, field management practices, water saving

Use of Wetted Front Radii for Estimation of Unsaturated Hydraulic Conductivity Function of Soil

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The saturated hydraulic conductivity (K_s) of soil is needed to understand the agricultural and hydrological processes such as ground water recharge. Unsaturated hydraulic conductivity function (K_h) of Gardener helps in understanding soil water movement under unsaturated flow conditions during crop or non-crop conditions. Wooding proposed a point source field dripper technique for estimating unsaturated hydraulic conductivity function for the most practical range of soil moisture. Steady state saturated front radii against different drippers discharges are used for estimation of unsaturated hydraulic conductivity of the soil by researchers in past. Demarcation and measurement of steady state saturated wetted front radii against point source dripper discharges is a tedious task. Demarcation and measurement of unsaturated steady state wetted front radii is much easier in measurement with least error while visual demarcation of saturated front is difficult and subjected to associated errors while measurement. Present study was focused to use unsaturated front radii of point source field dripper for assessing unsaturated hydraulic conductivity function. The experiments were conducted over cultivated recently tilled normal soil (CRTNS), cultivated untilled normal soil (CUTNS), cultivated recently tilled sodic soil (CRTSS) and uncultivated untilled sodic (UCUTSS) to measure the steady state saturated hydraulic conductivity and wetted front radii against dripper discharge rates of 18.2-91.12 cm^3hr^{-1}. Wooding (1968) relationship was employed to work out Gardeners' conductivity function of the soil. Saturated hydraulic conductivity (K_s) was worked out as 20.20, 8.62, 5.72 and 0.448 cm hr^{-1} using saturated wetted front radii and 12.33, 2.800, 3.123 and 0.399 cm hr^{-1} using wetted front radii over CRTNS, CUTNS, CRTSS and UCUTSS, respectively. Similarly inverse of scaling parameter of soil (á) were calculated as 0.041, 0.020, 0.012 and 0.00042 cm^{-1} using saturated front radii and 0.0465, 0.0101, 0.0114 and 0.00229 cm^{-1} for CRTNS, CUTNS, CRTSS and UCUTSS, respectively. The correction factors for converting K_s indices to K_s for different soils were worked out which ranged from 0.324825 to 0.781600 while it ranged from 0.505000 to 1.705882 for converting á-indices to á for CRTNS, CUTNS, CRTSS and UCUTSS, respectively. The K_s values obtained using unsaturated front radii deviated by 38.96, 67.52, 45.40 and 10.94% while inverse of scale parameter deviated by -13.41, 49.50, 5.00 and -445.24% over CRTNS, CUTNS, CRTSS and UCUTSS, respectively. The proposed method gave reasonably good estimate of K_s and α.

Key words: Saturated hydraulic conductivity, Scaling parameter, Saturated front and Wetted front

Variation in Soil Hydraulic Properties of Benggang Slopes in the Hilly Granitic Regions, South China

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Benggang erosion, a typical erosion phenomenon in the hilly granitic regions, is an important factor responsible for the deterioration of the ecological environment in southern China. The spatial distribution pattern of soil hydraulic properties influences rainfall infiltration and soil water retention along the pedon profile, and thus probably affects the stability of the granitic slopes. Previous studies about soil hydraulic properties in granitic gully erosion area were mostly focused on hydraulic variation with profile depth, but limited research has been conducted to explore the influence of slope position on the spatial variations in soil hydraulic properties. Here, field and laboratory tests were conducted in different Benggang slope positions in the direction along the collapsing wall to watershed of the slopes to investigated the spatial variations in hydraulic properties and explore the potential relationship between the spatial variations in soil hydraulic properties and the development of collapsing on Benggang slopes. The results indicated that slope position and erosion degree dominated to the variations in soil hydraulic properties. The Gardner á and hydraulic conductivity values in lower slopes were greater than those in upper and middle slopes. Slope position had significant impact on soil infiltration properties and erosion degree significantly influenced hydraulic conductivity. Effective macroporosity controlled both by erosion degree and slope position in the sampling sites. Under the same soil suction, the soil moisture contents at different slope positions were ranked as: upper slope > middle slope > lower slope and soils suffering from slight erosion had a higher soil water retention ability suffering from severe erosion. The spatial pattern in soil hydraulic properties of Benggang slopes may lead to the relatively higher antecedent moisture for the soils on the lower slopes which closed to the collapsing wall due to the downhill flow and the difference in hydraulic properties. And the lower slopes may develop more preferential flow generating the severe soil water variation and rapid changes in pore water pressure, accelerating collapsing eventually. The obtained results facilitate a better understanding of the hydrological processes on Benggang slopes and the interaction between spatial variation in hydraulic properties and the development of Benggang erosion.

Key words: Slope position, Soil infiltration, Soil hydraulic property, Benggang erosion, Spatial variation

Effect of Using Different Ratios of Saline and Non-saline Water through Pitcher Irrigation with Tillage under Tomato Production in an Coastal Soil of West Bengal

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Coastal saline soil of West Bengal suffers from the multi-dimensional production constraints, of which non-availability of good quality irrigation water is the prime factor. The high salt content of soil is detrimental for plant growth which does not allow the farmers to achieve more income. On this background, application of blended saline and non-saline water in pitcher pot for irrigation along with different type of tillage may have the opportunity to increase water use efficiency as well as reducing soil salinity and enhancing crop productivity. On this regard, a field experiment was conducted under tomato (var- Pusa Ruby) production at the farmer's field of the Simabandh village, Kakdwip, South 24 Parganas, West Bengal under Coastal saline Zone in rabi season of 2017-2018 and 2018-2019. Eight treatments viz. T_1 = Non-saline water $_+$ Conventional tillage, T_2= Non-saline water + Mulch Tillage, T_3= Non-saline water (25%) + saline water (75%) + Conventional tillage, T_4= Non-saline water (25%) + saline water (75%) + Mulch tillage, T_5= Non-saline water (50%) + saline water (50%) + Conventional tillage, T_6= Non-saline water (50%) + saline water (50%) + Mulch tillage, T_7= Non-saline water (75%) + saline water (25%) + Conventional tillage, T_8= Non-saline water (75%) + saline water (25%) + Mulch tillage were used for the experiment in a Split Plot Design with four replications. Results showed that the yield, attaining the highest value of 28.54 ton/ha in T_8 which is statistically at par with treatment T_6 which showed an yield of 27.85 ton/ha and also the highest benefit-cost ratio of 2.8 : 1 and lowest in treatment T_3 (15.68 ton/ha). The moisture use efficiency of the crop, was increased significantly by 35.22% in treatment T_8 over the lowest (treatment T_3). Though the best results were obtained in T_8, in terms of benefit-cost ratio T_6 had been proven more beneficial than any other treatments and for improving soil properties and building up soil fertility.

Key words: Coastal saline soil, Moisture use efficiency, Mulch tillage, Pitcher irrigation, Saline water

Evaluation of Circulated and Non-circulated Hydroponic Systems for Growth, Yield and Available Nutrients of Leafy Vegetables at Cold Desert Ladakh Region

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Ladakh is a high altitude cold desert region and is considered as one of most difficult terrain in the world. In this area during winter season minimum temperature is recorded as low as -30^{0}C to -35^{0}C. In order to meet the basic human requirements of fresh food in extreme high altitude condition, vegetables play the vital role in food and nutritional security and maintenance of human health. But the Ladakh region poses major challenges in fresh vegetables production throughout the year. Hydroponics is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution. Hydroponic cultivations can help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources especially in areas where soil and water are limiting factors for plant growth. Keeping in view, experiment was conducted during summer season of 2018 at Defence Institute of High Altitude Research (DIHAR), DRDO, Leh-Ladakh to evaluate different hydroponic systems viz. circulated (vertical and horizontal nutrient flow technique (NFT) system) and non circulated hydroponics system on growth, yield and nutrient content of lettuce and spinach.

Different hydroponics systems showed significantly difference in growth, yield and available nutrient content of lettuce and spinach. In case of spinach, plants from vertical system were found to be significantly better in plant height (30.3 cm); average root length (28.1 cm); leaf area (90.4 cm^2) as compared to non-circulated systems. Whereas lettuce crop exhibited highest values for plant height (20.6 cm) at non-circulating system and minimum value (19.2 cm) was recorded in vertical system, probably due to closer spacing at non-circulated systems. Significant increase in nutrients in lettuce viz. Ca (100.81 ppm), Zn (1.02 ppm) and Fe (5.22 ppm) was observed in vertical NFT system followed by horizontal NFT and non-circulating hydroponic system.

Significantly higher yield of leafy greens (lettuce and spinach) were recorded at vertical NFT systems (3.45 kg/m^2 and 3.15 kg/m^2 respectively), whereas minimum yield of lettuce (2.12 Kg/m^2) and spinach (1.35 Kg/m^2) were recorded at non-circulated system. In case of spinach, nutrient content of plants in horizontal NFT system were found to be higher for Ca (100.61 ppm), Mg (106.50 ppm) and Fe (3.16 ppm) followed by vertical NFT system. However, Zn content (0.97 ppm) was found to be higher in vertical NFT system. Leaf chlorophyll and anthocyanin content was found higher in circulated NFT systems. Early harvesting was also achieved at NFT system as compared to non-circulated hydroponics system.

Key words: Hydroponic cultivation, NFT system, Cold arid Ladakh

Impact of Tillage, Mulch and Deficit Saline Irrigation on Yield, Quality and Economics of a Sorghum-Wheat System in Northwest India

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Sustainable development of agriculture is restricted by fresh water shortage and water quality deterioration in some arid and semi-arid areas. Therefore, deficit irrigation and saline water irrigation have to be applied for sustaining crop yield. Therefore, we hypothesized that "Impact of tillage, mulch and deficit saline irrigation on yield, quality and economics of a sorghum-wheat system was conducted during 2015-2017 at Research farm of ICAR-Central Soil Salinity Research Institute, Nain, Panipat, Haryana, India. The experiment was conducted in split plot design with three replications. Three tillage treatments *viz.* zero tillage-reduced tillage (ZT-RT), conventional tillage-conventional tillage (CT-CT) and zero tillage-zero tillage (ZT-ZT) were taken in main plot and combination of irrigation treatments comprising of saline water (EC_{iw} 8 dS m^{-1}) irrigation with 100, 80 and 60 per cent of water requirement and rice straw mulch (0 and 5 t ha^{-1}) in subplots. Effect of tillage, saline irrigation and mulch on sorghum green and dry fodder yield, and dry matter content were statistically non-significant ($P > 0.05$) but interaction between tillage, deficit saline irrigation at 60% WR and mulch in ZT-RT showed significantly higher green fodder yield in sorghum. ZT-RT practice performed at par with conventional tillage (CT-CT tillage) for wheat grain yield. Mulching significantly($P < 0.05$) increased grain yield (4.9%), number of spikelets per spike (5.2%) and spike length (5.0%) over no mulch. The system productivity was 3.8% higher in mulch (10.3 t ha^{-1}) than no mulch (9.9 t ha^{-1}; $P<0.05$). Rice straw mulch increased system gross return significantly (Rs 192598 ha^{-1}; $P< 0.05$) by 3.2% over no mulch (Rs 186435 ha^{-1}). Mulching significantly improved quality of fodder sorghum and wheat straw by increasing crude protein, ash content contrarily decrease in neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). Deficit saline irrigation (60WR) had significantly lower ADF in fodder sorghum and NDF and ADF in wheat straw than 100% WR. Further, 100WR saline had significantly higher further ash content in fodder sorghum and wheat straw. Therefore, under limited irrigation conditions with rice straw mulching in zero tillage-reduced tillage for sorghum and wheat, respectively are effective in increase yield, improving fodder quality.

Key words: Mulching, tillage, fodder sorghum, wheat, saline irrigation, zero-tillage

Modelling Soil Water Balance and Crop Water Use in Wheat under Conservation Agriculture using Hydrus-2D

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Limited information is available about the effect of conservation tillage practices on the soil water balance and crop water use under maize-based cropping system. Hence, the objective of present study was to assess the impact of conservation agriculture practices on soil water balance and root water uptake in wheat (*Triticum aestivum* L.) in a maize-wheat-mungbean cropping system using HYDRUS 2D model. The study was carried out on long term conservation agricultural experiment which was initiated in *Kharif* 2008 at ICAR-IARI, New Delhi. There were two treatments: zero tillage (ZT+R) and conventional tillage (CT+R).The model predicted daily changes in profile soil water content (SWC) with reasonable accuracy (R^2=0.72, RMSE=0.016; n=112). Results showed that ZT+R had higher soil moisture content compared to CT+R. Larger variations in SWC were observed at 0-15 and 15-30 cm depth and lesser at 30-45 and 45-60 cm. Soil water balance simulated from the model indicated that cumulative transpiration (CRWU) values were higher in ZT+R (16.6 cm) than CT+R (14.27 cm) however cumulative evaporation (CE) was just the reverse, higher in CT+R (4.72 cm) than ZT+R (4.31 cm). Similarly, cumulative drainage was higher in ZT+R (17.09 cm) than CT+R plots (14.96 cm). Both initial and final SWC values of the soil profile and root water uptake under ZT+R were higher than in CT+R plots due to conservation tillage practices.In general root water uptake (RWU) was low during the initial crop growth period (30–70 DAS), however it was high during the mid-growth period (60–120 DAS) thereafter, itdeclined till the crop maturity. Hence, the present study clearly showed that ZT+R treatment improves soil moisture and root water uptake compared to conventional tillage practices under diversified maize-based cropping systems.

Key words: Hydrus 2D, conservation agriculture, soil water balance, root water uptake, wheat

SESSION-III

Climate Smart Techniques for Sustainable Agriculture

Soil and Water Conservation Role in the Raise and Fall of Civilizations

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The origin of soil and water conservation techniques is closely related to the origin of agriculture. From the beginning, the Neolithic farmer would develop rudimentary techniques of diversion and containment of water courses that would probably be accompanied by the construction of primitive structures for the storage of excess avenues water for use in periods of drought. At the same time, would gradually begin to manipulate the soil in a slow, intuitive and trial-and-error process, to achieve its stability and to facilitate the growth of the incipient crop plants. With both types of actions, we can consider that soil and water conservation (SWC) began. These primitive actions on land would occur in the historical places of the birth of agriculture (Fertile Crescent, Meso America, China) with adaptation to the environmental conditions of each region. New techniques for soil and water conservation would be developed slowly and progressively as agriculture expanded. This long historical process of evolution of conservation techniques represents a rich cultural and ingenuity legacy of humanity. All kinds of land in the world require some kind of transformation for agricultural use to enhance their stability, their productivity and their ability to provide ecosystem functions and services. When the users of these measures leave their maintenance, a tendency of deterioration can begin, which, if not controlled, can lead to the loss of essential resources of the territory and to the social and economic decline. There is significant and valuable literature on the historical relationship between land management and the development and flowering of civilizations. They highlight the historical role of SWC in human history and its influence on the rise and fall of civilizations. The objective of this paper is to analyze the implications of SWC in the permanence of civilizations highlighting the mismanagement or abandon of SWC as a crucial factor triggering the decline or even the collapse of civilizations. In this last aspect, historians and socio-economists expose a whole long series of theories without an acceptable level of consensus. In general, in these disciplines there is little consideration of the aspects of "depletion or mismanagement of land resources" as one of the causes of the decline of cultures. We believe that the link between the loss or deterioration of fertile soils, the development of conflicts and the decline and fall of civilizations is not sufficiently studied and requires a better conceptual approach and analysis. Experience seems to show that the decrease in the territory's available resources, such as land, water and food, and the competition to access scarce or degraded land, is closely related to the stability, progress and security of populations. In fact, history reveals that the conservation of soil and water resources has been crucial for the permanence of any type of civilization. In a broader sense we can consider that the management and conservation of the land has influenced and shaped human history.

Key words: Soil, water, culture, management, conservation, stability

Water Conservation for Climate Change Adaptation in Rainfed Agriculture

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Climate change impacts agriculture through direct effects on crop yields and indirectly through the impacts on natural resources like soil and water. Most climate models predict an increased rainfall variability and extreme events in future besides rise in temperature. The frequency and intensity of droughts are likely to increase further posing a major challenge to future of rainfed agriculture. In-situ and ex-situ water conservation are expected to play a major role in adaptation of rainfed agriculture to climate change in future. These technologies conserve rain water in the profile and utilize surplus runoff through harvesting and recycling.While many of the in –situ conservation practices are simple and farmers can adopt with little external support.

According to CRIDA maximum harvestable runoff is available in 1000-2500 mm rainfall zone (14.61 m.ha.m) followed by 750 -1000 mm (4.03 m.ha m).However cost –benefit ratios of supplemental irrigation are relatively higher in 500 – 750 mm zone, though the harvestable runoff is only 1.5 m.ha.m. Further, the current runoff estimates are likely to undergo major change with projected increase in rainfall and its distribution pattern due to climate change. An assessment of the water harvesting potential of rainfed regions based on rainfall and crop water balance indicated that many districts in central and eastern India growing rainfed rice and soybean have considerable surplus runoff which can be harvested.

Dugout ponds are the common interventions to harvest runoff in most rainfall zones.The location, size, storage volume, lining requirements and designs for dugout ponds have been optimized for different rainfall zones by CRIDA and its network.. Water lifting and irrigation methods are standardized. Sprinkler irrigation was found to be more feasible and cost effective. The cost benefit ratio and water productivity are higher when horticulture/cash crops are grown. In low rainfall regions with little surplus run off, the focus should be on *in-situ* conservation by adoption of land management practices. In medium rainfall zones, both *in situ* and *ex situ* strategies are to be followed since adequate runoff is available. In high rainfall regions of Odisha and Chattisgarh, considerable quantity of runoff is available for storage in large structures. On-farm reservoirs and tanks are ideal for harvesting and storing water. However, in future, with projected increase in rainfall intensity, water harvesting may be feasible and economically viable in arid and dry semi arid regions as well.

Realizing the importance of water harvesting in climate change adaptation, states like Telangana (Mission Kakatiya) and Maharashtra (Jalayukta Shivar) have launched state level mega projects. These projects focus on rejuvenating existing conservation structures and recharge of groundwater. In years to come, water harvesting will become an essential component of sustainable agriculture in rainfed regions while helping climate change adaptation.

Key words: Semi-arid region, rejuvenating, conservation structures, climate change

Development and Management of Land - Water Resources to Tackle Climate Change Effects

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For a projected population of 1700 million by 2050, a stock taking study was made with data from a large number of research projects of India and consultancy reports along with many international documents. There would have a shortfall of about 33 mha of land and water deficit would also be severe. The vast land area now out of use and of negligible productivity due to degradation, contamination by huge social wastes, both solid liquid, has to be brought back to higher productivity and raising large income generating green stock which would concurrently meet the huge non food grain biomass requirement. Similarly, waste and contaminated water has to be brought back to usable fresh water quality by bio remediation and using some for raising green stock especially on bad land. For managing land water resources and meeting projected high demand micro level planning and action plan would be needed as average holding size is small, unemployment or shadow employment is high and household income is low. It would involve relooking at hydrological functions of land, micro sources, area sown more than once under rain fed condition would be crucial. Similarly, increasing biomass productivity and production cultivation of annuals and biennial food crops has to be supplemented with perennial plants, adopt appropriate agricultural food crops and farming systems to increase carbon sequestering, total and organic carbon stock on agricultural land and thus a second carbon sink besides that on forest and permanent pasture land. Aim would be to asses periodically the population supporting capacity of each ha considering total biomass production from cultivated crops and perennial vegetation. Policy support to such management and incentives for using organic inputs and non-private public and village land largely would be essential feature. Use of large volume of inorganic inputs should be limited to the least through financial checks and disincentive. Watershed development should continue to be the key action strategy.

Key words: Land degradation, Climate change adaptation, Soil fertility and productivity, Freshwater, Livelihood security

Can Carbon Neutral Farming be an Option to Mitigating Climate Change?

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Agricultural lands occupy about 40- 50% of the Earth's land surface which accounted for an estimated emission of 5.1 to 6.1 Gt CO_2-eq/yr in 2018/19 (10-12% of total global anthropogenic emissions of greenhouse gases (GHGs). With this projected increase in population and shifts to higher-meat diets, agriculture alone could account for the majority of the emissions budget for limiting global warming below 2°C (3.6°F). This level of agricultural emissions would render the goal of keeping warming below 1.5°C (2.7°F) impossible. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. Carbon neutral farming can be one of the mitigation options to cut down the GHGs emission significantly from agricultural land. Carbon Farming is simply farming in a way that reduces Greenhouse Gas emissions or captures and holds carbon in vegetation and soils. It is managing land, water, plants and animals to meet the Triple Challenge of Landscape Restoration, Climate Change and Food Security. It seeks to reduce emissions in its production processes, while increasing production and sequestering carbon in the landscape.Carbon Farming can range from a single change in land management, such as introducing no-till cultivation or grazing management, to a whole-of-farm integrated plan which maximises carbon capture and emissions reduction. No till for 28 years (NT28) and No-till re-established (NTR: NT for 11 yrs followed by CT for 1 yr again NT) enhanced SOC by 159% and 90%, respectively. Thus NTR could additional increased SOC by 10% than continuous NT system. Substitution of 50% N-fertilizer by either green manure (GM) or FYM in Inceptisol, Vertisol and Mollisol and GM or crop residue (CR) in Alfisol emerged as the best management practice for higher stabilization of C for long-term C sequestration. Among the four soils, Vertisol showed the highest stability of C in colloidal organo-mineral fraction (COMF), followed by Mollisol, Inceptisol and Alfisol. There are number of studies conducted throughout the world regarding the impact of biochar for greenhouse gases (GHG) emission from soil. Being a stable source of C, pyrolyzed at different temperature ranging 200-800ÚC depending on the feedstock, biochar showed its prominence in climate change phenomena.The corn biochar addition decreased CO_2 and N_2O emissions by 11.8% and 26.9% in the acidic sandy soil, respectively whereas addition of olive biochar in the same soil triggered two-fold higher CO_2 emission rate and N_2O emission decreased by 68.4%. Integrated farming system with livestock management, poultry, fish culture, organic manuring, crop and soil management strategies including agroforestry need to be evolved and standardized for making different agricultural enterprises carbon neutral.

Key words: Biochar, CO_2 emission, C sequestration, agriculture enterprises

Classification of Disturbed Land and Estimation of Soil Loss in Such Land during Engineering Construction

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Land is often disturbed during or before engineering constructions, this is easily led to more serious erosion following decreased vegetation, unprotected soil control measures, and active human activities. However, special attention on estimating soil loss in such process is still rare, as existent soil erosion estimation models almost all focused on natural than artificial conditions. To develop scientific models to calculate the amount of soil erosion during engineering constructions, it is necessary to make reasonable classification for all disturbed lands, to extract the characteristics for each type, and to analyze the crucial indices which effect the erosion deeply. This contribution reports the results of an investigation for 470 typical construction sites in various disturbed lands around China. Generally, three types including general disturbed land surface, bare slope due to excavation of project, and congeries of project were classified according to the shape and disturbance characters. Some indices, such as slope gradient, slope length, soil layer depth, vegetation coverage were measured during the investigations. Soil samples were also collected from different sites representative of different types of projects and distributed in different areas of China. Measurements of soil density and soil particle size were tightly made on these samples after returning to the labs. A series of experiments, including natural and artificial simulation rainfall, natural and wind tunnel simulation were taken to evaluate the influence of relative factors on erosion modulus and hence to be used to construct the estimation models. Based on numerous both lab and field survey, experiments and analysis, models to calculate soil loss induced by water and wind during the process of engineering constructions for all kinds of disturbance types were developed.

Key words: Disturbed land, General disturbed land surface, Bare slope due to excavation of project, Congeries of project, Soil erosion caused by water and wind

Modelling-based Climate Change Adaptation Strategies for a Semi-arid River Basin of India

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Climate change significantly affects the hydrological cycle in the semi-arid and water scarce regions. It is very important to study the impacts of climate change on water availability for planning adaptation strategies at regional level. A study was carried out to assess the climate change impacts on the hydrologic behavior of a semi-arid Betwa river basin of central India for suggesting suitable adaptation measures. SWAT model was used to assess the hydrological behavior of the Betwariver basin using CMIP5 based Representative Concentration Pathway (RCP) scenarios from MIROC5.0 Global Climate Model. Analysis of MIROC5.0 projections revealed decrease in the mean annual rainfall in 2020s, by -1 to -3% and increase in the range of 4.6 to 9.1% and 5.7 to 15.3%, during 2050s and 2080s under different scenarios. The analysis of mean annual changes in surface runoff for 2020s revealed decrease in the range of -4.7 to -12.4%. The strategies in such case would be to adopt the soil and water conservation measures like farm ponds, check dams and percolation ponds to harvest surface runoff which is projected to increase in October. This can be utilized for pre-sowing or first post sowing irrigation and also during the summer months. In 2050s and 2080s the climate change is expected to increase the mean annual surface runoff, in the range of 14 to 29% and 12 to 48% respectively which may create a flooding and water logging situation during monsoon season. Thus, the climate change adaptation strategies should focus on management of flood and waterlogging during the wet season by enhancing the storage capacity of reservoirs and adjusting their operating rules and create secondary storage facility to store excess water. The temperature is also projected to increase in 2020s, 2050s and 2080s, as a result the mean annual evapotranspiration under different scenarios would increase in the range0.21 to 2.97%, 2.6 to 4.2% and 3.5 to 6.2%, respectively. The planting dates in rabi season may be adjusted in view of increase in the temperature during future periods. The effect of increased CO_2 on the basin hydrological response was also assessed using SWAT model. In future, increased CO_2 concentration combined with increased rainfall may further increase the surface water availability. However the crop water demand may not increase due to decrease in evapotranspiration which may further lead to a flood like situation. Under such situations the adaptation strategies would be toimprove the drainage efficiency in waterlogged areas and introduction of waterlogging tolerance varieties and adopting improved planting methods like broad bed furrow, ridge and furrow, raised bed and sunken furrow.

Key words: Climate change, Hydrological cycle, Surface runoff, Adaptation strategies

Farm Ponds – A Tool in Climate Smart Agriculture for Increasing Productivity of Agricultural Crops

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Harvesting of water in farm ponds is a proven watershed technology for a climate smart agriculture to be demonstrated in farmer's fields for increasing yields of crops. Keeping this points in view, a study was under taken in farmer's field in Varada Watershed area of hill zone of Karnataka to demonstrate the benefits for farm pond in giving protective irrigation for enhancing the crop productivity. For this purpose, three farm ponds were dug out in three different farmer's field in low land paddy areas and these ponds were used for giving protective irrigation. Three crops viz., green gram, cowpea and groundnut were grown in paddy fallows during *rabi*/summer season of 1999-2000 and two irrigation levels (no irrigation and protective irrigation) were imposed on these crops. In treatments having protective irrigation, two irrigations were given at 20 and 40 days after sowing in pulse and 30 and 50 days after sowing in groundnut. The yield of different crops was expressed in terms of green gram equivalent yield based on the prevailing market prices. The results indicated that the groundnut has recorded significantly higher green gram equivalent yield (1083 kg/ha) compared to green gram (775 kg/ha) and cowpea (910 kg/ha). Protective irrigation has given significantly higher green gram equivalent yield (1031 kg/ha) compared to no irrigation (814 kg/ha). The extent of increase in gain yield with protective irrigation compared to no irrigation was 26.7 per cent.

Key words: Farm ponds, protective irrigation, green gram, cow pea

Climate Smart Rainwater Management Technology with IFS Models for Water, Food and Nutritional Security in Rainfed Regions

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A field research on climate smart rainwater management was conducted in farmers field in a tribal watershed of 4700 ha for augmenting water resources and enhancing water productivity with profitability of the farmers. On farm reservoir (OFR) was designed for storing surface runoff based on the catchment area and runoff coefficient was determined through modelling approach for both *kharif* and *rabi* seasons by using SWAT. A size of 20x10x3.5 m with 600 m^3 capacity on farm reservoir was constructed with inclusion of SWC measures of contour bunds and field channels for collecting water into the structure. A portable raingun irrigation system was designed for water application in the critical stages of the crops during dryspells. Experiments in tribal farmer field during 2016-19 with two integrated farming system models: Pulse and cotton based systems with OFR for 2 critical irrigations to main crop during dry spells and 5-6 irrigations with 20-30 mm depth of water application at weekly interval in vegetable and fodder, were conducted. With Pulse based system, water productivity of black gram with 3 q/ha yield was 0.21 kg/m^3 as compared to rainfed as 0.13 kg/m^3. The water productivity for chilly was 0.5 kg/m^3, tomato - 3.7-5.0 kg/m^3, brinjal - 9.2 kg/m^3 and fodder 27.52 kg/m^3. In cotton based system, the analysis indicated that with 20-30 mm deficit supplemental irrigation during critical growth stages substantially increased the yield (8-30 q/ha) as compared to rainfed (3-10 q/ha). The water productivity in the SI cotton was 1.23- 3.41 kg/m^3 as compared to rainfed of 0.75-1.92 kg/m^3. In the project area, before the beginning of the project, the energy and protein availability with the mono cropping system of sorghum/cotton, were 962 and 1061K cal/d, 32 and 34 g/d, respectively for type1 and type 2 households. After the intervention the area became sufficient in terms of protein(54 – 67 g/d) as well as their BMR requirement (1478 – 1637 k cal/d) were well satisfied with the IFS intervention which not only supplied cereals but also green leafy vegetables and quality protein in terms of meat. The maximum net benefits were obtained in the cotton based IFS module varying from Rs 16,500/- to 23,500/- per acre as compared to pulse based (Rs 6,000/- to 11,500/- per acre). Apart from this, the system has provided drought proofing during 2016-17 and 2018-19, where even with 105-211 mm of rainfall during crop growth period, farmer was able to fetch good profits using OFR and water management system. The above investigations not only improved water productivity and also doubled the net income of the farmer who practiced mono cropping of sorghum and cotton alternatively under rainfed conditions.

Key words: Doubling farmers income, on farm reservoir, critical irrigations, IFS module

Carbon Sequestration Efficiency of Different Organic Manures in Long Term Fertilizer Experiment

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Soil is an important medium of global carbon(C) cycle and has double the capacity to store C compared to the atmosphere. The efficiency of soil organic carbon (SOC) sequestration is the relationship between annual carbon input and SOC accumulation rate. This is an indicator of soil C sequestration ability. Thus, we conducted the research based on 20 years (1997–2017) of long-term fertilization experiment. The LTFE consists of 12 treatments *viz.*,T_1: 50 per cent NPK (as per KAU POP recommendation), T_2 : 100 percent NPK, T_3 : 150 percent NPK, T_4 : 100 percent NPK + 600 kg ha $^{-1}$ $CaCO_3$, T_5 : 100 percent NPK, T_6 : 100 percent NP, T_7 : 100 percent N, T_8: 100 percent NPK + FYM @ 5 t ha $^{-1}$to the virippu crop only, T_9: 50 per cent NPK + FYM @ 5 t ha $^{-1}$,T_{10} : 100 percent NPK + *in situ* growing of *Sesbania aculeata* (for Virippu crop only), T_{11} : 50 percent NPK + *in situ* growing of *Sesbania aculeata* (for Virippu crop only) and T_{12} : Absolute control (No fertilizers or manures).

The objective was to study the effect of long term application of fertilizers and organic materials (farmyard manure, *in situ* green manuring with daincha) on soil carbon sequestration pattern under long term fertilizer experiments with rice-rice cropping sequence maintained at Regional Agricultural Research Station, Pattambi. The grain yield, straw yield, stubbles left after harvest and unincorporated weed biomass were quantified for calculating the carbon inputs into soil. The total carbon inputs and soil organic carbon sequestration rate were plotted to establish the relationship.

The soil organic carbon distribution pattern was analysed in different depths Integrated nutrient management practice T_8 (100 Per cent NPK + FYM) recorded the higher values for grain yield and growth related parameters followed by T_{10} (100 per cent NPK + *in situ* growing of *Sesbania aculeata*) and T_3 (150 per cent NPK).The treatment T_8 had the higher mass of total organic carbon in top soil followed by T_{10}. A significant positive linear relationship exists between carbon inputs and rate of carbon sequestration. The mean carbon sequestration efficiency was 8.4% in top soil. The average sequestration efficiency for FYM and daincha were 12.18 and 8.58% respectively. The decrease in dose of fertilizers incorporated along with organic manures decreased the carbon sequestration efficiency of the organic amendments. Therefore application of FYM seems to be a preferred strategy for enhancing SOC sequestration in lateritic soils due to its higher carbon sequestration efficiency.

Key words: Green manuring, daincha, carbon sequestration

Sustainable Intensification Strategies for Rice-Wheat Systems for Climate Change Mitigation and Adaptation

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Highly productive agricultural regions of world, like Indo-Gangetic plain, are facing immense pressure for increased crop production due to increasing population pressure. Management practices have key control over biogeochemical processes with effects on greenhouse gas (GHG) emissions, soil carbon sequestration and soil health, and crop yields. Rice-wheat is the most prevalent cropping system in the Indo-Gangetic region. Because of intensive operations conventional rice-wheat cultivated soils have much faster turnover (and losses) of carbon (C) and nitrogen. Major management practices which can have profound effects regarding climate change mitigation-adaptation include fertilizer application (rate and time), tillage (frequency and intensity), organic residue addition and recycling, and water management (frequency and intensity).

Two long term rice-wheat cropping experiments (since 2005) on a sandy loam soil at ICAR-CSSRI, Karnal, were used to study the interactions of these management factors on climate change mitigation and adaptation related indices like carbon cycling and soil C sequestration, nitrogen cycling and plant availability, and GHG emission signatures. Amongst the practices evaluated were six nutrient/ fertilizer management strategies, six combinations of tillage and crop residue retention strategies, and four combinations of water and residue management strategies. The six nutrient management options included five with reduced (50%) inorganic fertilizer doses in combinations with organic sources [LE- legume (*Vigna radiata*) in rotation, GM-green manuring with *Sesbania aculeata*, FYM- farmyard manure application, WS- 1/3 wheat stubble retention, RS-1/3 Rice stubble retention], compared to 'farmer's practice of using only inorganic fertilizer (F)'. Tillage and crop residue retention strategies included puddling and transplanting, reduced tillage and zero tillage, in combination with 1/3rd rice-wheat residue retention and no residue retention. The water and residue management strategies included surface irrigation, drip irrigation, and sprinkler irrigation, in combination with 1/3rd wheat residue and full rice residue retention as mulch or incorporation. Changes in organic C fractions after a decade of management were evaluated. Organic carbon and different fractions of organic C comprising very labile, labile, less labile and non-labile were determined by modified Walkley and Black's method (Chan *et al.*, 2001). Management indices indicative of C sequestration (Lability Index, Carbon Management Index, and Carbon Sequestration Potential) were calculated to interpret management effects. Plant assimilated C, and C input to soil were quantified by taking into account the *in-situ* and *ex-situ* organic matter contributions.

The studies revealed that the fractionation of incorporated carbon (C) under an integrated nutrient management practice for the rice-wheat system was driven by both quantitative as well as qualitative differences in the C inputs to the soil. LE (*Vigna* as opportunity crop between rice and wheat and its biomass incorporation) and GM (green manure crop *Sesbania* biomass incorporation) based management had high biomass incorporation into the soil, yet these materials also had high N and narrow C:N ratio. RS (rice stubble retention) and WS (wheat stubble retention) systems had lower C inputs as well as wider C:N ratio. Legume-based systems indicated higher benefits in terms of C sequestration. FYM constituted decomposed organic matter compared to others. Nitrogen availability indeed played a significant role. Both *Sesbania* and *Vigna* are high nitrogen (low C:N ratio) crops. Increase in biological yield with increased C input/ incorporation worked for high C:N ratio biomass incorporation, but yield under low C:N ratio biomass incorporation based system (GM, LE) remained unresponsive to changes in C input to soil C. Hence, not only quantitative C inputs, but also nutrient (particularly nitrogen) contributions through organic matter played important role. Management with crop residue retention, either on surface or incorporated led to increase in soil C. With conservation tillage (reduced tillage, zero tillage) the less labile fractions of soil C increased while labile fractions decreased, in comparison to puddling/tilled soil of conventional management systems. Conservation tillage and residue resulted in net reduction in greenhouse gas emissions. Our results indicate that conservation practices of residue retention and tillage reduction hold greater potential for GHG (CH_4, N_2O) reduction than soil C sequestration.

Key words: FYM, C:N ratio, C inputs, labile fractions, conservation tillage

Estimating Aboveground and Belowground Respiration from Eddy Covariance and Chamber Measurements

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The eddy covariance (EC) technique is increasingly applied to quantify the net ecosystem exchange (NEE) of CO_2, the balance between photosynthetic carbon gain and respiratory carbon loss. Partitioning NEE into assimilatory and respiratory components helps obtain mechanistic, process-based understanding of the terrestrial carbon cycle. However, one difficulty is to get accurate eddy flux measurements during nighttime periods due to the frequent suppression of turbulence and dominance of advective fluxes not measured by EC technique. In addition, data filtering based on the friction velocity, u*, is one commonly used approach to improve the estimates of nocturnal NEE. However, the u* criterion is subjective, varies spatially and temporally, and even is uncertain at some sites. So we seek an alternative approach to improving the estimates of nocturnal NEE using chamber and EC measurements. In this study, we introduce a method that rely on the light-response curve and temperature sensitivity of daytime NEE, concomitant with soil respiration to predict aboveground respiration(R_{above})and nocturnal ecosystem respiration (R_{eco}). Daytime EC records of NEE in conjunction with hourly continuous chamber measurements of soil respiration between 2005 and 2015 at the Missouri Ozark AmeriFlux (MOFLUX) site, USA were used to partition NEE into photosynthesis, aboveground and belowground respiration. The specific objectives of this study are to: (1) quantify nocturnal R_{eco}; (2) determine R_{above} and R_{below}; (3) compare nocturnal R_{eco} estimates with those obtained with EC.

Key words: Eddy covariance, terrestrial C cycle, above ground respiration

Pond-based Integrated Farming System (PBIFS): A Climate Smart Agriculture for Restoring Waterlogged Sodic Soil for Regional Livelihood Security

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Canal irrigation has played a major role in making India self sufficient in food grain production. India has large networks of unlined canals. Excessive seepage from canals had resulted extensive waterlogging and salinity problem in the country. Nearly 6.73 million hectare of land is suffering with salt accumulation problem in India. Uttar Pradesh once had more than 1.32 million hectare of sodic land. About 10 to 15% canal irrigated sodic lands suffer with twin problems of shallow water table and sodicity. Waterlogged sodic soils can neither be reclaimed by traditional gypsum technique nor subsurface drainage technique. Pond Based Integrated Farming System (PBIFS) Model has potential to reclaim waterlogged sodic soils assuring high returns with minimum payback period. A PBIFS model was constructed at Lalaikheda village along the Sharda Sahayk Canal Command located in district Lucknow during 2014-15. Cereals, pulses, oilseeds and vegetables were grown successfully besides normal and intensive fish farming.

Dhaincha-rice-wheat crop sequence must be followed for first two years for reclamation of sodic soil. Rice field must be continuously flooded with water for maximum leaching of salts. Retain all rainfall within the rice field for effective leaching of salts by proper bunding. Intensive fish farming and tomato production was found to be the most lucrative farming systems under PBIFS model under waterlogged sodic conditions. The first tomato crop gave an yield of 40.33 ton/ha resulting to land productivity, water productivity and water use efficiency as 4.03 kg/m^2 (Rs. 40.32/ m^2), Rs. 201.65/m^3 and 2016.49 kg/ha-cm. The B:C ratio of first tomato crop was recorded as 7.95. Second crop of tomato gave an yield of 32.589 ton/ha with land productivity of 3.26 kg/m^2 (Rs. 52.14/m^2) and water productivity of 260.70 kg/m^3. The water use efficiency of tomato crop was 1629.46 kg/ha-cm and B:C as 8.73. Intensive pungas fish farming with for the first time resulted a yield potential of 27.716 ton/ha with gross return of Rs. 587700.00 and B:C ratio of 1.55 against input cost of Rs. 378020. Similarly for second year intensive pungas fish farming resulted a yield potential of 20.263 ton/ha with gross return of Rs. 486300 and B:C ratio of 1.78 against input cost of Rs. 272500. Total net returns for first and second year of intensive fish and tomato cropping were Rs, 249241 (Rs. 621288/ha) and 265224 (Rs. 682897/ha) from one hectare model of PBIFS with elevated and pond area ratio of 1:1, respectively. The PBIFS Model with intensive tomato cultivation was found highly lucrative hence recommended for wider field applications.

Key words: Canal command, Integrated farming system, Sodicity, Subsurface drainage

Underground Transfer of Flood for Irrigation as a Component of Climate Smart Agriculture in the State of Uttar Pradesh, India

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Climate change is expected to impact rainfall patterns leading to higher uncertainty and difficulties in management of both drought and flood events. Floods occur frequently in Uttar Pradesh (almost every year) in some part of the state or the other. Major rivers that bring this disaster to the state are the Ganga, Yamuna and Ramganga. Groundwater depletion is major problem in many districts in western Uttar Pradesh with in Ramganga sub-basin along with frequent floods. Aquifer recharge is major component of water smart agriculture like rainwater harvesting, laser land levelling and on-farm water management practices.

To address the dual problems of groundwater depletion and floods, an innovative approach called Underground Transfer of Floods for Irrigation (UTFI) involves in transfer and storage of excess wet season flows into natural aquifers through recharge structures. Three-year pilot study of UTFI was conducted at Jiwai Jadid village Rampur district of Uttar Pradesh. In the pilot, the excess surface water during wet season is diverted from the nearby irrigation canal into the pond via a desilting chamber and stored underground through the recharge structures. Under a normal monsoon season, the one such system can intercept and recharge around 70,000 cubic metres of excess flow each year, sufficient to irrigate an additional 20-30 hectares of land. The benefits are multiple because from avoiding disastrous floods is added to that of reversing groundwater depletion

Uttar Pradesh has large potential to scale up UTFI. Around 75% of districts have high to very high suitability. Districts under the Ramganga sub-basin is targeted to upscale UTFI. Integration of UTFI model into existing or proposed government schemes can ensure the food and livelihood security of millions of farmers living in regions vulnerable to climate change

Key words: Aquifer recharge, UTFI and water smart agriculture

Carbon Stock Management under Agro-Silviculture System in North-East India

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Scientific community are creating opportunities and means to curb the menace of carbon concentration in the atmosphere. In every part of the world, there are special environmental behaviours to combat C concentration in its native way in relative to the environmental condition of the region. In North-East India, many native tree species have the capacity to obtain or reserve the carbon for longer period of time both above ground and below ground carbon stock. The region is enriched with diverse species of tree with their different capacity of carbon storage. Prominent species of Oak (*Quercus humboldtii)* shows different C storage capability with its different parts, the branches with diameters lower than 5 cm have the largest capacity of capturing C (40.3%) followed by wood contained in the trunk and in branches with diameters lower than 5 cm and the branches with diameters higher than 5 cm (38.75%) and fresh leaves and dead leaves show (35.95%) and (34.05%) of C retention, respectively. Pine tree species (*Pinus kesiya*) also act as a major reservoir of carbon which is anonymously distributed in the region. *P. kesiya* trees grow rapidly and strong natural regeneration ability over degraded ecosystem. The average carbon sequestration rate of *P. kesiya* is 12.7 Mg C ha^{-1} yr^{-1}. One of the most important vegetation which is also included in forestry is bamboo, which is known to be a largest reservoir of carbon due to its slow decomposition.. Bamboo is mostly prevalent in the region and its importance also depends on its abilities to sustain moisture in the soil. Intercropping of bamboo with turmeric and ginger is prominent in Meghalaya in turmeric and ginger growing belt. The average carbon storage and sequestration rate in woody bamboos range from 30-121 Mg ha^{-1} yr^{-1} and 6-13 Mg ha^{-1} yr^{-1}, respectively. Considering the above carbon storage benefit of diverse tree species in the region where *jhum* cultivation is in practice, intercropping with such species brings about replenishment of the degraded *jhum* land and can restore the original habitat of the ecosystem, thus enhancing carbon stock of the region.

***Key words*:** Carbon, agri-silviculture, North East India

Status of Soil Organic Carbon Recovery under Different Fallow Periods of Shifting Cultivated Sites in Central Eastern Ghats, India

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Shifting cultivation (SC) is the most primitive and subsistence farming system. It is being followed by many tribes inhabiting in the tropical and sub-tropical regions all over the world. Principally, it is a life supporting agriculture practice for the land less tribal communities. In India, it is prominently practiced in North-Eastern and Eastern Ghats regions. This irrational cultivation is still practicing in 1.45 lakh ha among the tribal villages of central Eastern Ghats. The major problems of SC are loss of forest cover and biodiversity, soil erosion and land degradation. Even though it has negative effects, the fallow period offers the opportunity for recovery of vegetation and soil fertility.With this background,a study was carried out to know the status SOC recovery during different fallow periods. We surveyed 5 and 2 plot clusters (locations) in the Eastern Ghats and North Eastern India, respectively, each plot cluster composed of one current SC site, seven different fallow periods sites (*i.e.* 5, 10, 20, 30, 40, 50 and >50 years) and three reference sites namely settled agriculture, forest and available plantation. Short term SC after clearing forest/ secondary forest resulted in sharp decline in the SOC stocks across the seven locations, creating a loss of 57 to 70% in Eastern Ghat and 39% in North East India. During the first year of SC at Lilliguma, 6.4 to 14.1 Mg C ha^{-1} was lost due to the SC depending upon the initial stock of SOC.During the first year of SC, considerable amount of SOC had been lost than the second and third years. The recovery of SOC showed a positive relationship with the fallow duration.In the initial years (up to 40 years) the build-up rate of SOC stock is at marginal and satisfactory quantity of SOC stock can be achieved only after 40 years of fallow period. During 50 year fallow periods, SOC stock reached 79, 86, 70, 72 and 60% of the forest values in Lilliguma, Sunki, Jeypore, Bonda hills and Balliguda, respectively. Whereas two sites in North East India recovery showed near to the forest values. Overall, SC sites in NE India recovered good quantity of SOC than the Eastern Ghats sites.Shorter shifting cycle (<10years) reduced the recovery potential of the land, resulting in a slow recovery of SOC. In steep slopes, the SOC recovery is very marginal even after 50 years of fallow period. In high sloppy lands, SC leads to degradation of land and replacement of multistore vegetation with pure crop of dominant tree species like *Shorea robusta*. It is concluded, that recovery of SOC stock showed a positive relationship with the fallow duration but the rate of recovery is varied with topographic and climatic factors and fallow duration. During recovery process, adjacent good forest contributing to higher SOC recovery of the SC sites. SOC stock recovery was significantly higher and faster in North East states than the Eastern Ghats clusters.

Key words: Soil organic carbon, Agroforestry, Tribal agriculture, Hill agriculture and fallow period

Strip Intercropping is a Way Forward for Adaptation to Climate Change

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Prevailing labour shortage and non availability of selective herbicides for intercropping (as most of the intercropping systems include both cereals and pulses) led to declined area under intercropping systems increasing the sole cropping in rainfed regions of India. Strip cropping although is considered to be the system for conserving soil and water, the variable time (crop durations) and space of different crops all along the season prompts/initiates the probability of raising an opportunity crop with extended monsoon or late rains besides the advantage of managing crop strips as sole crops. Therefore, to not only bring back the intercropping into practice but also to capitalize in on the late rainfall events received after the end of SW monsoon season in rainfed areas, strip intercropping was proposed.

An experiment was conducted for two years during 2016 -2018 on Hayathnagar Research Farm of ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad(14.41°N and 77.35° E and at an altitude of 334m). The experimental farm falls in the SAT region with mean annual precipitation of 760 mm spanning from June to September are monsoon months. Sorghum (S) (*Sorghum bicolor* (L.) Moench)) +Pigenopea (PP) (*Cajanus cajan* (L.) Millsp. intercropping combinations (4:4 and 2:1) were test systems tried (S+PP was sown during the first fortnight of June during both the years). Each strip of four rows of S (CSV 23) alternated with four rows strip of PP (PRG 176). Horsegram (HG) (CRHG-4) (*Macrotyloma uniflorum* (Lam.) Verdc) was the opportunity cropping as a sequence in place of harvested sorghum with late rains now the system called as S+PP-Sequence HG while 2:1 S+PP system was followed as control.

Rainwater use efficiency (RUE) calculated for the S+PP-Seq HG system was 10.11- 12.72 kg ha^{-1} mm^{-1} which was higher than S+PP (2:1) system (8.66 -9.57 kg ha^{-1} mm^{-1}) by improving the performance of all the three crops with the extra rain events. Besides accommodating opportunity cropping of horsegram as evident from the RUE, the yields of long duration intercrop pigeonpea also got boosted due to improved microclimatic conditions clearing the air space replacing carbon during extended monsoon season year especially in rainfed lands. However, during the drought year, no significant difference was observed between these two systems as they performed at par.

Key words: Strip Intercropping, rainfed lands, opportunity cropping, climate change, adaptation

Impact of Future Climate Variability and Potential Adaptation Strategies on Yield of Kharif Rice in Eastern India

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Food and energy security of India are crucially dependent on favorable weather and timely accessibility of adequate amount of water. Air temperature, CO_2 and precipitation are principle elements of weather systems. Therefore, to study the impact of future climate scenario these three weather elements must be assessed. Temperature and CO_2 are the two most important climate parameters that affect crop yield directly. Hence, in this study, the effect of these two parameters on the productivity of rice under the sub-humid and sub-tropical condition of Eastern India was evaluated using experimental data and the DSSAT CERES-Rice v4.5 model. Experimental outcomes of rice during monsoon season of 2013 with 4 sowing dates (30th June, 15th July, 30th July and 15th August) were used as the baseline scenarios. The future weather data for the periods 2020, 2050, and 2080 from the CSIRO-Mk3-6.0 model for RCP 4.5 and 8.5 were used to the CERES-Rice crop model to simulate the yield. The change in yield was compared with the baseline (1980–2013) yield of rice cultivar (IR-36) at Kharagpur, West Bengal, India. CO_2 concentrations used in the model, as projected by IPCC, were 390, 420, 530, and 650 ppm for the years 1980-2013 (baseline), 2020, 2050 and 2080, respectively. However, simulation were made using the model for percent change in mean temperature of 3.36°C for 2020, 7.59°C for 2050, and 10.4°C for 2080. The simulation results obtained from the CERES-Rice model showed rice yield was increased significantly to the baseline yield varying from 15.89 to 20.38% during 2020 to 2080 scenarios. While the decrease in total biomass yield under RCP 4.5 and 8.5 were highest during 2050. Rice yield would gradually increase (34 to 35%) with the increase in CO_2 concentration from 420 ppm to 530 ppm and 650 ppm. However, the total biomass yield would decrease by 37 to 39% with the elevation of CO_2 concentration against the baseline yield under different future changed scenarios during 2020, 2050 and 2080. Therefore, appropriate agronomic and input management options need to be adopted to reduce the adverse impact of climate change on growth and yield of rice.

Key words: Baseline, CERES-Rice v4.5, Climate change, CO_2 concentration, Representative concentration pathways

Sustaining Rice Production in Rainfed Lowland Areas of Eastern India Using Contrasting Rice Varieties under Climate Change

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Rainfed rice farming is the livelihood for a large population in eastern India. Their estimates of losses to drought can be as high as 45% annually. These are expected to get more pronounced in the context of changing climate, where the rains are getting concentrated to shorter duration and in less number of rainfall events. In these ecologies, soil moisture is highly unpredictable and droughts are common. The crop adaptation strategies in such areas include (a) harnessing yield potential for mild drought (where yield loss is less than 50%), (b) drought escape utilizing appropriate phenology, and, (c) drought tolerance traits of leaf water potential, sterility, flower delay and drought response index for more severe drought conditions. Drought incidences in successive years in eastern India vary in severity, so sustaining rice production needs cultivars that demonstrate a higher yield potential with adaptive phenology and tolerance levels. A Field experiment was carried out in two successive *kharif* seasons at Sabour, Bhagalpur. The soil of the experimental field was silty clay loam in texture and low in fertility status. The treatments comprised of five varieties of rice namely Shushk Samrat, Sahbhagi Dhan), Abhishek, CR-Dhan-40 and Rajendra Suhasini / Sabour Ardhjal were evaluated for their performance in a randomised block design with three replications. 25 day old seedlings of the these varieties were transplanted at a R-R spacing of 20 cm and a plant to plant spacing of 15 cm during the third week of July, in both the years. The performance of some rice varieties in rainfed conditions was evaluated in terms of root morphological characters using PVC pipe method for the minor root study. Usually, all drought tolerant varieties are of short duration (105-115 days) suitable for bunded uplands and rainfed drought prone shallow low lands in eastern India. They have a potential to reduce losses from intermittent drought while ensuring stable rice yield even in drought periods. Based on soil type and moisture availability, Sahbhagi Dhan can be transplanted or directly sown. Significantly higher grain yield was recorded with Rajendra Suhasini (42.4 q/ha) in comparison to CR Dhan-40 (39.8 q/ha). Significantly higher straw yield was recorded with Abhishek (60.3 q/ha), Rajendra Suhasini (55.7 q/ha) and Shushk Samrat (52.4 q/ha) over others. Studying the yield and yield contributing characteristics of various cultivars serves towards characterising the cultivars for their suitability for cultivation under rainfed conditions when there is an increasing risk of more frequent and severe droughts.

Key words: Drought, plant spacing, cultivars

Depth Function of Stored and Sequestered Organic Carbon in Cotton Growing Soils of South Gujarat

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Soil organic carbon (SOC) plays an important role in the carbon cycling of terrestrial ecosystems and variations in soil organic carbon stocks are very important for the ecosystem. The SOC stock gradually decreased down the profiles in both irrigated and rainfed conditions. However, extent of decrease was not uniform and was found to vary from profile to profile for any particular depth in both the condition and thus, SOC stock gradually decreased with depth in all profiles. The highest and the lowest mean SOC stock (t ha^{-1}) in 0-120 cm soil depth of irrigated profiles were 111.6 and 63.6, respectively. In rainfed condition, the concomitant values were 87.6 and 54.6, respectively. In general, SOC stock in irrigated soils was higher than that of rainfed soils. Mean SOC stock at 0-15, 15-30, 30-60, 60-90 and 90-120 soil depth of irrigated profiles (considering all profiles collectively) were 15.0, 12.6, 21.5, 19.3 and 15.3 t ha^{-1}, respectively. Up to 30, 60 and 120 cm soil depth from surface, the mean SOC stock of irrigated profiles were 27.6, 49.0 and 83.6 t ha^{-1}, respectively. In case of rainfed profiles, up to 30, 60 and 120 cm soil depth from surface, the mean SOC stock was 22.2, 41.4 and 69.7 t ha^{-1}, respectively. Further, the highest and the lowest SOC stock up to 30 cm soil depth for irrigated profiles 34.8 and 21.0, respectively and the same for rainfed soils were 30.4 and 14.9, respectively. The OC content (sequestered OC) differed slightly in different sized WSA at all depths of irrigated and rainfed soil profiles. WSA-OC content generally increased with decrease in WSA size. WSA-OC generally decreased with increase in depth of profile with irregular trend. Moreover, the OC associated with different sized WSA was markedly higher in surface layer as compared to sub surface layers. The SOC stored / sequestered (water stable aggregate associated organic carbon) in micro-WSA (< 0.25 mm) in irrigated profiles varied widely from 1.7 to 11.7 tha^{-1}, while the same in rainfed profile soils varied from 1.4 to 20.5 t ha^{-1}. However, mean of irrigated profiles with respect to carbon stock associated with micro-WSA < 0.25 mm was found slightly lower (5.7 tha^{-1}) than that of rainfed profiles (6.0 tha^{-1}). Thus, WSA < 0.25 mm size acts as storing/ sequestering C within it for long periods, as the carbon stored in small WSA sizes were less disturbed and thus was difficult to decompose and release which ultimately helped in the stabilization of soil carbon causing reduction in release of CO_2 to atmosphere and subsequently less effect on global warming.

Key words: Carbon, Cotton, Sequestered carbon, Depth function, South Gujarat

Agricultural Land-uses Affecting Sequestration of Carbon and its Distribution in Different Pools in the Soils of Semi-arid India (south-western Punjab)

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The investigation was aimed to assess the long-term influence of agricultural land-uses on sequestration of soil organic carbon (SOC), depth-wise distribution in different soil carbon pools and their contribution towards C loss through mineralization in the form of CO_2. Soil samples of semi-arid India (south-western Punjab) were collected from four depths (0-15, 15-30, 30-60 and 60-90 cm) around Dhanaula (30°18′N, 75°27′E); district Barnala, Bhucho (30°15′N, 75°03′E) and Phul (30°19′N, 75°14′E); district Bathinda, Punjab,under three land-uses *viz*., croplands (cotton-wheat), horticultural lands (Guava and Kinnow) and uncultivated lands. Sampleswere assessed for physico-chemical properties, SOC, SOC stock, KMnO4-oxidizable C (KOC), total particulate OC (TPOC), coarse POC (cPOC), fine POC (fPOC), mineral associated OC (Min-OC) and mineralized C (CO_2-C_{cum}). Orchards showed highest potential to sequester carbon imparting a trend of horticulture > croplands > uncultivated lands regarding SOC and most of its pools (KOC, fPOC, TPOC, CO_2-C_{cum}).Orchards showed highest SOC stock (74.89 Mg ha^{-1}) followed by croplands (53.87 Mg ha^{-1}) and uncultivated lands (43.72 Mg ha^{-1})upto a depth of 90 cm. Horticultural landsare related to greater addition of OC into the soil through leaf litter fall, rhizo-deposition as well as less removal and disturbance while lack of these along with continuous removal, soil turnover and disturbances under croplands and overgrazing and erosions under uncultivated lands lowered their C storing potential.A different trend of horticulture> uncultivated lands > croplands were observed regarding cPOC although differences between croplands and uncultivated lands were not significant. Greater TPOC was found under orchards, as the fruit trees imparts a positive impact on stable C build-up by improving soil aggregation and stability.Reduction in soil C and its pools along the profile was noted in all land-uses but was pronounced under croplands. The studied pools were positively correlated with highest magnitude observed in between POC and SOC (r=0.831, p=0.01). Least positive linear relation with C mineralization was exhibited by POC particularly under horticulture and highest was recorded in case of KOC, under cultivation. Larger TPOC contents under horticultural land-use which is less susceptible to mineralization loss imparts long-term stability of soil C thanthat of croplands.Faster C loss in croplands of soil C may be due to the presence of oxidation pronelablie KOC fraction in a comparatively greater extent. Therefore, inclusion of horticultural land-use could be considered as a positive strategy to maintain the future productivity as well as sustainability of the studied area where intensive cultivation is prevailed.

Key words: Land-uses, Soil organic carbon pools, SOC stock, C sequestration

Carbon Balance and Energy Balance Closure in Tropical Lowland Rice-Rice Ecosystem

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A field experiment was conducted during the year2017 to study the carbon balance, surface energy components and energy balance closure (EBC) in tropical low land rice-rice system using data from Eddy covariance (EC) system at Cuttack, Odisha, India. Various parameters were measured in two cropping seasons: dry(DS) and wet seasons (WS) and their respective fallows (Dry fallow, DF; wet fallow, WF). The rice paddy was cultivated in DS (January-May) and WS (July-November) in low wet lands and the ground was kept fallow during the remaining of the year. The Eddy covariance based CO_2 flux measurement was done continuously throughout the study period. The season-long integrated net ecosystem exchange of carbon dioxide (NEE) was -751.6 g C m^{-2}. Highest cumulative NEE was found in wet season (-416.87 g C m^{-2}). The carbon balance of the system was calculated by using difference between input and output of carbon in the system. It was observed that the potential of carbon balance in the system in dry and wet seasonsare 0.37and 1.13Mg C ha^{-1},respectively.

Among the different components of energy, the sensible heat flux, H varied in the range of -60 to + 65 W m^{-2} in both dry and wet seasons. The latent heat, LE was in the range of 0.03 to +194 W m^{-2}. Average sensible heat fluxes was highest in the period of fallow than cropping period but in case of average latent heat flux was highin cropping season than fallow period. Energy balance closure was measured by three ways: energy balance ratio (EBR), residual heat flux (RHF) and ordinary least squares (OLS) method. During the study period it was observed that 59-65% of the energy is balanced using energy balance ratio method. Residual heat flux (R) during all the seasons and fallows were>0, which indicated the surface energy supply was greater than the loss in tropical rice-rice ecology. Linear regression coefficients from the OLS relationship showed a very good coefficient of determination in the case of DS, DF (more than 70%) and less in WS and WF (d”60%). Energy imbalance mainly happened after the rainfall events.

From above studies it is concluded that (i) the rice-rice ecology is able to sink carbon (positive carbon balance), (ii) The daily average LE dominated over H due to the presence of standing water in the rice field and (iii) the energy balance closure, derived using three methods showed that it is not perfectly closed.

Key words: Carbon balance, Energy balance closure, Rice, Net ecosystem exchange of carbon dioxide, Residual heat flux

Soil and Water Conservation Techniques for Enhancing the Land and Water Productivity and Mitigating Climate Change Impact in Rainfed Regions

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The rainfed regions of India are characterized by aberrant behaviour of monsoon rainfall, eroded and degraded soils with water and nutrient deficiencies, poor water holding capacity, declining ground water table resulting low and unstable yields. Climate variability including extreme weather events resulting from global climate change is yet another threat to rainfed agriculture. The experiments were conducted under externally funded and institute projects on soil water conservation measures in rainfed regions of India for enhancing the land &water productivity. Based on the experiments, it was observed that conservation furrow system was produced maximum green water harvesting (up to 80%) and minimum runoff and soil loss.Under limited water supply situations in rabi season, among the various irrigation techniques; alternate furrow with surge flow irrigation is better option and this method saved the irrigation water upo 50%. The cost effective check dams and recharge filters are more effective and durable and reduce the cost considerably. Vegetative filters in crop fields and waterways ware reduced the sediment concentration of the runoff water significantly and thereby reducing the sedimentation of downstream water bodies. Bamboo plantation based interventions for reclamation of ravine lands significantly conserve the natural resources of ravine lands. Annual return from these lands varies from Rs.63910-Rs. 88,780/-, and benefit cost ratio varies from 1.96-2.09. A model watershed (Vejalpura-Rampura) in Kapadwanj Taluka, Kheda Ditrict, Gujarat was developed as "Site of Learning" under NWDPRA, Ministry of Agriculture funded project. The developed Vejalpura-rampura model watershed used as a "Model project" and "*Site of Learning*" for watershed development programmes for various stakeholders. All these technologies were disseminated to various stakeholders.

Key words: Rainfed regions, Climate change, Water harvesting techniques, Cost effective check dams, Vegetative filters, Bamboo based interventions

Conservation Tillage Potential for Reducing CO_2 Emission in Paddy and Increasing Soil Organic Carbon in Acidic Soil of Meghalaya

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The study of soil carbon dioxide fluxes is very critical as small changes in soil CO_2 can significantly alter its concentration and soil carbon sequestration process. Switching from conventional to conservation agriculture has the potential to reduce CO_2 emissions from soil and increased soil organic carbon (SOC). Tillage practices disrupt the soil carbon balance by exposing the organic matter present in soil to microbial decomposition leading to emission of CO_2 into atmosphere. Low tillage activity coverts soils from carbon sources to carbon sinks. The present investigation, therefore, was carried out to estimate the soil CO_2 fluxes and SOC content in paddy fields under conventional and conservation tillage and evaluates the potential of conservation tillage in reducing CO_2 emission and increasing the SOC content. Two paddy plots are selected for this experiment in at farmers' field in Ri-Bhoi district of Meghalaya and two different treatments of conventional and conservation tillage practices were followed. Climatic factors and soil physical properties were also evaluated. For collection of gases emitted from the paddy plots, two gas chambers of acrylic sheets are built and from this carbon dioxide fluxes were estimated. The results indicated a positive change in carbon sequestration and SOC in soil due to conservation tillage practice. The study illustrates the potential of conservation tillage practices in significantly improving the soil quality and reducing carbon dioxide emission from the soil. Conservation tillage requires minimum input and maintains soil health. It can be concluded that management practices can greatly influence the soil physical and chemical properties and alter the emission pattern of CO_2.

Key words: Tillage practices, CO_2 emission, soil organic carbon, paddy, acidic soil

Integrated Nutrient Management as a Stable Practice for Improving Crop Productivity and Sequestering Soil Organic Carbon in the Context of Rising Temperature Scenario

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The Permanent Manurial Trials (PMT)-(tall and dwarf) and the All India Co-ordinated Project on Long term fertilizer experiment (LTFE) have been laid out at Regional Agricultural Research Station, Pattambi with the main objective of studying the effect of continuous application of plant nutrients (NPK) in organic and inorganic forms and in combinations on sustainable production in the rice-rice cropping sequence. The PMT consists of 8 treatments. The LTFE consists of 12 treatments. In PMT, the organic nutrient management (T_1) wherein whole of the mineral N was applied as cattle manure and Integrated Nutrient Management (INM) practice (T_5) where 50 per cent N was substituted by cattle manure were equally superior in growth and productivity to other treatments. Treatment T_5 (45 kg N ha^{-1} as cattle manure + N:P_2O_5:K_2O 45:45:45 kg ha^{-1}) was found to be significantly superior with respect to the soil biological properties including dehydrogenase activity and microbial biomass carbon. The physiological properties of the plant like stomatal conductance and photosynthetic rate, yield attributes such as panicle length, number of panicles per plant and number of filled grains corroborated the trend in yield. In LTFE, the integrated nutrient package T_8 had significantly higher dehydrogenase activity and microbial biomass carbon in post harvest soil which was positively reflected on yield and yield attributes. Application of FYM had beneficial role over green manures towards organic carbon build up in soil.

In LTFE with 20 years history, it was seen that all the carbon pools (active, slow and passive) contributed towards yield whereas in PMT, with 44 years history, it was the slow pool of carbon that showed higher correlation with crop yield. Data on analysis of different carbon pools revealed that slow pool is the most predominant yield determining pool in the long run. Thus, the percentage contribution of different carbon pools towards total soil organic carbon in paddy soil of the present work can be rated as: passive (54%) > slow (36%) > active (10%). An incubation study was conducted at four different temperature regimes (15, 25, 35 and 45^{0}C) using the soil collected from the plots of LTFE as well as PMT. The values on activation energy and the rate constants provided a good insight on decomposability of organic matter and the pace of mineralization in soil. Thermal stability studies indicated that the rate of reaction decreases with increase in temperature indicating exhaustion of labile pools available for microbial decomposition. Q_{10} values were also lesser than 1 in both the experiments. Treatments with inorganics recorded lowest activation energies indicating the instability of even recalcitrant or passive pools. The study fortifies INM as a stable practice for sequestering soil organic carbon and crop productivity in the context of rising temperature scenario.

Keywords: INM, manures, inorganics, soil carbon, crop productivity

Development of a New Protocol to Estimate Phosphorus under Organic Production System for Adapting Climate Change

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Agricultural ecosystems have evolved under human management. Since Green Revolution, application of chemical fertilizers had increased for maintaining the food demand. Large amount of chemical fertilizer application ultimately degraded our agricultural sustainability. Shifting towards organic farming paved a way for sustainable agriculture andmitigate the climate change phenomenon through reducing the greenhouse gas emission. Lack of research regarding the contribution of nutrient pools, their importance and poor estimation method are mostly responsible for unscientific nutrient management in organic farming.On this backdrop, an investigation was done to find out soil testing method for the estimating potentially available P. For this, an experiment with four main sources of organic nutrient and their combinations under organically managed french bean was carried out. A conventional chemical fertilizer treated replicated plots were maintained as check. Soilssamples were collected at early stage, full growth, flowering and harvesting stages of French bean. Twoextractants including basic EDTA and 1% K_2CO_3 were used to estimate different organic P fractions and their dimensions remained in organic P pools that underwent mineralization. Whereas, 2% citric acid and 0.05M á keto-glutaric acid were used to assess organic acid solubilized P. Olsen extractantmethod was taken to compare between the testing methods. Results showed that basic EDTA extracted enormous amount of organic P but with a lower mineralization rate. On the other hand, higher mineralization of extractable organic P was achieved by 1% K_2CO_3. 2% citric acid and 0.05M á keto-glutaric acid extracted a sizable amount of solubilized P. Both basic EDTA and K_2CO_3extractant driven mineralized P or solubilized P had poor relationship with crop P uptake, pod and biomass yield. While combination of mineralized P and solubilized P derived by combination of extractants exhibited strong relationship with different crop parameters. In this context,1% K_2CO_3+ 2% citric acid strongly correlated with P uptake (0.736**), pod yield (0.736**) and dry matter yield (0.686*) of french bean. On the other hand. regression analysis showed that 1% K_2CO_3+ 2% citric acid derived potentially available P and established a strong relationship with P uptake (0.5778**) and DMY (0.5626*). Thus, this extractant may putatively be selected as a suitable extractant for potentially available P estimation under organic production systems. Method developed out of the investigation will be helpful for routine P estimation to cater the need of organic farmers and certifying agencies.

Key words: Sustainable agriculture, extractants, potentially mineralizable P

Soil Organic Carbon Variability in the Foothill Himalayas

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Organic carbon has been designated as the most reliable indicator of soil quality.However, there are wide variations in the soil organic carbon over short distances within among different land covers for obvious reasons as well as within similar land uses owing to management practices, topography, etc.GIS (Geographical information system) technique is now widely used to delineate variation in soil properties as well as their mapping for a more site specific approach. A study was, therefore, carried out to assess the spatial variability of soil organic carbon (SOC)on watershed basis in the Shivaliks of Jammu.Soil samples were collected from two different watersheds representing shivalik hills of Jammu. Shivaliks is a dry semi hilly belt deeply affected by soil erosion. The samples were air dried and processed. These samples were analysed in the laboratory using standard procedure. The data was subjected to geo-statistical analysis and semivariogram was constructed with the help of Surfer (demo software). Soil carbon maps were generated using interpolation technique with the help of ArcGIS. Preliminary studies revealed that topography, vegetation and management practices seem to be the major factors contributing to their variability.Soil organic maps provide clear picture of the distribution of soil organic carbon within the watersheds. Interesting variations with respect to SOC content were observed. Based on the limits for OC ie. low (<0.50%), medium (0.50-0.75%) and high (> 0.75%), the soils were in general low to medium in organic carbon content in the cultivated agricultural fields based on the initial values obtained. The forest areas of the watershed had relatively higher organic carbon often falling in the high range.

Key words: Soil mapping, Spatial variability, Organic carbon, Soil health, Watershed

Nitrogen Mineralization and Chemical Properties in Soil as Influenced by Rice Stubble Management

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A laboratory experiment was carried out to evaluate nitrogen mineralization and chemical properties in soil as influenced by rice stubble addition. Bulk surface (0-15 cm) soils (sandy clay loam with pH 4.6 and organic carbon 6.2 g/kg), collected from winter rice (*variety* - Ranjit) field after harvest of the crop, were processed and used to fill the PVC (polyvinyl chloride) pipes (diameter 9.0 cm) to a depth of 15 cm and incubated for 105 days imposing different treatments. Rice stubbles were treated in the field by spraying glyphosate (2.05 g a.i/l) and commercial yogurt (5 g/l) mixtures solution. Both treated and untreated stubbles were collected from the field, chopped into small pieces (1.5 to 2.0 cm long) and added to the columns with and without incorporation. A column was incubated without addition of the rice stubbles. The soil columns (over a layer of 10 cm sand) were kept in a tray filled with sand under constant saturation in a completely randomized design with four replications. The soil moisture content of the columns varied from 27.6 to 31.4% (w/w) and the maximum temperature varied from 21.3 to 29.3 ^{0}C during the experiment. The NO_3-N significantly increased up to 84 days of incubation with stubbles, irrespective of incorporation and glyphosate-yogurt treatment compared to without stubble. The NH_4-N content in soil significantly increased due to incorporation of glyphosate-yogurt treated rice stubble over all the treatments throughout the incubation period. The soil pH was affected only at 105 days after incubation, where it significantly decreased due to retention of treated stubble or incorporation of stubble compared to without stubble and retention of untreated stubble. However, the exchange acidity and total acidity in soils significantly increased after 63 days after incubation due to incorporation of treated or untreated stubble and retention of treated stubble. The cation exchange capacity, exchangeable cations, viz. NH_4^+, Ca^{2+}, Mg^{2+} significantly increased with incorporation of rice stubble, while the effect for K^+ was observed only with treated stubble incorporation. The available phosphorous (P) and potassium (K) significantly increased due to stubble incorporation, but available nitrogen was unaffected by the treatments. The most of the differences in the treatments were explained on the basis of substrate nature (treated or untreated), its management (incorporation or retention), change in ambient temperature and microbial activity and community dynamics in the soil.

Key words: Rice stubble, Mineralization, Soil properties

The Three Principle of Conservation Agriculture *vis a vis* Soil Organic Carbon: Evidence from Western Indo-Gangetic Plains of India

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Global research based evidences suggested that there are multiple benefits of higher soil organic carbon sequestration. To address the problem of crop residue burning and declining soil organic carbon content, the concept of conservation agriculture (CA) is being popularized. CA is based on three principles, *i.e.,* minimum soil disturbance, crop residue management and diversified crop rotation. We evaluated the impact of each CA principle towards C-sequestration, C-quality and mineralization at different temperature. Adoption of all the three principles of CA, results in more C-sequestration and subsequently higher C-mineralization with a lesser C-decay rate. The temperature sensitivity of soil organic carbon (SOC) mineralization (the Q_{10} value) was not altered by the principles of crop residue management. The principle of diversified cropping system had differential crop biomass production and in turn different SOC sequestration rates. The sequestered SOC under different cropping system had different liability too, related to crop residue quality. Practicing different cropping system for a medium term did not alter the Q_{10} value significantly. The principle of minimum soil disturbance, *i.e.,* adoption of CA-based permanent bed (PB) and zero tillage (ZT) considerably decreases the Q_{10} value for SOC mineralization in the sub surface soil layer (15-30 cm), whereas the surface sequestered SOC had similar temperature sensitiveness in all the tillage practices. Under the conventional tillage, there may be a threat of more loss of SOC at elevated temperature from sub surface soil layers. The carbon management index (CMI) was not altered by the diversified cropping system, whereas reduction of tillage and crop residue management increased the CMI. The nature of the carbon, *i.e.,* the C-lability was mostly influenced by the diversified crop rotation, although the minimum tillage and crop residue management had also altered the C-sequestration in various fractions. Thus each principle of conservation agriculture alters the C-sequestration and C-mineralization differently.

Key words: C-sequestration, C-mineralization, C-pools, Q_{10} value, carbon management index

Carbon Sequestration Potential of Six Major Nutrient Management Systems for Rice-Wheat in Indo-Gangetic Plain

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Carbon (C) sequestration in cultivated soils has been recognized as one of the strategies to counter increased levels of CO_2 in atmosphere and global warming. Being very energy intensive, the rice-wheat cropping systems have low buildup (and depletion) of soil organic C, which ultimately leads to low productivity. In this study, in a ten year old experiment, major organic management options for rice-wheat cropping systems were compared for their potential to sequester organic C in soil in form of different stable fractions. Effects of seven treatments namely no fertilizer (control, O), recommended inorganic fertilizers only (F), legumes (*Vigna radiata*) in rotation (LE), green manure (*Sesbania esculeata*)in rotation (GM), farmyard manure (FYM), wheat straw retention (WS) and paddy straw retention (PS) were studied. In the treatments with organic inputs, inorganic fertilizers doses were reduced to 4 55%, compared to fertilizer only treatments. Organic carbon (OC) and different fractions of organic C comprising very labile, labile, less labile and non-labile were determined by modified Walkley and Black's method. Management indices indicative of C sequestration (Lability Index, Carbon Management Index, Carbon Sequestration Potential) were calculated to interpret management effects. Plant assimilated C, and C input to soil were quantified by taking into account the *in-situ* and *ex-situ* organic matter contributions. Evidently, with increased C return to soil, the most significant contributions went to very labile carbon (C) fractions. C stocks showed decreasing trend with increase in depth and was found maximum in case of GM (1724.14 g m2) at 0-15 cm depth. Plant assimilated C, and C return to the soil were maximum in case of GM i.e. 20.8 ± 1.3 and 7 ± 0.3 t ha^{-1}, respectively. LE and GM management showed no responses to increased soil C inputs in different years, perhaps indicating nutrient richness shadowing the beneficial effects of soil C (beyond a certain level). *Sesbania* in cropping cycle (GM) and FYM indicate better managements for surface soil (0-15 cm). The fractionation of incorporated carbon (C) under an integrated nutrient management practice for the rice-wheat system was driven by both quantitative as well as qualitative differences in the C inputs to the soil. LE and GM managements had high biomass incorporation into the soil, yet these materials also had high N and narrow C:N ratio. RS and WS systems had lower C inputs as well as wider C:N ratio. Legume-based systems indicated higher benefits in terms of C sequestration. Legume-based management systems (GM, LE) are, therefore, the best management options for rice-wheat systems in Indo-Gangetic plain of India to enhance crops productivity and soil C sequestration.

Key words: Sequestration, carbon fractions, organic, rice, wheat, crop residue

Yield Capacity, Water use Efficiency, Root Development and Economics of Linseed by Varieties and Fertility under Rainfed Condition

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The field experiment was conducted at Soil Conservation and Water Management Farm of C.S. Azad Univ. of Agril. & Tech., Kanpur during 2013-14. The experiment was laid out in Randomized Block Design replicated thrice. The treatment comprises 15 combination viz., 5 varieties viz., V_1- Ruchi, V_2-Shubhra, V_3-Shekhar, V_4-Padmini and V_5-T-397 and 3 fertility levels viz., F_1- RDF (50+40-40 kg NPK/ha), F_2- 75% RDF (37.5+40+40 Kg NPK/ha + 25% through vermicompost) and F_3- 75 RDF (37.5 + 40+ 40 kg NPK/ha) + 25% through vermicompost + 30 kg sulphur. Soil of the experimental field was sandy loam in texture and slightly calcareous in reaction. The result revealed that amongst varieties Ruchi was found superior over other varieties in respect the growth and yield, yield attributes, seed yield, net return and B:C ratio. The fertility level of 75 RDF (37.5 + 40+ 40 kg NPK/ha) + 25% through vermicompost + 30 kg sulphur produced highest seed yield of 10.55 q/ha with net return of Rs. 10,204.00 under rainfed alluvial tract of Uttar Pradesh.

Key words: Fertility levels, yield, vermicompost, sulphur

Performance Evaluation of Biomass in Combustor for Turmeric Drying

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Drying is a major heat energy consuming operation in agro processing industries. The research deals with the performance and characteristics of a small scale biomass fuel through heat exchanger for turmeric drying. A biomass combustor has been used to convert agricultural residues in to thermal power. Then, the clean air is heated as a system product, through a steel heat exchanger. The average combustion zone, hot air and exhaust gas reduction temperature using maize cobs, sized wood and saw dust briquettes were varied between 435 to 785 ºC, 54 to 102 ºC, 85 to 175 °C and 570 to 778 °C, 61 to 109 °C, 122 to 211 °C and 459 to 803 ºC, 58 to 109 ºC, 100 to 179 °C at all the five levels of fuel consumption rate for (1,2,3,4 and 5 kg/h) and five levels of air flow rate (100,200,300,400 and 500 m^3/h) respectively. The maximum and minimum biomass combustor efficiency using maize cobs, sized wood and saw dust briquettes was found 59.10 to 9.58 and 69.89 to 9.55 and 64.38 to 8.54 per cent at all the five levels of fuel consumption rate and five levels of air flow rate respectively. Based on the maximum and minimum biomass combustor efficiency using maize cobs, 855 min and 968 min was observed in case of 500 m^3/h air flow rate, 1kg/h fuel consumption rate and 100 m^3/h air flow rate and 5 kg/h fuel consumption in the system respectively. In case of sized wood, the maximum and minimum biomass combustor efficiency, 870 min and 610 min was observed in case of 500 m^3/h air flow rate, 1kg/h fuel consumption rate and 100 m^3/h air flow rate and 5 kg/h fuel consumption in the system respectively. In case of saw dust briquettes, the maximum and minimum biomass combustor efficiency, 885 min and 920 min was observed in case of 500 m^3/h air flow rate, 1 kg/h fuel consumption rate and 100 m^3/h air flow rate and 5 kg/h fuel consumption in the system respectively.

Key words: Maize cobs, saw dust, biomass combustor efficiency

Effect of Biochar Application on Soil Carbon Dynamics and Crop Productivity in a Dry Tropical Cropland of South India

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Soils in the dry tropical croplands of south India are in herently low in soil carbon (C) stock, and it is necessary to increase soil C sequestration for mitigating climate change. Additionally, low soil C stock critically decrease the crop yield in south India. Biochar is generally considered to be a useful material that enhance the soil fertility and crop productivity, however, the effect of biochar application on soil C dynamics and crop productivity is still unclear in the dry tropical croplands such as south India. Thus, our objective was to evaluate the effect of biochar application on soil C dynamics and crop productivity for optimal management system in a cropland of south India. Field experiment was conducted in Tamil Nadu state (Inceptisols) from Sep. 2017 to Nov. 2018 (14 months), which include two times sorghum cultivation (each 4 months) with six treatment plots (control(C), biochar (B) (8.2 Mg C ha^{-1}), farmyard manure (FYM) (F) (1.1 Mg C ha^{-1}), chemical fertilizer (CF) (100 kg N; 40 kg P; 0 kg K ha^{-1}), biochar and FYM (B+F), and biochar and chemical fertilizer (B+CF)). We applied biochar onceat the beginning of the experiment to evaluate the effective duration of biochar in soil after application, and periodically measured the soil C stock (0-15 cm) in the biochar application plots, while, we applied FYM every year before crop cultivation. We periodically measured the CO_2 efflux rate (25 times totally) with continuous environmental data including soil moisture (0-15 cm), and estimated the total CO_2 flux as C output, based on the relationship between the CO_2 efflux rate and environmental data. We also measured the sorghum yield. We found that soil moisture in the B plot was significantly maintained higher than the C plot. We also found that the CO_2 efflux rate in the B+F plot was significantly lower than the F plot through the experimental period, and that cumulative CO_2 flux in the B+F plot (1.8 Mg C ha^{-1}14 month^{-1}) was also lower than the F plot (2.0 Mg C ha^{-1}14 month^{-1}). This might be because biochar application with FYM decrease the soil microbial activity, resulting in the lower FYM decomposition in the B+F plot. Additionally, biochar application clearly increased the soil C stock, and the increment amount was equivalent to the applied amount of biochar. On the other hand, biochar application did not clearly affect the crop yield in both cultivation years, while crop yield in the B+CF plot was significantly higher than the C plot only in the second year. This is possibly because rainfall in the second year was highduring the cultivation period (529 mm) compared to the first year (218 mm). These results suggest that better soil moisture condition caused by biocharmay improve the crop productivity only in the much rainfall and nutrient condition. Our results indicate that biochar application would effective for mitigating climate change due to soil C sequestration, though only biochar application did not improve the crop productivity.

Key words: Biochar, CO_2 flux, soil carbon stock, crop productivity

Assessment of Climate Change Impact on Crop Water Requirements in Narsinghpur in 2060 using CROPWAT Model

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One of the most problems in facing the effects of climate change on crops is identification of efficient and sustainable mitigation and adaptation options for selected crops in agriculture. At present, changes in cropping pattern and land-use and land cover pattern, over-exploitation of water resources and changes in irrigation methods, are modifying the hydrological cycle in river basins. Considering this, a study was carried out to assess the impact of climate change on crop water requirement in Narsighpur block of Narsinghpur district, Madhya Pradesh. For this study, daily meteorological data like maximum temperature, minimum temperature, wind speed, relative humidity sunshine hours and rainfall for the period 1980 to 2005 are used.Crop dataand cropping pattern data were also used for this study. Future climate data were predicted for the periods of 2040-2060, considering A1B and A2 scenario of the Inter-governmental Panel on Climate Change Special Report on Emissions Scenarios (IPCC SRES) using stochastic weather generator named Statistical Downscaling Model Decision centric (SDSM-DC 5.2) considering CGCM3 (Canadian Global Circulation Model 3) scenario file. CROPWAT 8.0 model was used to calculateReference evapotranspiration (ETo) and then crop water requirement (ETc) was determined. The Result shows the direct effect of climate change on Rabi crops. Increase in crop water requirement of Rabi crops (Wheat, Gram and Pea) in average month January to April in the period 2040-2060 is observed, as compared to base period 1980-2005 under A1B and A2 scenarios and slightly decrease in average month October to December in the period 2040-2060 as compared to base period 1980-2005. Future climate change will bring greater challenges, due to increase in agricultural water demand, to increase yield. Hence over all water resources should be increased by doing water conservation practices effectively. The conventional method should be refused, and modern practices should be adopt for better utilization of available water resources. The predicted future climatic condition will be greatly useful to improve the matter related on planning, decision making system etc.

Key words: Climate change, IPCC, Evapotranspiration, CROPWAT, SDSM-DC, Crop water requirement, Water resources, Decision making

Enhance the Achievement of National Food Security by Climate Smart Agriculture

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Agricultural sectors must become climate-smart to successfully tackle current food security and climate change challenges. Agriculture, including forestry and fisheries, is crucial for food security and rural incomes as well as other essential products, such as energy, fibre, feed and a range of ecosystem services. Climate-smart agriculture is a pathway towards development and food security built on three pillars: increasing productivity and incomes, enhancing resilience of livelihoods and ecosystems and reducing and removing greenhouse gas emissions from the atmosphere. Climate-smart agriculture contributes to a cross-cutting range of development goals. There are many opportunities for capturing synergies between the pillars of climate-smart agriculture, but also many situations where trade-offs are inevitable.

Working at the landscape level with an ecosystems approach, combining forestry, fisheries, crops and livestock systems is crucial for responding to the impacts of climate change and contributing to its mitigation. Inter-sectoral approaches and consistent policies across the agricultural, food security and climate change are necessary at all levels. Institutional and financial support is needed for farmers, fishers and forest dependant peoples to make the transition to climate-smart agriculture. Some effective climate-smart practices already exist and could be scaled-up, but this can only be done with serious investments in building the knowledge base and developing technology. Investments in climate-smart agriculture must link finance opportunities from public and private sectors and also integrate climate finance into sustainable development agendas.

Early action is needed to identify, pilot and scale-up best practices, strengthen institutional capacities, and build experiences that can help stakeholders make informed choices to make the transformation to climate-smart agriculture. Tools and knowledge on climate-smart agriculture must be further developed and shared. We must invest in education, capacity development and communication. Financial mechanisms that link climate finance to agriculture investment must be established.

Key words: Climate-smart agriculture, landscape, mitigation, capacity development and knowledge

Carbon Sequestration under Various Rice based Cropping Systems in Rainfed Rice Ecologies under Fertigation

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For decades, various practices have been known to affect soil carbon stocks. These include inappropriate tillage practices and cropping systems, among others. The researchers have, however, largely focused on sequestering carbon in soil by reducing tillage, crop residue management and adopting favorable cropping systems. Shifting from conventional to zero tillage leads to major changes in carbon stocks of soil. This carbon stock change directly results from the reduced emission of carbon dioxide. Carbondioxide is one of the important greenhouse gases which contributes to climate change. In rice based cropping systems, increasing the cropping intensity may also have a positive impact on carbon sequestration. Increasing the cropping intensity will also increase the crop residues but this will result in carbon sequestration only when this carbon is not lost to atmosphere as CO_2 by decomposition. More sequestration leads to less emission of carbon dioxide in the atmosphere. Results from simulated runs of Cool Farm Tool Model indicate that a shift from conventional to zero tillage regime maintained a positive carbon sequestration up to 20 years of conversion to zero tillage. Carbon sequestration was more in lower fertigation regimes followed by medium and then higher fertigation regimes. In case of cropping systems it followed the order rice-lentil >rice-chickpea >rice-durum wheat > rice-barley. Leguminous crops sequestered more carbon in comparison to cereal crops due to low C:N ratio.

Key words: Climate change; Global warming; Carbon sequestration; rainfed farming; crop intensification

Effort to Mitigate Climate Change through Legume Intercrops in Sisal Plantation for the Drier Plateau Region of Odisha

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Sisal (*Agave sisalana*), a xerophytic species, is an important fibre crop for western Odisha farmers. It is the most suitable cash crop option for the region especially in the climate change scenario characterized by lower amount of rainfall (only 882.7 mm from 46 rainy days during kharif 23-40 standard meteorological week of last 10 years, which was 20.7% lower than LTA) and unpredictable rainfall distribution pattern. But due to several reasons including lower profitability from such cropping, farmers are not interested to continue the sisal plantation. As the sisal crop is most suitable for the region in the climate change scenario today and the days to come, appropriate agronomic intervention is necessary to retain the farmers in growing sisal plantation with higher profitability. The recommended spacing of sisal in double row planting system (4 m + 1 m × 1 m) keeps a large amount of land area unutilized in between the rows during the initial three years growth period of sisal as harvesting of leaves are not recommended during this phase. Therefore, the inter-row space may be utilized by inter-cropping with annual kharif legumes in sisal plantation to get additional income. So, field experiment was conducted for 3 consecutive years to find suitable legume intercrops for sisal plantation in the plateau region of Odisha.The treatments were, T_1: sole sisal; T_2: sisal + cowpea (cv. Triguna); T_3: sisal + green gram (cv. Pant Mung 5); T_4: sisal + green gram (cv. Pant Mung 6); T_5: sisal+ black gram (cv. Sarada or WBU 108); T_6: sisal + pigeon pea (cv. B 20/105).The mean cowpea (green vegetable) productivity was 352 kg/ha when grown with sisal as intercrop. The yield of pulses was 81 kg for green gram (cv. PM6), 104 kg (cv. PM5), 94 kg for black gram and 154 kg for pigeon pea in the sisal intercropped situation. The sisal equivalent yield from the system was the highest in case of cowpea (546 kg), followed by green gram (475 kg) and pigeon pea (435 kg). From the field experiment conducted it may be inferred that the vacant space in between the double rowed sisal plantation could be successfully utilized for growing legume intercrops like cow pea, green gram,pigeon peaand black gram in the kharif season during the initial three years of sisal plantation. This new system of legume intercropping in sisal increased sisal equivalent yield, enhanced farmers' income, increased availability & affordability of protein rich legumes to the sisal farmers' family, decreased soil erosion by rain water during the monsoon season due to soil cover by dense foliage of legume intercrops, smothered unwanted weeds & thereby kept farm clean and also maintained soil health. The developed technology of legume intercropping with sisal during kharif season was extensively demonstrated among the tribal farmers, resulted more farmers attracted towards sisal plantation and thereby contributed in mitigating climate change for the drier plateau region of Odisha.

Key words: Sisal, intercropping, soil erosion, mitigating climate change

Evaluation of Mitigation Potential of Precision Nutrient Management through Mitigation Option Tool in Eastern India

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Asia accounts for over 90% of the world's production of rice and almost 90% of the world's rice land areas. India is the second largest rice-producing country, and much of the rice within India is produced and consumed in Eastern India. Eastern India has, however, lagged behind the rest of India in rice yields that is mainly due to several constrains such as drought, floods, salinity,low soil fertility, and insufficient or inefficient use of fertilizers. More effective use of fertilizer is recognized as an opportunity for increasing rice production in Eastern India. With change in fertilizer management, it is crucial to investigate the GHG emissions from rice fields to make rice production sustainable. Site specific nutrient management (SSNM) through rice crop manager (RCM) is developed by the International Rice Research Institute (IRRI) and customised by national partners for Eastern India to enhance the productivity of rice. RCM is a web-based decision support tool that was developed for crop management in addition to field-specific rates and timing of fertilizer application. Climate Change, Agriculture and Food Security mitigation option tool (CCAFS-MOT) is used to quantify GHG mitigation options for Eastern India.CCAFS-MOT differs from existing agricultural greenhouse gas emissions calculators. Rather than estimating emissions from a given farm or practice, it suggests mitigation options that are well suited to the production system, soils and climatic conditions of the farm. The suggestions are based on empirical models and data from over a dozen different research studies. This study evaluates the GHG mitigation potential of field specific nutrient management and compared to business as usual in rice production.Several studies found the ability of CCAFS-MOT to estimate emissions and explore mitigation options for maize, rice, potato and livestock systems that are feasible and achieavable at farm level. The results will not only provide estimation of GHG but will also offer mitigation options for each field. Eastern India as a major rice consumer will not only produce more but also emit GHG less to make the rice production sustainable.

Key words: Field specific nutrient management, rice crop manager, mitigation options

Seed Biopriming with PGPR for Climate-resilient Agriculture

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Promotion of climate-resilient agriculture in the present global scenario where there is a huge fluctuations in climatic and weather conditions have been observed along with the destruction of natural resilient systems, becomes all the more important especially for the agricultural productions as cropping and farming systems tend to be mostly affected by aberrant and extreme climate situations. Food security and ecological sustainability are already at risk. Such production management and agricultural techniques need to be adopted which can help the ecological resilience to be maintained and also supplement them side by side. Biopriming with PGPR is such an alternative which in combination with existing inorganic inputs can enhance the resistance and resilience of the cropping systems whichever is suitable. Bio-priming is a combination ofseed hydration and inoculation with beneficial microbial agent which allows the bacteria to acclimatize in theprevalent or changed climatic conditions. Biopriming using PGPR increases germination; quality and yield as these are known to produce different phytohormones, enzymes and various volatile organic compounds. This review is focused on the implications of PGPR used for biopriming and its functions so as to improve crop productivitywhile mitigating stress along with prospects of this technique.

Key words: Biopriming, Plant growth promoting rhizobacteria, Climate-resilient agriculture

Climate Smart Forestry for Green Environment

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Climate change is causing lot of problems to the human civilization during recent past. The concentration of CO_2has gone very high approximately 411 ppm during the year 2018which will touch the threshold limit of 450ppm in the coming years. If it happens then the earth may experience so many catastrophic effects such as cyclones, slides, floods, drought, loss in crop productivity both forest and agriculture, water crisis and so on. The whole world is worried about this and has united through concerted efforts in the form of Paris climate change agreement 2018 and formulated a rule book to be followed globally in place of Kyoto protocol for the arrest of greenhouse gas emission and sustainable development. Climate resilient smart forestry can be a powerful tool to mitigate the emission of greenhouse gaseswho are the culprit of global warming and climate change. This paper with through light on the methods which can be used effectively at the time of logging of the forests for reduction of the emission of CO_2 greenhouse gas. This will also give insight how climate smart forestry can be used in the place of conventional forestry based on a comparison between conventional forestry and climate smart forestry.

Key words: Climate change, Climate smart forestry, CO_2 emission, Sustainable development

Land and Water Management for the Climate-Smart Agriculture

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Land and water management is a key element of Climate-Smart Agriculture (CSA). More productive and more resilient agriculture requires a major shift in the way land and water are managed to ensure that these resources are used more efficiently. Sustainable Land and Water Management (SLM) includes a broad range of practices and methods including the restoration of peat lands and degraded lands. The SLM also increases the amount of carbon sequestered in the soil, enhancing the soils nutrients and its water retention capacity. Securing land tenure enables farmers to benefit from the value added on the land and to encourage them to adopt a long-term perspective. The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security, recently adopted by the Committee on World Food Security, play an important role. They promote secure tenure rights and equitable access to land, fisheries and forests as a means of eradicating hunger and poverty, supporting sustainable development and enhancing the environment. Other issues to be considered include cultural, environmental and political factors such as land rights. Secure land rights provide the enabling environment for the investment in sustainable land management including the restoration of peat lands and degraded lands and the management of grasslands, rangelands and forage crops and water and irrigation management - a key element of CSA.

Land cover and soil information including soil mapping are a critical input for predictive models related to environmental protection, climate change, biodiversity, land degradation and regional and national food security early warning systems, natural resources monitoring and management. FAO has been assisting countries in the Asia-Pacific region to develop an enriched high resolution/detailed land cover (LC) database and soil information systems which provide base information for natural resource use planning and management.

Key words: Resilient, Sustainable Land and Water Management, Food security, Degradation and planning

Bio-char Stability and Interactive Soil Carbon Priming: Implications for Carbon Sequestration and Climate Change Mitigation

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Bio-char application to soil is an important strategy to mitigate climate change, particularly where bio-char stability is high while interactive carbon (C) priming [for example, between bio-char, soil organic C (SOC) and labile organic matter (LOM)] retains new C and minimize native SOC loss, with implications for long-term C sequestration. There is, however, a poor understanding of interactive C priming, including shifts in microbial community structure and the persistence of bio-char C (BC) in a clay-rich soil amended with bio-char and LOM. Moreover, understanding the temperature sensitivity (Q_{10}) and interactive priming of organic matter with different stabilities in the clay-rich soil with aged bio-char is also required to enable better forecasting of bio-char C sequestration potential under a warming climate. Here, we conducted two separate incubation studies using one soil i.e., Vertisols (δ^{13}C–14‰). (1) Input of "fresh" woody bio-chars (450 or 550°C; δ^{13}C–36‰) at 2% (w/w), in combination with 0, 1, 2 or 4% (w/w) labile organic matter (LOM; sugarcane residue; δ^{13}C–13‰) and incubated at 20°C for two years. (2) Re-incubation of 4-year "aged" woody, leaf or poultry litter bio-chars (550°C; δ^{13}C –25 to –28‰; 0.82% w/w) at 10, 20, 30 and 40 °C for ~9 months, in combination with 4% (w/w) of LOM (fresh leaf litter; *Eucalyptus saligna*; (δ^{13}C –38‰), with the aim to quantify the temperature sensitivity and interactive priming of LOM-C, aged bio-char-C, or aged native SOC.The results showed that at the low LOM application rates (0 and 1%), there was a positive priming effect of BC on organic C in soil (i.e. native SOC+ LOM C), which shifted to being negative when the LOM input was increased to 2 or 4%. The negative priming of native SOC + LOM C mineralization by bio-char would have been facilitated by greater shifting in fungal communities, while enhancing BC mineralization. Positive priming of SOC mineralization was greater by LOM (*cf.* aged BC). The aged bio-chars resulted in negative priming of LOM-C mineralization, mainly at 10 °C, with no impact on the LOM Q_{10}.In conclusion, over the long term, the amount of LOM stabilized by BC was greater than that of positively primed BC mineralization by LOM, in particular at the large LOM input. Bio-char can persist in soil on a centennial scale and decreases the turnover of native SOC + LOM C over the long term, whereas LOM input can shift microbial communities, favouring LOM stabilization in the bio-char amended Vertisosl. However, climate warming may lower the C sequestration potential of bio-char, by reducing its capacity to slow the mineralization of LOM-C, while increasing the mineralization of aged bio-char-C and stable native SOC.To enable better forecasting of C sequestration potential of bio-char in agro-systems, future work is needed on the responses of organic C priming to changes in temperature via climate change under field conditions in different environments.

Key words: Temperature sensitivity, Labile organic matter, Bio-char carbon sequestration

Identification of Contingent Crops for Delayed Sowing under Changed Climate in Dryland Agriculture

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A field experiment was conducted during *kharif* 2018 on "Identification of contingent crops for delayed sowing under changed climate in dryland agriculture"at Dryland Agriculture Project Unit, All India Coordinated Research Project (AICRP) on Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. The experiment comprised of two factors laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Treatments consisted of two factors. *i.e.*, sowing windows and crops. Sowing window consists of August 2nd fortnight, September 1st fortnight and September 2nd fortnightand the crops were foxtail millet, finger millet, field bean, french bean and quiona. Date of sowing decides the availability of weather conditions mainly temperature, light and humidity to the plants which have great influence on expression of growth characteristics in plants. Delayed dates of sowing caused drop in growth parameters which may be due to unfavorable weather conditions to the plants as well as high temperature which might have caused in lower rate of photosynthesis and reduced accumulation of food materials. Among the contingent crops and delayed sowings in *kharif* season under dryland condition, french bean is the most efficient contingent crop suitable for delayed sowings during August 2nd fortnight, September 1st fortnight and September 2nd fortnight for obtaining higher vegetable yield (2394, 1822and 1150 kg ha^{-1}, respectively) and rain water use efficiency (14.08, 10.98 and 8.16 kg ha-mm^{-1}, respectively).French bean is the best contingent crop suitable to dryland condition to obtain higher finger millet equivalent yield (1789 kg ha^{-1}), net returns (Rs 33191 ha^{-1}) and B C ratio (2.62) compared to field bean, finger millet, foxtail millet and quinoa.

Key words: Sowing windows, dryland, french bean, net returns

Optimization of Elevated CO_2 Levels and Nutrient Management for Lowland Rice Ecosystem

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Experiments were conducted to assess the optimum CO_2 levels and nutrient management strategy for enhancing the rice yield and soil fertility status with rice (var.CO. 50) as test crop in open top chambers (OTC). The treatments comprised of three levels of CO_2 enrichment viz., Atmospheric CO_2 (C_0): 370 ppm (Control); OTC I (C_1): 550 ppm and OTC II (C_2): 750 ppm. Both the OTC chambers were connected to a control monitoring system and the each chamber has a regulator to adjust CO_2 flow. Rice crop was fertilized with four varying nutrient management techniques viz., inorganic (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1}), organic (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis), IPNS (Integrated Plant Nutrient System) (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}) and untreated control. Maximum grain and straw yields were recorded due to the application of Integrated Plant Nutrient System (150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}) in the CO_2 concentration of 750 ppm. Highest acid phosphatase activity was registered at the CO_2 concentration of 750 ppm followed by 550 ppm and 370 ppm. Acid phosphatase activity was the highest due to the application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. With increase in CO_2 concentration an increase in CO_2 emission and microbial biomass were observed. Application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) recorded higher microbial biomass C content followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. Application of inorganics alone and untreated control recorded lowest microbial biomass C content. With increase in CO_2 concentration, an increase in organic C content was observed. The labile soil C pools, namely microbial biomass C, readily mineralizable C, and potassium permanganate oxidizable C were increased under elevated CO_2 concentration than ambient $CO_{2.}$ Application of organics (1/3rd FYM+ 1/3rd Vermicompost + 1/3rd Neem cake on N equivalent basis) recorded higher organic carbon content followed by the application of 150:50:50 kg N, P, K ha^{-1} +25 kg $ZnSO_4$ ha^{-1} +FYM @ 12.5 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}. Application of inorganics alone and untreated control recorded lowest organic carbon content.

Key words: Elevated CO_2 level, Nutrient management, Rice, Soil enzyme, Microbial biomass, CO_2 emission

SESSION-IV

Land Use Planning and Management for Food and Livelihood Security

Two Decades Retrospect and Prospect of Water and Soil Conservation Plan for Production and Construction Projects in China

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In the aim of providing technical support for the "power delegation, fair supervision and efficient service" reform of production and construction projects in China,a systematic review is made on the past two decades of report compilation, examination and approval, and acceptance of soil and water conservation plan, as well as the enactment of related laws and regulations, standards and specifications. Problems, characteristics and development trend in different stages are also analyzed. Relevant data from river basin institutions,water administrative department of the government, and compilation agencies for soil and water conservation plan are collected by searching periodical database and the official website of the Water and Soil Conservation Monitoring Center of the MWR. Due to related policies, the soil and water conservation plan for production and construction projects has experienced early stage, stable development stage and the ongoing stage of "power delegation, fair supervision and efficient service". Despite that the editing techniques of soil and water conservation plan had been basically perfected, the acceptance process is still complicated due to the misalign between plan compilation and acceptance. Over the past two decades since the implementation of the soil and water conservation plan for production and construction projects, soil and water conservation plan have been compiled and implemented for more than 300,000 projects nationwide, preventing and controlling an area of water and soil loss over 150,000 km^2, reducing water and soil loss effectively. The "power delegation, fair supervision and efficient service" reform to the water and soil conservation work could improve work efficiency, and in the meantime enhance the responsibility awareness of construction organizations.

Key words: Production and construction projects, Water and soil conservation plan, Review and prospect, Power delegation, Fair supervision and Efficient service, Prevention and treatment of soil water loss

Effect of Land Use on Soil Organic Carbon and Soil Physical Characteristics in North-Western Tract of India

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The adoption of monoculture such as paddy –wheat over the last 4 to 5 decades in north-western tract of India (state of Punjab) played havoc in withdrawal of ground water and affected both soil physical and chemical characteristics. Such-monoculture proved to be dangerous from soil and water management point of view in the state of Punjab. The recent evidence states that if the ground water withdrawal continues at the present rate, the water resources from the ground level up to 300 m depth shall deplete in 20-25 years and those at 100 m depth will deplete in the period of 10 years especially in the overexploited blocks of the state of Punjab. In order to evaluate the effect of other land uses over paddy- wheatcropping system, for better management of water resources, creating better soil physical environment and maintaining better environment sustainabilitycomparable studies on all these land uses is pre-requisite. Keeping these points in view, the study was initiated in the central districts of Punjab i.e. Ludhiana with four land uses such as bare, paddy-wheat, grasses and pear. These land uses were evaluated with respect to their effect on soil physical characteristics *viz*., soil organic carbon (SOC), bulk density (BD), mean weight diameter (MWD), infiltration, saturated hydraulic conductivity (Ks) and drainage rate. Under the land use grasses, SOC content and MWD were highest. However, the same were lowest under the land use paddy-wheat. The BD was observed to be highest under land use paddy-wheat and minimum under the grasses both in surface and subsurface depths of the soil. The other physical characteristics such as infiltration and Ks were higher under land use grasses over the other land uses. The drainage rate was in the order of magnitude under a land use: Grasses>Pear>Bare>Paddy-wheat. The land use grasses shall prove to be better in terms of improvement of soil physical characteristics than that in other land uses over shallower depths and on short term perspectives. However, the land use pear on a longer term perspective prove to be better both in surface and subsurface depths of soil which can improve SOC stocks and physical characteristics in north- western tract of India (Punjab), India.

Key words: Bulk density, Cumulative infiltration, Drainage characteristics, Horticultural crops and Monoculture

Land-based Agricultural Water Pollution – A Study under Participatory Rural Appraisal Approach in Thirappane Cascade Tank System, Anuradhapura, Sri Lanka

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Land based water pollution due to agriculture has been suspected as themain cause for environmental problems faced in the dry zone of Sri Lanka, under emerging water safety and security concerns aggravated by climate change effects. Even though this problem has been widely discussed at many climate and Chronic Kidney Disease of unknown etiology (CKDu) related forums, positive efforts on providing solutions with scientific approach are limited. This studyis an effort towards controlling such pollution with changing farmers attitude onthe use of agrochemicals and their impact on soil and water quality. This practical research study focuses on the Thirappane tank cascade system (TCS) which has got hydrological characteristics traditionally inherited by Sri Lanka. This paper discussesthe assessment of baseline water and soil quality indices. Also farmers attitude towards present agricultural practices in the TCS measured throughparticipatory rural appraisal (PRA) techniques verified with transect walks. PRA with the transect walks identified thenon-functioning of some ecosystem components such as *Thaulla* (upper peripheral region of a tank) and *Kattakaduwa* (Salt trapping area of a tank) throughout the TCS. PRA recognized the present use of agro chemicals in the TCS and identifiedthe necessities to use less inorganic fertilizer and pesticide. Water quality survey identified the parameters which exceeded the FAO irrigation water quality standards and Sri Lankan Standard (SLS) drinking water quality standards. The project focused on Drinking Water Quality Index and Irrigation Water Quality Index based on the number of samples. In terms of irrigation water quality index, the project concludes that the water of all tanks at high flood level can be used for any crop and soil without any detrimental effects. However, water at *Meegassagama*, *Bulankulama*, *Vendarankulama*, and *Badugama* tanks werepoor to very poor quality being used as a source of drinking water. Interpolation of water quality data helps to identify the spatial risk areas where more attention is needed.Soil survey identified the soil health of the area including the nutritional deficiencies and metal accumulations in the TCS. The baseline data collected warrants the immediate interventions to improve the water, soil and food quality of the TCS.

Key words: Pollution, Rural appraisal, Water quality, Soil quality

Construction and Engineering Application of Salt Discharge Model for Clay Saline-Alkali Soil in Yellow River Delta

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A scope of saline-alkali soil in the Yellow River Delta is determined to study a salt discharge model which is constructed mainly with runoff, without middle flow and considering a little infiltration. For the clay saline-alkali soil without joints is poorly permeable there is not obvious middle flow in soil, that two times of saturated layer states are both adjoining a strong rainfall states the saline-alkali soil during the research period may satisfy the sufficient and necessary conditions to produce surface runoff, and the main flow mode is the slope flow without miscible flow above the saturated layer, this established salt discharge model will be a permanent engineering plan to solve the located saline-alkali soil. Eighty four clay saline-alkali soil samples covering surface layer to 1000 mm depth have been collected in 111 days to measure their salt contents. The salt content-conductivity relationship $Y=0.0274x$ of the clay saline-alkali soil is constructed by drying method on selected forty two soil samples. With the increase of depth, salt contents of soil samples decrease and stabilize at depth of 60 cm, which will give suggestion that the depth of drainage channels or other projects used in salt discharge from the clay saline-alkali soil should be beyond 60 cm. As the mean permeability coefficient K of each position in the saline-alkali soil is low and the salt content of the middle and lower points is not only low but also stable, which indicate there is not obvious infiltration and middle flow in soil, and salt contents of the clay saline-alkali soil in saturated states have decreased greatly after two times of surface runoffs, these may prove the effectiveness of the engineering method for salt discharge. By analysis of precipitation data, because precipitation is only 74.95 mm and is not concentrated within ninety four days between the second and third sample sampling, that is, lacking action of surface runoff, difference of the salt contents of the last two kinds of soil samples is not significant, which has shown that the runoff-based engineering salt discharge model is suitable for the treatment of the clay saline-alkali soils.

Key words: Yellow river delta, Salt discharge model, Clay saline-alkali soil, Surface runoff, Engineering application

Pigeonpea-based Intercropping Systems under Rainfed Ecosystem

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An experiment was conducted during *kharif* 2013-14 and 2014-15 at C. S. Azad University of Agriculture and Technology, Kanpur to find out the effect of cropping systems, organics and moisture conservation practices on growth, yield, moisture use efficiency and economics of crops. The soil of experimental field was sandy loam in texture having pH 7.9, 0.30% organic carbon, 0.027% total N, 170.5 kg ha^{-1} available N, 16.4 kg ha^{-1} available P_2O_5 and 180.1 kg ha^{-1} available K_2O. The treatments comprised of eight cropping systems i.e. (i) pigeonpea sole, 60 cm apart – regular sowing (ii) pigeonpea sole, 40/80 cm apart – paired sowing (iii) sesame sole, 30 cm apart (iv) blackgram sole, 30 cm apart (v) pigeonpea + sesame (1+1) – additive series (vi) pigeonpea + blackgram (1+1) – additive series (vii) pigeonpea + sesame (1+2) – paired sowing (viii) pigeonpea + blackgram (1+2) – paired sowing; two organics i.e. (i) FYM @ 20 t ha^{-1} (ii) FYM @ 20 t ha^{-1} + bio-fertilizer and two moisture conservation practices i.e. (i) conventional practice (one weeding and hoeing at 20DAS) (ii) ridging and furrowing after 3 weeks of sowing in between the crop rows were tested in Split plot design with 3 replications. Results obtained showed that the growth and yield of individual crop depressed in additive intercropping where depression was more in sesame than blackgram. The yields of pigeonpea, sesame and blackgram were highest in their sole stands. The yield of sole and intercropped sesame and blackgram in terms of pigeonpea equivalent seed yield showed significant variation, whereas pigeonpea + blackgram (1+2) paired sowing (40/80 cm apart) brought out significantly the highest production as compared to other cropping systems. Moreover, the land equivalent ratio, moisture use efficiency, gross return, net return and benefit : cost ratio were also found to be the highest, while the lowest derived from the sole sesame. Application of FYM @ 20 t ha^{-1} + bio-fertilizer brought out significantly higher vegetative growth, yield components and yield of crops as compared to FYM @ 20 t ha^{-1} alone. Ridging and furrowing in between the crop rows after 3 weeks of sowing resulted higher pigeonpea equivalent seed yield, land equivalent ratio, net return and benefit: cost ratio than one weeding and hoeing during both the years. The increase in seed yield due to ridging and furrowing treatment over conventional practice was 4.03 q ha^{-1} (18.75%).

Key words: Cropping systems, Moisture conservation practices, Additive series, Ridging and furrowing and Paired sowing

Phytoremediation Potential of Sunflower and Asparagus for Coal Mined Heavy Metal Polluted Soil of Jaintia Hills, Meghalaya

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Due to extensive coal mining, large areas of Jaintia Hills of Meghalaya had turned into degraded land, creating unfavourable condition for crop cultivation. Owing mostly to acidity-related fertility stress, average crop productivity in acid soil regions like Meghalaya is very low, coupled with increasing contents of heavy metals, productivity had further dropped. Phytoremediation is an aspect of bioremediation that uses plants for the treatment of polluted soils. Therefore, a pot culture experiment was conducted using heavy metal polluted from coal mined soil of Jaintia Hills in order to assess the phytoremediation effect of the two crops *viz.* sunflower and asparagus. From the pot culture experiment, it is observed that Sunflower was superior phytoremediating crop in comparison to Asparagus as it accumulated more heavy metals *viz.* Cr, Cd, Pb, Ni and Co as 51.83, 15.05, 10.40, 30.88, and 5.68 μg pot^{-1}, respectively while Asparagus accumulated 42.98, 14.30, 9.20, 21.43 and 4.06 μg pot^{-1}, respectively. The analysis of heavy metals *viz.* Cr, Cd, Pb, Ni and Co in the soil after harvesting of phytoremediating crops indicated significant reduction in the heavy metals content of both the soils phytoremediated by Sunflower (41.63, 9.32, 7.10, 20.02 and 0.79 mg kg^{-1}) and Asparagus (51.70, 11.25, 8.80, 30.30 and 2.44 mg kg^{-1}) compared with the heavy metals content of non-phytoremediated soil recorded as 95.05, 25.20, 17.07, 50.59 and 6.65 mg kg^{-1}. The soil phytoremediated by Sunflower recorded least heavy metals content indicating its superiority over Asparagus.

Key words: Heavy metal pollution, Coal mined soil, Jaintia Hills, Phytoremediation, Sunflower and Asparagus

Effect of Resources Conservation Techniques on Production Potential of Baby Corn

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Maize (*Zea mays* L.) is the most important crop in the world because of its high yield potential than other crops. Urbanization has brought a marked shift in the lifestyle, changing economic scenario and feeding habits towards milk products with resultant increase in the demand for livestock products. Baby corn consists of the corn ear harvested two or three days after silk emergence. However, the increasing demand of cereals and cash crops result in declined the area under fodder cultivation. Therefore, there is a tremendous pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. Conservation tillage practices, like zero tillage and raised beds combined with straw mulching, may offset the production costs and other constraints associated with land preparation. Nitrogen fertilization in baby corn has influenced fodder yield and quality by influencing leaf area index, leaf area duration and photosynthetic efficiency. Kipping in view of above points in mind a field experiment was conducted at ICAR-NDRI, Karnal during 2016-17 to 2017-18 on crop establishment methods and nitrogen management on dual purpose corn. The results revealed that significantly higher yield (baby corn and fodder yield) was recorded under RB and ZT as compared to CT. However, ZT and RB were on par with each other. Among the nitrogen levels increasing nitrogen levels up to 100% with azotobactor gave significant higher baby corn as well as fodder yield as compared to rest of treatments. Increasing levels of nitrogen increased fodder quality protein, and NDF content up to 125% N. The highest economic returns were obtained in zero tillage followed by RB and lowest in conventional tillage.

Key words: Azotobactor, Baby corn, Nitrogen management, Tillage

Resource Conservation, Productivity, Economics and Soil Fertility under Rain-Fed Pearl Millet Crop at Varying Slopes of Yamuna Ravine

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Soil, essentially a non-renewable resource, can be deteriorated due to possible high rate of degradation/soil erosion and extremely slow rate of regeneration processes. This can lead to qualitative decline in soil fertility/properties potent to adversely influence the agricultural productivity or bring certain unwanted land use changes. Therefore, to quantify the impact of runoff and soil loss on soil fertility, economics and sustainability and resilience of prevalent pearl millet cropping on sloping sides/beds of Yamuna ravine, a study was carried out during 2010-2016 on standard runoff plots (38.88 m^2) of 0.5, 1.0, 2.0 and 3.0% slope equipped multi-slot devisors and runoff collection tanks. Results showed that during crop period, average yearly total rainfall (529.8 mm, range 172.2-719.4 mm), average yearly rainy days (23 days, range 14-32 days) and average annual maximum daily rainfall (94.9 mm, range 26.0-133.8 mm) registered a wide variation which led to fluctuations in pearl millet productivity during different years except the years 2014 and 2015 when no runoff, soil loss and pearl millet grain yield was recorded at all the land slopes. Average runoff and soil loss increased 4.26 and 5.45 times with increase in slope from 0.5% (17.41 mm and 409.6 kg ha^{-1}) to 3.0% (74.1 mm and 2231.4 kg ha^{-1}), respectively. However, increase in slope resulted in decrease in the average grain and stover yield of pearl millet from 1684 and 4794 kg ha^{-1} at 0.5% to 1054 and 3305 kg ha^{-1} at 3.0% slope which corresponded to 37.11 and 31.06%, respectively. Increase in land slope also decreased the gross return, net return and benefit cost ratio from Rs 34135 ha^{-1}, Rs 22544 ha^{-1} and 2.96 at 0.5% slope to Rs 19784 ha^{-1}, Rs 10311 ha^{-1} and 1.89 at 3.0% slope, respectively. There was decrease in organic carbon (77.3, 127.8 and 115.4, 169.2%), available P (10.43, 20.14 and 10.08, 35.21%) and available K (2.77, 76.8 and 6.75, 99.76%) content in soil both at 0-15 and 15-30 cm layer at 2 and 3% land slopes, respectively. However, decline in available N (11.42%) was only noticed in 15-30 cm soil layer at 3% land slope. This establishes that pearl millet farming at increasing side/bed slopes of Yamuna ravines becomes gradually risky, less economical and unsustainable due to rise in pH (1.1 and 1.73%) and EC (25 and 15.79%) at 0-15 and 15-30 cm soil layer over and above different slopes, respectively.

Key words: Runoff Soil loss, soil fertility Yamuna ravines, Economics

Location Specific Traditional Practices *vis-a-vis* Soil and Water Conservation in North-Eastern Region of India

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The North Eastern Region (NER) represents three provinces (East Himalayas, Brahmaputra Valley, and North East Hills) and covers about 7.7% of the total geographic area of India. Around 56% of the cultivated area of the NER is under low altitude (valley or lowland), 33% under mid-altitude (flat upland), and the rest under high altitude (upland terrace). Traditionally, farmers in both upland terrace and valleys practice mono-cropping under rain-fed agriculture, where rice (*Oryza sativa*) is the major crop occupying more than 80% of the cultivated area followed by maize (*Zea mays*). Approximately, 84 per cent of the soils in the NER are acidic in reaction, having low available phosphorus and zinc whereas toxicity of iron and aluminum. Majority of the fields in the region are situated across the hilly slopes. The region contributes only 2.8 per cent to the total food grain production of the nation because based on ground realities of this complex, diverse and risk prone agro-ecology, farmers opted to retain traditional practices, especially soil and water conservation practices, with emphasis on stability, resilience, long term sustainability over the attainment of higher productivity. The major traditional practices are *Jhum Cultivation, Bun Cultivation*, *Apatani System, Zabo System, Bamboo Drip Irrigation System, etc.*

The *Jhum Cultivation* (slash and burn agriculture or shifting cultivation) is practiced on about 0.88 million ha area. Deforestation and biomass burning in *Jhum* aggravate soil erosion and ecosystem degradation. Annual soil erosion on steep slopes (44-53%) under shifting cultivation can be as much as 40.9 Mg/ha along with attendant losses (in kg/ha) of 702.9 of soil organic carbon (SOC), 63.5 of phosphorus (P) and 5.9 of potassium (K). Soil erosion, during the 1st and 2nd years on the abandoned land has been estimated at 147, 170, and 30 Mg/ha, respectively. Steep slopes, cultivated along the slope, with negligible nutrient replacement and high rainfall are among the major causes of land degradation in the NER. *Bun Cultivation*, a modification of shifting cultivation, is mostly followed in the Meghalaya plateau. Similarly, the *Apatani System*, a potential water harvesting system is practiced in *Apatani* plateau of Subansari district, Arunachal Pradesh, *Zabo System* in Nagaland, and *Bamboo Drip Irrigation System* in Meghalaya. The uniqueness of these practices is their suitability to the local conditions, their economic feasibility and easy implementation. However, indiscriminate use of intensive agriculture has adversely impacted soil and water conservation over the past decades and therefore integration of modern scientific knowledge and proven eco-friendly area specific techniques of conservation and utilization of natural resources is the best possible way.

Key words: North Eastern Region, Soil and water conservation, Location specific traditional practices, Modified systems

Paddy-based Strip Cropping for Sustainable Productivity on Uplands of Southern Odisha

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Conservation Agronomy is an important aspect of soil and water conservation for sustainable management of natural resources. Strip cropping is the raising of soil conserving and soil depleting crops in alternate strips running perpendicular to the slope of the land or to the direction of the prevailing winds for the purpose of reducing erosion. Rainfed paddy is grown on upland and medium lands in an area of 0.85 M ha in Odisha constituting 16% of rice area and contributes 10.8% of total rice production and productivity of 1000 kg/ha. Upland areas in Eastern ghat highland zone of odisha suffer from heavy soil loss. This high intensity rainfall area region (1550 mm, average) posses low productivity in uplands due to poor selection of crops and faulty management practices. Keeping the above points in consideration, a paddy based strip cropping experiment was carried out during the rainy seasons (July–October) of 2011-13 at the Research Farm of IISWC, Research Center–Koraput, Odisha. The climate of the study area is sub-tropical humid. The experiment consisted of 4 strip crop ratios of 6:4, 8:4, 10:4 and 12:4, with two checks of sole crop (paddy and Blackgram) in 3 replications on 2% and 4% slopes respectively in a randomized complete-block design with plots size of 18 m ×10 m. Results showed that maximum canopy (38%) was recorded in sole Black gram followed by Paddy: BG (6:4) strip cropping ratio on 2% slope and on 4% (32%), respectively. Inclusion of Black gram as intercropping in upland paddy significantly affected the paddy equivalent yield in comparison to sole paddy values. Strip cropping of paddy with Black gram in ratio 8:4 improved the equivalent yield by 42, 19.6 and 40% for the year 2011, 2012 and 2013, respectively. On average basis, this strip ratio recorded equivalent yield of 1928 kg ha^{-1}. Strip ratio 6:4 gave 28% less runoff and 115% less soil loss over sole paddy. Paddy: BG (8:4) ratio reported 19.05, 21.41 and 26.98% less runoff in comparison to sole paddy cultivation. For soil conservation the values obtained were 47, 44.6 and 70.5% in consecutive years of 2011, 2012 and 2013, respectively in 8:4 strip ratio. This can be attributed to spreading growth habit of erosion resisting Black gram. Among different strip cropping ratios paddy: Black gram 8:4 recorded maximum conservation efficiency of 47.5 (runoff) and 63.9 (soil loss). On the basis of energy calculations same ratio (8:4) gave maximum values of energy output *i.e.* 28300 MJ ha^{-1} as well as net energy 21400 MJ ha^{-1}. Maximum value of energy efficiency 409 was also recorded for Paddy: BG (8:4). Following 8:4 strip cropping system in uplands of the region it will help controlling soil erosion and stabilizing the fragile degraded ecology with sustained production.

Key words: Strip cropping, Black gram, Intercropping, Conservation efficiency

Study of Sustainable Coastal Zone Management Strategies for the Western Ghats of Karnataka, India

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The sustainable use and management of important tropical forest ecosystems cannot be done without understanding the direct and indirect impacts of the man. This research paper studies about the forest ecosystem degradation and also the resilience, recovery capacity of following impacts must be determined. The coastal land use and land cover features in the South West coast of Western Ghats are dynamically regulated due to marine and terrestrial processes and often controlling by natural and anthropogenic activities. The primary objective of this study is to estimate the decadal changes and their degradation of forest in near the coastal areas and study the changes of land use and land cover (LULC) features under Level I category of USGS-LULC Classification System using Landsat ETM+ and TM images using Maximum Likelihood Classifier (MLC) algorithm for the period 2000–2019. The classified LULC features are categorized as dense forest, moderate dense forest, agriculture, scrub forest, barren land, settlements and water bodies. The geo-database is prepared for LULC feature class with an attributes of name, location, area and spatial distribution, etc. The geodatabase of LULC features is used as primary source for sustainable land resource management in the coastal region. Climate parameters are also impacts on the sustainable management like rainfall, temperature, humidity, wind speed, runoff and so on. For this study area these data is using to meet our objectives for the research.

Key words: Coastal, land use, land cover, climate

Effect of Nitrogen, Phosphorus and Zinc on Nutrient Uptake, Yield and Quality of Ber (*Zizyphus mauritiana* Lamk.) cv. Umran

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Ber is an important fruit crop of arid region. It can be grown successfully on marginal lands with high economic returns. Ripe fruits are rich in vitamins, minerals and sugars. Generally, the manuring and fertilization aspect never drew much attention but it responds favourably and productivity be improved to a large extent if applied regularly. Soil and leaf analysis alone in combination provide satisfactory tone for the maintenance of proper nutrient status. However, leaf analysis are generally more useful to predict nutrient requirement in perennial fruit crops.

Experiment was conducted on 15 year old, healthy and uniform plants of ber cv. Umran at experimental orchard of SKNCA, Jobner under split plot design with four replications. The main plot treatments comprised of four levels of nitrogen + phosphorus as F_0 (control), F_1(250g+150g), F_2(500g+300g), F_3(750g+450g) per plant and sub plot treatment consisted of five levels of zinc like Zn_0 (0), Zn_1 (20g) Zn_2 (40g) zinc as soil application) and along with Zn_3 (0.5%) and Zn_4(1.0%) as foliar application. A recommended dose of 30kg FYM and 150gK plant^{-1} were also applied with nitrogen, phosphorus and zinc as basal application during the month of July (at active growth stage) and rest two levels of zinc were applied through foliar application during the months of September (Flower Bud Differentiation Stage) and November (Fruit Set Stage). The nitrogen, phosphorus and zinc were applied in the form of urea, SSP and zinc sulphate, respectively and recommended culture operations were followed in order to maintain the plants.

The nutrient combination of nitrogen + phosphorus (500gN+ 300g P_2O_5 plant^{-1}) along with foliar spray of 0.5% zinc sulphate being the efficient nutrient combination in order to leaf nutrient status, significantly higher yield (70.93 kg plant^{-1}) and quality of ber cv. Umran under semi- arid climate along with maximum B:C ratio (3.30:1).

Key words: Ber, zinc, semi- arid climate, yield

Effect of Integrated Nutrient Management on Quality of Pomegranate (*Punica granatum* l.) Cv. Ganesh

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A field experiment was conducted to find out the effect of integrated nutrient management in pomegranate crop during 2006 to 2007 under Marwar agro – climatic condition of Rajasthan. The results revealed that among the different treatments used in the present study, the application of Vermicompost @ 10 kg + 25 per cent recommended dose of NPK + 5kg *neem* cake+ *PSB* 20 per plant significantly increased the quality components of pomegranate. Further, this treatment also improved fruit quality in terms of TSS (14.91%), TSS: Acid ratio (41.62), ascorbic acid (14.39 mg/100 g pulp), total sugar (14.24%) and organoleptic score (8.51) as well as leaf and soil nutrient status as compared to recommended dose of NPK (500g : 200g: 500g). The leaf nitrogen (2.75%), phosphorus (0.47%) and potassium (1.76%) content at harvest was significantly increased by the application of Vermicompost @ 10 kg + 25 per cent recommended dose of NPK +5kg *neem* cake+ *PSB* 20 per plant. Similarly, same treatment recorded maximum net return and B: C ratio.

Key words: Vermicompost, Farm yard manure, Biofertilizer, Quality parameters, TSS

Analysis of the Effects of Soil and Water Conservation Measurements in Typical Urban Production and Construction Projects-taking Shenzhen City as an Example

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With the high quality development of economy and society and the acceleration of industrialization and urbanization, soil and water loss caused by urban production and construction projects has been received more and more attention. Exploring effective treatments to urban soil and water loss has become a new technical focus. In this paper, six types of urban production and construction projects in Shenzhen City were selected to investigate, including channel improvement projects, housing construction projects, slag disposal projects, road construction projects, pipeline construction projects and water source conservation projects. In each type of projects, the current situation of typical soil and water conservation measurements were investigated, and the effects of those measurements were analyzed. The results showed that the soil and water conservation measurements in production and construction projects were divided into three situations of basic implementation, partial implementation and non-implementation. The effect of soil and water conservation was good in the project field where the measures, such as temporary covers, blockings, drainage ditch and desilting basins, were carried out. Utilization of desilting basin, especially the combined utilization of multi step desilting basin and temporary drainage ditch, played good effect to prevent soil and water loss. In terms of construction management, it was found that the following special design of soil and water conservation program was not carried out in most projects, funds for soil and water conservation measurements were not fully implemented, and many construction organization designs were unreasonable, because of neglects of the natural conditions of Shenzhen City, such as hilly areas, more precipitation and dense population. Based on the above observations, it is suggested that management system of urban soil and water conservation should be further improved, design specifications and standards of urban soil and water conservation should be drawn up as soon as quickly, and the public awareness of soil and water conservation should be more strengthened. Relevant achievements will provide technical support for the supervision of urban soil and water conservation, and further promote the development of urban ecological civilization construction.

Key words: Urban soil and water conservation; Production and construction projects; Soil and water conservation measurements; Effects; Shenzhen City

Land Resource Inventory for Integrated Watershed Development in 11 Selected Sujala-III Districts in Karnataka, India

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Watershed Development in India and the world over is reckoned as the engine of growth in the sustainable development of rain fed dry lands and drought – prone areas. The State of Karnataka has the highest percentage of drought – prone areas after Rajasthan in the country and is the first state in India to create Watershed Development Department (WDD) in the year 2000. Till to date, a number of projects are implemented by the WDD and one such World Bank aided project presently being implemented as Sujala –III in 11 districts covering 12.65 lakh ha across 2531 micro-watersheds benefiting 9.6 lakh households in Karnataka is selected for the present study. The Land Resource Inventory (LRI) was conducted in all the micro-watersheds using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of satellite imagery were interpreted for physiography and the physiographic delineations were used as base for mapping soil and land resources. The soils were studied in several transects and also outside the transect areas and a soil map was prepared with phases of soil series as mapping units. The soil phase map shows the geographical distribution and extent, characteristics (morphological, physical and chemical), classification, behaviour and use potentials of the soils in the soils in the micro-watersheds.

The analysis and interpretation of LRI (spatial and non-spatial) database generated for all the micro-watersheds has revealed that most of the micro-watersheds suffer from major problems like shallow rooting depth, high gravel content, low available water capacity, moderate to severe erosion, alkalinity, and acidity in some red and lateritic micro-watersheds, low/deficient in major and micronutrients, loss of forest and vegetation cover, and an aberration of weather due to climate change. There are also some inherently potential areas that have deep soils, non gravelly, clayey or loamy soil, high available water capacity, slight erosion, high in available potassium, sufficient in manganese and copper. The maps showing the potential and problem areas for each of the micro-watershed are prepared and presented.

The entire spatial and non-spatial database generated through LRI were converted into digital form and then integrated in GIS and being housed in the Digital Library established in all the partner institutes that will be made available to various line departments on a real-time basis through Land Resources Portal. By interfacing LRI data with RS, GIS and GPS, different management scenarios were analysed to arrive at the best management alternatives (optimum land use plans showing the degree of suitability for major crops along with associated problems) that would be most appropriate and sustainable. This data handling system, its storage, retrieval, analysis, web-based DSS and display capability and easy accessibility will be a very valuable tool for the planners, administrators, researchers, extension workers and NGO's for making land use decisions and providing advice to the farmers on their land parcels/survey numbers on real-time basis. The Land Resource Inventory Cards (LRI-Cards) giving information on soil and land characteristics and also the fertility status for each of the land parcel/survey number along with farmer's name are being prepared and distributed to all the farmers in the micro-watersheds. The officers at the district and taluk level disseminate this scientific knowledge through pilot demonstration activities at watershed level with the help of RSK's and NGO's. The Self Help Groups, Common Interest Groups, Watershed Executive Committees and Farmer Producer Organizations are being promoted for ensuring community participation, transparency, accountability and better convergence.

Key words: Land Resource Inventory, Integrated Watershed Development, Digital Library, Land Resources Portal, LRI Card

Study on the Nature, Distribution and Management of Sodic Soils in Yadgir District of Northern Karnataka, India

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A study was conducted in the Yadgir taluk and district of Northern Karnataka under Sujala - III project to assess the nature, distribution and management of sodic soils at microwatershed /village level through Land Resource Inventory (LRI) by using Remote Sensing, GIS, Field Survey and Mapping Techniques. The Yadgir taluk has 247 microwatersheds and out of that, 176 microwatersheds are selected for the present study which covers a total area of 98,324 ha. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. The comprehensive study of the morphological and physico-chemical characteristics of soil profiles was carried out for each series and surface soil samples were analyzed for fertility status (major and micro nutrients) at 320 m grid interval. A total number of 46 soil series were identified and mapped. Of the 46 series, nine series namely, Anur (3.5%), Gowdagera (3%), Yadgir (2%), Thumakura (1.7%), Rachanahalli (1.2%) Sangawar (1.1%), Vankasambar (1%), Gudalgunta (0.1%) and Mylapura (0.1%) were categorized as sodic soils accounting for an area of 13578 ha (13.8%). The series which referred to as sodic shows elevated pH and ESP (%) values ranging from 9.25 to 10.80 and 16.10 to 40 respectively. Elevated values are mainly because of the predominance of carbonate and bicarbonates of sodium. Excess exchangeable sodium affects the soil physical and chemical properties, which results in consequent reduction in crop yields. The ground truth collected during LRI also revealed the prominent occurrence of salt crusts, poor crop growth, poor vegetation, scurb lands, low permeability and absence of natural drainage.

There is a strong need for reclamation and management of sodic soils to maintain the sustainability of agricultural lands through the selective use of suitable amendments, sub soiling, deep tillage, drainage treatments, phytoremediation, growing tolerant crop species, creating awareness among the peasants through the generation and distribution of soil health and LRI cards and other feasible and economic friendly techniques.

Such studies are useful for precise planning and management of sodic soils to prevent further conversion of potential lands into degraded waste lands and documentation of the study area as benchmark for further monitoring of the status of the sodic soils.

Key words: Land resource inventory, Soil series, Reclamation and management of sodic soils

Assessing Contribution of Land Use in Soil Erosion Vulnerability in Lesser Himalayan Region using Multi Criteria Decision Method

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Vulnerability assessment of sub-watersheds provides an understanding of degradation status and helps in planning conservation strategies and best management practices of watershed. Land and water interaction plays an important role in prioritization of watersheds. Thus, soil erosion vulnerability involves many components i.e. soil quality, morphological characteristics, land use and land cover and water quality. In this study, morphology, land cover and soil quality were considered as influencing factors and water quality as the indicating factor for soil erosion vulnerability. The study area of the Tons River in lesser Himalayas region consists of 21 sub-watersheds and morphometric parameters of each were determined byASTER DEM (30m) usingArcGIS 10.3. For determining soil and water quality, samples were collected for different seasons from the watershed to check impact of soil erosion especially in the rainy season on water quality. The water and soil samples wereanalyzed by standard procedures in laboratory for all three seasons. To assess soil erosion vulnerability, Multi Criteria Decision Making (MCDM) tool was used to assign compound value (Cp) to each sub-watershed. Taking morphological parameter, slope percent, land use and land cover and soil properties all sub-watershed were divided into four different categories i.e. Very High, High, Medium and Low based on their susceptibility towards soil erosion. To assess the role of land use in soil erosion vulnerability, the ranking with help of MCDM was performed twice, once taking all four criteria (soil quality, morphological characteristics, slope percent, land use and land cover) and second time without considering land use and land cover as a criteria.The sub-watershed (SWS 20) with lowest compound (8.82) value indicated highest degree of proneness to the soil erosion.Sub-watershed (SWS20) with lowest compound value (20) has only 2.4% of forest area, 2.3% of agriculture land with 1.4% barren and 0.18%forest area of the total watershed.The difference in soil erosion vulnerability status for each sub-watershed when performed twice with and without considering land use and land cover as a criteria indicated the role of land use while assessing soil erosion vulnerability of the watershed. The water quality was also assessed for each sub-watershed indicated the degraded quality of water in rainy season which coincided with the status of watershedanalyzed with MCDM. Also, water quality indicated that the least prone sub-watershed (SWS12) has better water quality than the one with the lowest rank (SWS20) which has high TSS (2.13g/l) and turbidity (1.08NTU). Sub-watershed with lowest rank (20) is the most vulnerable therefore, in need of management and conservation practices. This study implies the importance of land use consideration in assessment of watershed soil erosion vulnerability. Also, it suggeststhat considering influencing and indicating factors to assess the proneness of watershed with help of MCDM provides a better approach to study processes in a watershed.

Key words: Soil erosion vulnerability assessment, Land use, Water quality, Soil quality, Multi Criteria Decision Method

Soil Chemical Properties in Irrigated and Rainfed Cotton Growing Belt of South Gujarat

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Soils of cotton growing areas of South Gujarat spreading over Bharuch, Surat, Jhagadia, Jambusar, Amod, Vagra, Narmada, Tilakwada, Dediapada, Sagbara and Hansot talukas, was taken into consideration under the present research study. The variation of soil pH, EC, ESP, SOC and SIC with depth of irrigated pedons were respectively from 7.81 to 8.14 (neutral to very strongly alkaline), 0.62 to 9.40 dSm^{-1} (low to high salinity), 1.3 to 19.7, 2.40 to 8.85 g kg^{-1} (low to medium) and 0.78 to 12.60 g kg^{-1} (low to very high), while the corresponding values in rainfed pedons were 7.85 to 8.54 (mildly to strongly alkaline), 0.27 to 2.95 dSm^{-1} (normal to saline), 3.1 to 16.6, 2.10 to 7.20 g kg^{-1} (low to medium) and 1.02 to 22.22 g kg^{-1} (low to very high), respectively. Available N, P_2O_5, S and DTPA-Fe, Mn, Zn and Cu in irrigated pedons, varied respectively from 111.4 to 303.2 kg ha^{-1} (low to medium), 17.1 to 63.3 kg ha^{-1} (low to high), 6.5 to 20.1 ppm (low to marginally high), 2.47 to 10.42 mg kg^{-1} (low to high), 4.02 to 16.88 mg kg^{-1} (low to high), 0.06 to 0.51 mg kg^{-1} (low to medium) and 0.48 to 4.02 mg kg^{-1} (medium to high), while the corresponding values of rainfed pedons were 94.7 to 299.8 kg ha^{-1} (low), 10.8 to 57.1 kg ha^{-1} (low to marginally high), 6.2 to 18.7 ppm (low to medium), 1.63 to 10.27 mg kg^{-1} (low to high), 3.09 to 14.90 mg kg^{-1} (low to high), 0.08 to 0.48 mg kg^{-1} (low) and 0.40 to 4.34 mg kg^{-1} (medium to high), respectively. Means of above available nutrients were found slightly higher under irrigated sitautions as compared to those of rainfed situation. The overall results suggested that rainfed situation and surrounding areas need SOC content improvement through addition of various organic matters in order to improve drainage, reduce BD, decrease ESP, increase available N, S and Zn status (particularly in low status area as above) to fullfil crop requirement, minimize the adverse effect of SIC, enhance crop productivity index, and thereby sustain overall soil health and ultimately possible increase in cotton yield which inturn, also would minimize the release of CO_2 in air leading to less effect on global warming.

Key words: Carbon, Cotton, sequestered carbon, South Gujarat

Soil Test and Target Yield Based Integrated Nutrient Management on Jute Fibre Yield, Agronomic Efficiency and Soil Properties in Gangetic Alluvium Soil of West Bengal

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An experiment was undertaken at experimental firm of ICAR-Central Research Institute for Jute and Allied Fibre,Barrackpore, West Bengal, India to study the effect of soil test and target yield (ST-TY) based integrated nutrient management on jute fibre yield, agronomic efficiency and soil properties. The experiment was initiated in 2010-11. The treatments considered were T1-control, T2 – ST-TY (4 tha^{-1}), T3- ST-TY (3.5 tha^{-1}), T4- T3+FYM (5tha^{-1}), T5- T3 + Azotobacter+Phosphorussolubilizing Bacteria (PSB), T6- T4+ Azotobacter+PSB, T7- FYM (5 tha^{-1}), T8- T7+ Azotobacter+ PSB, T9- Recommended dose of fertilizer (RDF) and T10-Farmers' practice (FP). Jute (JRO 8432) was used as test crop. Inorganic fertilizer was used on the basis of soil test and target yield based fertilizer prescription equation. After 8 years of experiment, application of fertilizers as per ST-TY could achieve the target of jute fibre yield (4tha^{-1}) with (-)7.25% yield deviation whereas integration of ST-TY (3.5 tha^{-1}) with FYM and biofertilizers (Azotobacter + Phosphorus Solubilizing Bacteria) achieved the target yield of jute fibre with (-) 3.75% yield deviation. The agronomic efficiency of P and K increased over recommended dose of fertilizers (RDF) and farmers' practice (FP) with the combined application of fertilizers as per ST-TY, FYM and biofertilizers. Maximum N, P and K uptake was recorded in T2-ST-TY (4tha^{-1}) treatment followed by T6- ST-TY (3.5 tha^{-1}) + Azotobacter+PSB+FYM. Application of inorganic fertilizer as per ST-TY in presence and absence of organic manure, improved the soil fertility status. The available N after jute harvest was recorded maximum with T4- ST-TY (3.5 tha^{-1}) +FYM followed by T2-ST-TY (4.0 tha^{-1}) but maximum available P and K was recorded with T2 followed by T6- ST-TY (3.5 tha^{-1}) + Azotobacter +PSB+FYM. Enzymatic activity was also improved in ST-TY based integrated nutrient management approach.

***Key words**:* Soil test, Target yield, Integrated, Biofertilizer, Agronomic efficiency

Studies on Agricultural Soil of District Saharanpur, Uttar Pradesh

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A reconnaissance study was carried out Soil Testing Lab Krishi Vigyan Kendra Saharanpur U.P. for the Innovation of Soil status of district Saharanpur U.P. against Availability of Organic matter. pH range and Micronutrients particularly Cu, Zn, Fe and Mn. Total 22 Soil sample were collected From different Blocks covering whole district and analysed for DTPA extractable Micronutrients and evaluated their status in agricultural soil. The result revealed that ph range is going up to neutral soil it range found 7.42-8.53 and Organic matter is decreasing and it became average 0.27-0.56 mean value 0.415% and Micronutrients available Zn,Cu,Fe, and Mn ranged ppm with the mean value). 86,0.64, (.53 and 6.62ppm respectively and require their judicious application while available Cu, Fe and Mn were found adequate in the soil. due to low Organic matter the water holding capacity of soil decreasing resulting number of irrigation increasing so that the cost of cultivation also increased.it is recommended that Farm Yard Manure, Green manure or Organic manure are needed for sustainable agriculture in Future. if pH is more than 8.30 than reclamation is needed through gypsum or any other amendment.

Key words: Organic C, micronutrients, water holding capacity

Pea (*Pisum Sativum* L.) Performance with Residual Phosphorus in Coal Mined Heavy Metal Polluted Soil of Jaintia hills, Meghalaya

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Due to extensive coal mining, large areas of Jaintia Hills district of Meghalaya had turned into heavy metal polluted land, creating unfavourable condition for plant growth. Owing mostly to existing acidity related phosphorus (P) stress, average crop productivity in acid soil regions like Meghalaya is very low, that further dropped coupled with heavy metal pollution in these soils as phosphorus and heavy metals interact in soil resulting in the formation of insoluble metal phosphates which adversely affect the absorption, translocation and assimilation of P by plants. Therefore, a pot culture experiment was conducted taking maize as a phytoremediating crop superimposing eleven P levels *viz.*, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 mg P kg^{-1} soil in heavy metal polluted soil collected from Jaintia hills district, Meghalaya to phytoremediate the polluted soil. As in acid soils, the residual effects of P fertilizer can persist for as long as 5-10 years (or more), depending on the initial P fertilizer rate applied, crop removal and soil buffering capacity, an another pot culture experiment was carried out during *rabi* 2017-18 at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam utilizing the phytoremediated soil by maize (*Zea mays*) to assess the performance of pea (*Pisum sativum* L.) cv. Arkel with residual phosphorus under Completely Randomized Design (CRD) and replicated thrice. The residual P levels corresponding to the above imposed doses are 1.4, 2.13, 3.08, 4.41, 6.26, 8.71, 11.73, 15.48, 19.98, 25.63, 32.37 mg kg^{-1} soil, respectively. The experimental results revealed that plant height, number of pods plant^{-1} and number of seeds pod^{-1} of pea is markedly increased with the increasing levels of residual P up to the highest level of residual P. The lowest plant height (25.50 cm), number of pods plant^{-1} (3.03) and number of seeds pod^{-1} (2.9) was observed under lowest residual P (1.4 mg P kg^{-1}) which significantly improved by 39, 76 and 56%, respectively in the highest residual P (32.37 mg P kg$^{-1)}$. Similarly, the seed and straw yield of pea significantly and markedly increased with the increasing level of residual P. The highest seed (16.8 g) and straw yield (44.24 g) was observed under highest residual P, which were 11 and 10 fold more in comparison to that received with lowest residual P. It may be concluded from the present investigation that the increasing residual soil available P maintained by higher P application rate under first pot culture experiment may be utilized and almost normal yield of pea cv. Arkel can be achieved with the highest residual P (32.37 mg P kg^{-1} soil).

Key words: Heavy metal polluted soil, coal mining area, Jaintia hills, residual P, pea, growth and yield

Inventorization of Land Resources in South Telangana Plateau (Rayalseema) and Eastern Ghat, Hot, Dry Semi-arid Eco-sub Region, India

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Systemic study of soil as natural resource provides information on nature and type of soil, their constraints, potentials, capabilities and their suitability for various uses. Land resource inventory on 1:10,000 scales is the prerequisite for developing site specific information, which paves the way for applying right land use, right technology at the right place. Study has been conducted to inventorize land resources in Rayachoty mandal (total geographical area of 23,246.85 ha, covering 17 villages) of agro-ecological subregion South Telangana Plateau and Eastern Ghat, hot, dry semi-arid eco-sub region, India. Geology is granite gneiss. Major land use is paddy, redgram, cowpea, groundnut, sunflower, mango, sesamum, mulberry, coconut. Natural vegetation is Prosopis Juliflora, Pongamia, Neem, Palmyrah and Tamarind. 14 land form units delineated. 102 soil profiles studied, 10 representative soil profiles and 89 fertility samples analysed for physicochemical properties. Soils are moderately shallow to deep, well drained to somewhat poorly drained. surface colour is reddish brown, brown and dark gray whereas subsurface is dark reddish brown, reddish brown, grayish brown, brown, dark reddish brown, light yellowish brown, dark yellowish brown, dark brown, dark red, red, gray and dark gray. Textures are loamy sand, sandy loam and sandy clay loam surface to sandy clay, sandy loam, sandy clay loam and loamy sand subsurface, are non-gravelly to gravelly. Plant available water content ranged from 2.73 to 14.41 percent in surface and 5.18 to 14.02 percent in sub soils. Percent calcium carbonate equivalent ranged 0 to 5.64 in surface and 0 to 13.39 in sub soils. Clay percent ranged 5.77 to 81.57 in surface and 5.23 to 69.52 in sub soils. The cation exchange capacity ranged 0.28 to 15.60 cmol (+) kg^{-1} in the surface soil and 4.10 to 18.30 cmol (+) kg^{-1} in subsoil. Base saturation is 2.41 to >100 percent in surface to 5.15 to >100 percent in sub soils. Fertility status of soils shows that, soils are strongly acidic to strongly alkaline. Organic matter is low to high. Available P, K and S are low. DTPA extractable Fe, Mn and Cu are sufficient. DTPA extractable Zn is deficient. Hot water extractable boron is low. Based on the morphological, physical and chemical characteristics, soils were classified as *Lithic Rhodustalfs, Lithic Ustipsamments, Rhodic Paleustalfs, Typic Haplustalfs, Typic Haplustepts, Typic Rhodustalfs and Typic Ustorthents.* Soils were mapped in to 10 soil series and 54 mapping units in the GIS environment. The land resource inventory information generated can help the researchers, farmers and planners to take up best land management practices and also for developmental planning.

Key words: Inventorization, land resources, Rayachoty mandal, South Telangana Plateau

Vertical Distribution of Available and Total Micronutrients and their Relationship with Soil Properties in Different Land Management Units of Kanginhal Sub-watershed in Northern Dry Zone of Karnataka

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A study on vertical distribution of available and total micronutrients (B, Fe, Mn, Zn and Cu) in different land management units (LMUs) of Kanginhal sub-watershed of Gadag district in Northern dry zone of Karnataka was undertaken during 2017-18. Available and total boron did not follow any definite trend in their distribution in almost all the LMUs and were positively and significantly correlated with clay and negatively and significantly correlated with sand. Available boron positively and significantly correlated with organic carbon, whereas total boron showed positive correlation with organic carbon. Available cationic micronutrients (Fe, Mn, Zn and Cu) decreased with depth and were positively and significantly correlated with OC and clay and negatively correlated with pH and $CaCO_3$. Total Fe, Zn and Cu contents decreased with depth and showed significant positive correlation with OC and positive correlation with clay. However, total Mn did not follow any regular trend with depth and was significantly and positively correlated with clay. Among the six LMUs, the highest available boron recorded in Ap horizon of LMU-6 and lowest in Ap horizon of LMU-1. The available Fe, Mn, Zn and Cu contents were maximum in Ap horizon of LMU-5 and minimum in Ap horizon of LMU-1.

Key words: Land management units (LMUs), sub-watershed, available and total micronutrients

Fractal Characteristics of Soil Particle Composition in Different Parent Material Types

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To explore the influence of parent material types on the heterogeneity of soil particle size distribution and soil structure, laser particle size analysis method and fractal theory were used to study the grain composition and fractal characteristics of soil developed by alluvium, granite residues, quaternary clay and neritic deposit, and the influence of soil physical and chemical properties on particle composition and fractal parameters. The results showed that: 1) the soils developed by granite residues and neritic deposit have large range of particle size distribution, high content of big particle and small non-uniformity. The particles of soil developed by alluvium and quaternary clay concentrate on the fine grain area ranging from 2 to 200 microns, and have big heterogeneity. 2) the D value reflect that the influence of parent material type on the heterogeneity of grain composition in different layers was different: the heterogeneity of particle size distribution of soil developed by alluvium and granite residues diminishes from A to C layer; for the soil developed by neritic deposit, the heterogeneity of particle size distribution enhances from A to C layer; and for the soil developed by quaternary clay, the heterogeneity of particle size distribution resembles in three layers. According to the results reflected by D_0, the type of parent material has little influence on the distribution range of particles in different layers. 3) the contents of pH, CEC, free oxide, vermiculite and kaolinite in soil of different parent material types are consistent with the zonal differences in the heterogeneity and distribution range of soil particle size distribution ($p < 0.05$).The above results show that the parent material type has a significant effect on soil particle size distribution and fractal characteristics.

Key words: Types of parent material, Soil particle size, Multi-fractals, Laser particle size analysis, Zonal differences

Studies on Soil Organic Carbon as Affected by Different Land Uses in Eritrea

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The study was conducted at Adi-jin, Dekigebru, Habrengkaand and Hamelmalo in Eritrea, Africa, to investigate the effect of different land uses (LU) on soil organic carbon (SOC). Stratified random sampling method was used to collect soil samples from three land uses (natural forest, cultivated and grazing lands). Soil samples were collected from two depths (0-20 cm and 20 -50 cm) using soil probe from all land uses and composite samples were prepared for analysis; separate samples were taken with core sampler from 0-20 cm soil depth for bulk density determination. The samples were analyzed for bulk density, organic matter (OM), and SOC. Irrespective of the sites and depth, OM, SOC (%) and SOC stock were in the order of forest> cultivated> grazing LUs. Within the natural forest LU, SOC percentage increased with increase in elevation, however in the remaining LUs the change in SOC percentage did not show any specific trend. Conversion of natural forest into grazing and cultivation caused 43.24% and 37.84% SOC loss, respectively. OM and SOC were significantly different among the LU. SOC was found to be highly significantly and positively correlated with OM.

Key words: Land use, soil organic carbon, soil organic matter, soil organic carbon stocks

Assessment of Soil Fertility Constraints of Tamil Nadu Uplands for Sustainable Soil Management

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Soil fertility degradation is the major cause for soil productivity decline. Soil fertility capability classification is a technical soil classification system that focuses quantitatively on the physical and chemical properties of the soil that are important towards soil fertility and productivity management. The present study is an attempt to classify the soils of Palani block located in leeward down of Palani hill ranges representing semi-arid Tamil Nadu uplands. Different soil series were identified at 1:10000 scale and major typifying pedons were analyzed and taxonomically classified. FCC classification was applied for these identified major soils. Condition modifiers in FCC system illustrate the soil fertility related constraints. The major limitations are dry soil moisture (d), gravelliness (r+), basic reaction (b), vertic clay (v), low soil organic matter (m), low nutrient retention (k) and low cation exchange capacity (e). The condition modifier d (100%) dominates in most of the soils followed by m (71%), k (50%), b (50%), r+ (43%) and e (33%). Among the soils identified, Kk Fine Typic Haplustalfs (KkFTH), Kvp Coarse loamy Typic Rhodustalfs (KvpCTR), Ayk Fine Vertic Haplusterts (AykFVHrt) and AnP Coarse Loamy Typic Haplustepts (AnPCLTHt) soils had been found with more number of Conditional modifiers like low cation exchange capacity (e), low nutrient reserve (k), low organic carbon content (m) and gravelliness (r). These limitations of different soil types should be rectified by adopting appropriate management options like organic manure and fertilizer application and cultivating suitable crops by considering the extent and severity of each limitation to achieve better soil and crop productivity of upland system.

Key words: Soil productivity, Fertility capability, Tamilnadu uplands, Condition modifier and crop productivity

Rain Water Harvesting and Recycling for Sustainable Crop Production in Kandhamal District of Odisha, India

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A trial was conducted during 2007 to 2009 at All India Coordinated Research Project for Dry land Agriculture Phulbani, Odisha, India., with an objective to obtain the water loss and economics of the lined ponds.There were three treatments T1-Lined pond with soil cement plaster (6:1) 8cm thickness, T2-Unlined pond,T-3-No pond.10% of the cropped area was dug for construction of the pond in Lined and Unlined pond treatments. The size of the pond is 7m top widths, 1m-bottom width, 3m heights, and 1:1side slope. The water loss was 17 lit/day/m^2 in lined pond and 831 lit/day m^2 in unlined pond. Provision of dugout pond in 10% area of the plot at the downstream side with 8 cm thickness soil cement plaster (6:1) gave 41% higher cauliflower equivalent yield compared to no pond. The B:C ratio was found to be 2.25 in lined pond. The light textured well-drained upland soils in North Eastern Ghat Zone provide scope for cultivation of vegetables during rainy season. Harvesting of this run-off water in farm pond with proper lining will conserve the run-off water and recycling of this water for life-saving irrigation will protect the crop from drought/dry spell grown in 90% of land area. The ponds will be helpful for sustainability in productivity of dry land crops. Soil structure and organic matter status decide the water holding capacity of the soil. Keeping those points in view, the present experiment involving two water management systems (no pond and pond) has been designed.

Key words: Rainwater, harvesting, sustainable, crop, production

Mapping of Soil Physico-chemical properties in the Transition Zone of North Western Himalayas of J&K

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Advancement in space technologies has led to the evolution of opened application of Remote Sensing & GIS technologies in creating data base for soil based research. Mapping based on remote sensing technologies has not only created a revolution in tackling second generation soil problems but to a larger extent towards early disaster management. The current study is also conducted with an aim to create a database related to soil physico-chemical properties of the transition zone of North West Himalayas of J&K in order to formulate site-specific fertilizer recommendations and thereby having a direct impact on yield related parameters. Digitized map of Soil pH, electrical conductivity and Soil Organic Carbon was created utilizing modern tools of GIS which have the ability for visual representation of various parameters making the data easily understandable. Soil pH, electrical conductivity and Soil Organic Carbon were analyzed using standard procedures.The pH of the soil varied from 2.98 to 8.55 with a mean value of 6.76. The coefficient of variation (CV) was only 13.13 percent. The data was slightly negatively skewed (-0.14) having a Kurtosis value of 0.68. The electrical conductivity (EC) of the soils ranged from 0.004 to 1.027 dS/m with a mean value of 0.19 dS/m. The CV was 83.05% with Skewness and kurtosis being 2.23 and 7.48, respectively. Soil Organic carbon (OC) varied from 0.15 to 3.90 percent. The mean value was 1.70. The CV for Organic Carbon was 54.04 percent. The Skewness and Kurtosis value was 0.28 and -1.28, respectively. More than 50 percent of soils of area were having neutral pH but some areas depicted values ranging between 7 to 8 on pH scale. Very few areas were having pH less than 5. The areas near international border and areas that were on northern side of NH-1A depicted pH status ranging between 6 to 8. The hilly terrains lying on southern side of NH-1A in majority depicted pH status ranging between 6 to 7. The Electrical Conductivity map represented a higher EC in hilly terrains as compared to low land plain areas and low hill terrains. The hilly terrains noticed EC reading more than 0.3 dS/m whereas central portion of district observed EC in between 0.1 to 0.2 dS/m. The Organic Carbon in hilly terrains or on the left hand side of NH 1A usually lies between 1.50 to 3.00 percent and the portion on the right hand side lies between 0.75 to 1.50 percent. Soil Carbon in the soils of area was usually high because most of the area of hilly terrains is least cultivated and covered with forest type of vegetation that facilitates the addition of organic material to the soil through leaf and plant litter. However for the lower areas where less values of OC were observed, there is need to apply organic fertilizers or in combination to improve the Soil Organic percentage. The wide variation in soil pH was mainly on account of variation in topography, slope and use of FYM at varying rates. Soils did not show any salinization as the maximum value of EC was 1.027 dS m^{-1}.

Key words: Soil pH, Electrical conductivity, Mapping, GIS

Mapping of K-Pools Variability in Soils of North Bihar: A Case Study

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This study was conducted to understand the spatial distribution of K-pools along with soil textural variability in North Bihar plains using Global Positioning System and Geographic Information System as a tool for spatial analysis. Soil texture is one of the most important soil properties whose variability may contribute to the variation in K storage and availability, water retention and transport, and binding and stability of soil aggregates. It can directly or indirectly influence many other soil functions and threats related to soil erosion. Continued cropping with inadequate K-fertilization leads to depletion of forms and pools of K (Sen and Ghosh 2011) may causes constraint for sustainable crop production. In the last two decades the high level of K category in Bihar as well as Indian soil has been decreased. K-pools like water soluble, available, exchangeable, HNO_3- soluble, non-exchangeable and total K are the important pools of soil K, invariably contribute to the K nutrition of plants during the crop growth. Geoinformatics has been extensively used for quantifying the spatial pattern of soil properties and K-pools besides Kriging techniques are proving to be sufficiently robust for estimating values between two sampled locations in most of the cases. For the purpose 150 surface (0.00 -0.15 m) soil samples from North Bihar were drawn in 2016-17 at 40 km x 40 km grid interval and spatial distribution maps were prepared for texture and K-pools under GIS environment using TNTmips version 2010. The maximum spatial distribution of soil texture was found for silty loam (55.63%) followed by clay loam (20.86%) and loam (17.46%). The spatial distribution for available K (61 to 121 ppm), water soluble K (15 to 30 ppm), exchangeable K (50-120 ppm), HNO_3-soluble K (750 to 1500 ppm) and non-exchangeable K (>600 ppm) were largest and found 68.52, 59.40, 63.43 and 74.05% respectively. Spatial distribution map generated by GIS technique enables a more precise approach for considering K fertilizer recommendations in the different soils of north Bihar as compared to blanket application, by overlaying the spatial distribution map of readily available K on the spatial distribution map of non-exchangeable K reserves.

Key words: Spatial distribution, Pools of K, Soil Texture, GIS

Effect of Household Waste based Vermicompost and Fertilizer on Major Nutrient Availability, Rice Crop Yield, Nutrient Uptake and Nutrient Use Efficiency

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A pot experiment was conducted during *Kharif* 2018 at RPCAU, Pusa with an objective to find out the effect of vermicompost prepared from household waste and cow dung (1:1, w/w) on soil properties, rice yield, nutrient uptake and nutrient use efficiency. Four levels of vermicompost 0, 1.25, 2.5 and 3.75 t ha^{-1} along with three levels of chemical fertilizers viz. 0, RDF (120:60:40 kg ha^{-1}. N: P_2O_5: K_2O) and 50% RDF in a completely randomized design. Results indicated a significant build-up of available major nutrients in post-harvest soil of rice on application of graded dose of vermicompost alone or in combination with different dose of fertilizer. Integrated application of vermicompost @ 3.75 t ha^{-1} and RDF recorded 25.55%, 14.79% and 41.27% increase over control in available N, P_2O_5 and K_2O respectively in post-harvest soil. Increasing dose of vermicompost and chemical fertilizer separately and in combination significantly increased grain and straw yield as well as major nutrient uptake. Whereas, nutrient use efficiency was observed greater on combined application of vermicompost and chemical fertilizer than their alone application and treatment receiving vermicompost and 50% RDF recorded greater nutrient use efficiency in comparison to same dose of vermicompost and full dose of fertilizer (RDF).Treatment involving application of vermicompost (2.5t ha^{-1}) along with full dose of fertilizer (RDF) gave superior results and emerged out as best treatment combination with respect to nutrient availability, growth and yield of rice crop. However, application of vermicompost (1.25 t ha^{-1}) with 50% RDF yielded equally as full dose of chemical fertilizer (RDF) alone which indicates that 50% of chemical fertilizer could be saved on application of vermicompost even at lower dose combined with 50% RDF without reduction in grain yield.

Key words: Vermicompost, Rice, Post-harvest soil, Nutrient use efficiency

Comparable Research of Lake Water Quality and Land Use in Urban and Rural Areas of Chennai, India

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Chennai, on the Bay of Bengal in eastern India, is the capital of the state of Tamil Nadu,has been experiencing abrupt contraction since last two decades, arising in major changes in land use and abasement of wetland. The urban water course yielded the maximum total hardness, total suspended sediment (TSS). They were strongly corelated with BOD (Biochemical Oxygen Demand), surfactant concentration but a negatively with total organic carbon. The urban (Nanmangalam) units have major pollution but the best water quality, the agricultural area (Perungudi) have minor pollution and not so good water quality. Thisboth lakes are maintained by government department.The rural people's did not use the water for drinking purpose and so on because the water was contaminated with high amount of salinity,phosphate. In previous decades,the water was used for all purpose. During rainfall the water is mixed into contaminated water and take sampling on wet periods was strongly correlated with turbidity, TSS (Total Dissolved Solids), BOD. The waste water in flows with inorganic salts and nutrients. The uncontrolled development of the catchment and infringement in Nanmagalam lake. It reduce the interdependence of lake and improve the position of disuse.The approaching environment expenditure caused by urbanization to thislakes will only be tackled, if the major problem of domestic and industrial effluent and encroachment are addressed properly.

Key words: Lakes, Pollution, Quality of water, Rainfall, BOD

Land Suitability Potentials for Barley Cultivation in The Northern of Syria Using Sys Model

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The agricultural sector in Syria was badly affected by the Syrian conflict, where most of the agricultural lands out of service, so far. Similarly, grazing area was destroyed due to the current situation in the eastern part of Syria. Thus, the aim of these research is to investigate the suitability of the southern part of Syria for barley cultivation as a basiccrop for the livestock sector, where the most of grazing areas had destroyed. To achieve the study goal, soil survey had conducted and soil samples were collected and analyzed.

Three major soil orders(*Vertisol, Inceptisols, and Entisols*) are thedominated orders withinthe study area.Land evaluationbased on Sys model showed that most of the study area is classified as Suitable for barley cultivation where sub orders range between S_1, S_2, and S_3. Also, the study concludes that no limiting factors on barley cultivation. The result from this research can be provided a good tool for adoptingpotential area for barley cultivation.

Key words: Land use Suitability, Sys Model, Barley, Syria

Assessment of Carbon Fractions Under Different Land Use Systems in Nandipura Mini-watershed of Chikkamagalur District, Karnataka

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A survey was conducted in Nandipura Mini-watershed of Tarikere Taluk, Chikkamagalur District, and Karnataka, India to evaluate the impact of different land use systems. The eight land use systems were selected viz., areca nut, coconut, pomegranate, groundnut, maize, ragi, scrubby land and fallow land in three micro-watersheds (Nandipura, Biranhalli and Basavapura) areas under two soil depths (0-20 and 20-40 cm) on soil carbon fractions. The texture varied from sandy loam to sandy clay loam and pH was moderately acidic to neutral in reaction. The highest soil organic carbon content was (14.5 g kg^{-1}) noticed in areca nut land use system and lowest was in maize system (6.8 g kg^{-1}) at surface depth. Soil microbiological biomass carbon ranged from 187 to 408 mg kg^{-1} and cold water extractable carbon ranged from 16.15 to 44.58 mg kg^{-1}. The highest soil microbiological biomass and lowest cold water extractable carbon were observed in areca nut and maize use systems respectively. Total organic carbon content of surface soil ranged from 1.98 to 13.56 g kg^{-1} and inorganic carbon ranged from 0.16 to 0.40 g kg^{-1}. Highest total organic carbon was observed in areca nut and lowest in maize system respectively. The highest soil organic carbon stock was recorded in areca nut land use at surface depth (316 t c ha^{-1}). The study also indicated that different fractions of carbon were decreased with depth in all the land use systems. All the carbon fractions were positively and significantly correlated with each other.

Key words: Carbon fractions, Correlation, Land use systems, Micro-watershed.

Land Suitability Assessment and Land Use Planning for Sustainable Agriculture in Muradihalli Microwatershed in Yadgir District in Karnataka, India

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A study was undertaken for land suitability assessment of different crops grown in Muradihalli microwatershed under Sujala-III project in Yadgir district which covers an area of 591 ha. The Yadgir district lies in the northern plains of Karnataka and falls under semiarid tract and is categorized as drought-prone area with total annual rainfall of 866 mm. Land Resource Inventory (LRI) was conducted using cadastral maps and Cartosat-1 and LISS IV merged at 1:7920 scale and a soil map with phases of soil series as mapping units was prepared. Ten soil series were identified and mapped into sixteen soil phases. The soils are shallow (25-50 cm) to deep (100-150 cm), sandy clay loam to clay in texture, non gravelly (<15%) to very gravelly (35-60%) and slightly to moderately eroded. The pH of the soils were slightly to strongly alkaline (7.3-9.0) and sodic in nature (ESP >15%). Land suitability is assessed for 29 crops grown in the microwatershed. Of these, five major crops grown in the microwatershed *viz.*, Maize, Sorghum, Red gram, Groundnut and Cotton were selected and presented in this study. The crop suitability classification was made based on FAO Framework for Land Evaluation.

The results of land suitability assessment revealed that Maize crop has 130 ha under highly suitable, 335 ha area is moderately suitable and 114 ha area is marginally suitable with different degrees of limitations of sodicity, calcareousness, rooting depth, texture, and gravelliness. Sorghum crop has 44 ha under highly suitable, 413 ha moderately suitable and 122 ha is marginally suitable with limitations of sodicity, calcareousness, rooting depth, texture and gravelliness. Red gram has no highly suitable lands whereas, 219 ha area is moderately suitable, major area of 343 ha is marginally suitable and 17 ha area is currently not suitable with limitations of sodicity, rooting depth, texture and calcareousness. Groundnut has 130 ha under highly suitable, 135 ha is moderately suitable, 209 ha area is marginally suitable and 106 ha is currently not suitable. Cotton has 44 ha under highly suitable, 148 ha is moderately suitable, 387 ha area is marginally suitable with limitations of sodicity, calcareousness rooting depth, texture and gravelliness. The limitations like sodicity, calcareousness, gravelliness and texture that can be modified to some extent through appropriate interventions would help in enhancing the crop suitability ranking. This in turn helps in achieving the potential yield thereby increasing productivity and farm income. Based on the crop suitability assessment, a suggested land use plan has been prepared by considering only the highly and moderately lands for each of the crop.

Key words: Land Resource Inventory, Land suitability, Crop limitations, land use plan

Land Resource Inventory for Assessing the Potentials and Problems of Some Subwatersheds in Kalaburgi District, Karnataka, India

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The Land Resource Inventory (LRI) of Khairat, Matki, Alur and Padasavli Subwatersheds in Aland taluk, Kalaburgi district in Karnataka was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The present study covers an area of 5508 ha and the climate is semiarid and categorized as drought prone with an average annual rainfall of 786 mm. The length of growing period is about 150 days starting from the 3rd week of June to 1st week of October. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soils were grouped into 10 soil series and 63 phases of soil series were mapped based on the surface texture, slope, erosion, gravel etc. From the master soil maps, several interpretative and thematic maps like, land capability, soil texture, gravelliness/stoniness, AWC, slope and erosion were prepared. Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at 250 m grid interval. Land suitability for growing major agricultural and horticultural crops was assessed and crop suitability maps prepared showing the degree of suitability with associated limitations.

LRI data and maps generated were assessed and the potential and problem areas were identified. The potential areas identified were about 90% is suitable for agriculture, 96% area has clayey soil at the surface. Entire area is nonsaline, 69% high in available potassium, 89% sufficient in available iron and available manganese and copper are sufficient in all the soils. About 63% area is moderately to highly suitable for Bengal gram, 24% for sorghum, cotton, red gram, custard apple and amla, 16% for lime and mosambi. The problem areas identified were 81% soils are very shallow to moderately shallow, 58% are gravelly, 75% are low in AWC, 21% are gently to moderately sloping, 70% are moderately and severely eroded. About 56% is moderately alkaline, 75% are medium to low in organic carbon, 96% are low to medium in available phosphorous, 27% are medium in available potassium, 89% are medium to low in available sulphur, 96% are low to medium in available boron and 64% are deficient in available zinc These potentials and problems are highlighted and presented in the LRI cards that are prepared for each of the land parcel and given to the concerned farmers for taking up corrective measures.

Key words: Land Resource Inventory, soil fertility, crop suitability, crop suitability

Soil Organic Carbon Status under Different Land Use Systems of Rachanahalli Subwatershed, Yadgir District in Karnataka, India

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The study was conducted in Rachanahalli Subwatershed of Yadgir taluk and district, Karnataka under SUJALA-III project to assess the soil organic carbon status of different land use systems through Land Resource Inventory (LRI) on 1:7920 scale by using Remote Sensing, GIS Techniques and Field Survey. The study was carried out in 6359 ha using high resolution IRS LISS IV and Cartostat-1 merged satellite imagery and cadastral maps. A total of 589 surface soil samples at 320 m grid interval along with land use details and soil morphological features of soil profiles were studied and collected. The soils were analysed for soil organic carbon and fertility status (macro and micronutrients) using standard methods of analysis. The major land use identified in the study area were groundnut, paddy, cotton, redgram, jowar, ragi, currently fallow, permanently fallow and scrub land. The soil organic carbon status of the study area under different land use systems revealed that the soils under groundnut are high in soil organic carbon content (0.91%) followed by paddy (0.81%), cotton (0.79%), currently fallow (0.75%), redgram (0.74%), jowar (0.71%), ragi (0.66%), permanently fallow land (0.61%) and scrubland (0.49%). The soils under groundnut cultivation have high organic carbon content as compared to other land use systems and lowest carbon content was in the scrub land areas. The soil fertility status of the study area revealed that majority of the soils area are slightly to strongly alkaline in soil reaction in about 77% area. Electrical conductivity of the entire subwatershed is <2dSm^{-1}and thus the soil are non saline. Soil organic carbon is high and medium in 42% area each. Available phosphorous is medium in 48% and low in 36% area, available potassium is medium in 73% area of the subwatershed. Available sulphur is low in 66% area, available boron is medium in 55% and low in 21% area, available iron is sufficient in 80%, available copper and manganese are sufficient in the entire area and available zinc is deficient in the entire area of the subwatershed. Based on LRI and fertility data, LRI Cards are prepared for each of the land parcel and are given to the concerned farmers. There is a great potential to increase the crop production by implementing the proper land management and land use strategies developed for each of the land parcel in the watershed.

Key words: Soil Organic Carbon Status, Land Use System, Soil Fertility, Subwatershed.

Land Resource Inventory to Assess Soil Suitability for Crops using Geospatial Techniques for Kilgere-1 Micro-watershed, Achattipura Sub-watershed Chamarajanagara, Karnataka

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Land resource Inventory of Kilgere -1 micro-watershed which comes under AESR 6.2 and Agroclimatic Zone 6 of Karnataka and located between North latitude 11° 44′ 58.74″ and 11° 47′ 0.354″ and East longitude 76° 48′ 19.468″ and 76° 50′ 10.001″ covering an area of 656 ha was undertaken to provide comprehensive site- specific cadastral level information useful for farm level planning, watershed planning and integrated development of the Kilgere-1 micro-watershed under Sujala – III, Karnataka Watershed Development Project- II. The average rainfall of the micro-watershed was 745.1 mm during 2001 to 2017.The database was generated by using cadastral map of the village as a base map along with high resolution satellite imagery [Cartosat-1 PAN 2.5 mts andResourcesat-2 LISS-IV MX merged Image]. Current land use in Kilgere-1 micro-watershed indicated that in major area sorghum as a sole crop or intercropped with sunflower or tomato/turmeric as sole crops are being cultivated.Land capability classification indicated most land area in Kilgere-1micro-watershed falls under IIs land (27.8% of the total area) with soil limitation of depth/gravelliness/texture/salinity/alkalinity followed by class IIIs land.Using the data generated based on detailed soil survey 44 soil phases have been identified and thematic map was generated to indicate their spatial distribution. Soil phase, HRVcC2g1St1 (Shallow, well drained, sandy loam, derived from granite gneiss, occurring on gently sloping land (3 – 5%), moderate erosion, 15-35 per cent gravels) covers 39.6 ha. The soil surface texture in nearly 30.2 per cent area was sandy loam with very gentle slope (43.5%) and slight erosion (66.7%). However, land containing gravels to the extent of 15-30% were 44.1% of the total area. The major limitation in nearly 43.4% area for growing deep rooted crops is soil depth. Soil characterization indicated that soil reaction in 48.7 ha was neutral (6.5-7.5 pH). The soil organic carbon content was low and medium in 257.1and 242 ha, respectively in the micro-watershed suggesting regular addition of organic manure is necessary to improve the soil fertility in the micro-watershed. In the micro-watershed available nitrogen and phosphorus status was low (60.4 and 81.5% of total area, respectively) and medium in available sulphur status (386.6 ha). Among the micronutrients, zinc is most deficient (65% of the total area) nutrient. Land suitability assessment indicated that nearly 50% of the area are moderately suitable for ragi with limitation of gravelliness and rooting depth.Nearly 45% of the land is marginally suitable for sorghum and turmeric while 45% of the area is not suitable for cultivation of banana, guava, jamun, mango and coconut. Thematic maps have been generated to indicate the soil and site characteristics, soil suitability, soil phases, which helps in knowing the soil suitability, with soil characteristics parcel wise. The information on parcel wise is of great importance in managing the production system.

Key words: Micro-watershed, land resource inventory, soil suitability, land capability class

Soil Nutrient Characteristics in Different Land Uses of Mengzi Gabin Basin

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In order to investigate the characteristics of soil nutrients content in different land use types of karst gabin basin, Mengzi Gabin basin was used as the study site, soil organic matter, soil total nitrogen, soil total phosphorus, soil total potassium soil pH and soil texture in woodland, agricultural land, orchard and grassland were surveyed and determined.The difference of soil indicatorsbetween vegetation types was analyzed, and soil fertility quality of four land use types was comprehensively evaluated by the soil quality index (*SQI*). The results showed that land use significantly affects soil organic matter content, soil organic matter content was the highest in grassland, followed by agricultural land and forest land, while orchard was lowest. There was a significant difference in soil total nitrogen content between different land uses. The total nitrogen content in farmland soil was highest, followed by grassland and woodland, and the lowest in the orchard. Woodand had the highest total potassium content and the lowest total phosphorus content. The grassland soil had the highest total phosphorus content and the lowest total potassium content. pH value in the four land use types was acidic, ranged from 5.82 and 6.67. The soil quality index showed that woodland had the highest soil fertility quality. The results of the current study could provide the basis of soil nutrients variation and status in Gabin basin, it also provides support for evaluating the soil improvements during vegetation restoration in fragile Karst ecosystems.

Key words: Mengzi Gabin Basin, Land use, Soil nutrients, Soil quality index

Disturbed Land Monitoring Based on Unmanned Aerial Vehicle

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It is inevitable to make land disturbed during the process of engineering construction. This undoubtedly increase the risk of soil loss with the decrease vegetation coverage and destroyed soil structure. To provide soil erosion control measures will be very helpful to minimum the risk caused by artificial disturbance. However, it is difficult to make the on-site survey as there are numerous construction sites and many of them distributed in the area where is hard to access. In addition, to estimate the disturbed area and congeries quantity either for temporally or permanently are also challengeable. This work described an on-site survey for a constructing motor way in northern China by virtue of unmanned aerial vehicle. The disturbed land was easily to find, the disturbance area and borders, the quantity and dimensions of spoils, the coverage and growth situation of vegetation, the designment and effects of soil erosion control measures, and their changes in different periods were obtained successfully.Further, the 3-D construction for the disturbed land provided visual analysis for place reasonable soil erosion control measures. This technique make on-site disturbed land survey more convenient, faster, and more reliable, and hence has broad development prospect.

Key words: Disturbed land, Monitoring, Unmanned aerial vehicle, Disturbed area, Quantity of congeries

Soil Physical and Physico-chemical Properties of Soils of Telangana State

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Seven typical pedons from Jangon district were studied for physical, physico-chemical and chemical properties of the area. The soils were moderately deep to very deep, reddish brown to dark reddish brown in colour, gravelly sand to clay in texture and had varied structure including granular and sub-angular blocky structure. The clay content in soils varied from 2.9 to 59.3%. The clay content increased with depth in all pedons. Silt fraction in the soils ranged from 6.9 to 30.7%. The sand content in the soils under investigation varied from 13.9 to 89.3%. Most of the pedons exhibited more or less an increasing trend in bulk density with depth. These soils were near slightly acidic to strongly alkaline in reaction, non-saline and very low to medium in organic carbon. The CEC varied from 1.7 to 44.5 cmol (p^+) kg^{-1} soil and dominated by Ca^{+2} followed by Mg^{+2}, Na^+ and K^+. The soils were very low to medium in available nitrogen, low to medium in available phosphorus and potassium. Available zinc was deficient to sufficient in the entire horizon. The soils were deficient in available iron, copper and manganese. The soils were classified as Typic Haplustert, Typic Haplustepts, Vertic Haplustepts and Typic Rhodustalfs.

Key words: Soil physical, physico-chemical, nutrient status and classification

Physico-chemical Properties as Affected by Transmission Characteristics of the Soils of Jorhat District, Assam

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The study on "Physico-chemical properties as affected by transmission characteristics of the soils of Jorhat district, Assam" was carried out with the objective to evaluate transmission characteristics of soils of Jorhat district. Bulk soil samples were dug out from 0-30 and 30-60 cm depth in polyethylene bags and were later dried in shade. Besides the bulk samples, soils were collected in soil cores fabricated from GI pipes for determination of saturated hydraulic conductivity and bulk density of soils at each location. The bulk samples after air drying in shade, were ground with wooden hammer, passed through 2 mm sieve and stored in polyethylene bags for further analysis. The bulk density and particle density ranged from 1.16-1.59 and 2.24-2.65 Mg/m^3 in 0-30 cm depth and 1.19-1.61 and 2.28-2.68 Mg/m^3 in 30-60 cm depth, respectively. The organic carbon content at 0-30 cm depth ranged from 0.87-1.86% while at 30-60 cm depth it ranged from 0.38-1.21%. The soil pH in both the depths were acidic and ranged from 4.50-6.60 and 4.23-6.84 at 0-30 and 30-60 cm depth, respectively. The texture of the soils ranged from heavy at the higher elevation to light in the lower elevation areas. The mean saturated hydraulic conductivity of the soils for the two depths were 1.01 and 0.65 cm/hr, respectively, indicating higher saturated hydraulic conductivity at surface as compared to sub-surface soil. Saturated hydraulic conductivity showed positive correlation with sand and negative correlation with clay. The unsaturated hydraulic conductivity of the soil at different matrix suctions (*i.e.* 0.1, 0.3, 1, 10 and 15) had highly significant positive correlations with organic carbon and sand while it had higher significant negative correlation with clay due to porosity effect in soil. The findings of the study leads to the conclusion that the organic carbon and saturated hydraulic conductivity of the soils at both the depth i.e. 0-30 and 30-60 cm in Jorhat District are in congenial range and should present no adverse effect for management of soils. In general sub-surface soils showed better homogeneity over the surface soils.

Key words: Bulk density, hydraulic conductivity, acidic soil, organic C

Farming Situations based Land Utilization Plan for *Kunkuri* Block of Jashpur District in Chhattisgarh

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Land utilization involve the modification and management of the land such as arable field, pasture land and barren land. Land use practices have a major impact on natural resources including water, soil nutrient, plant, soil loss and, agriculture production. In view of the above a study on development of land utilization plan based on farming situation was carried out in block (*Kunkuri*) of Jashpur District, Chhattisgarh. Soil samples from two different locations were taken for the study and analyzed for physico-chemical properties for categorization of soils. The soils belong to four Orders *i.e*. *Entisols (Bhata), Inceptisols (Matasi), Alfisols (Dorsa)* and *Vertisols (Kanhar).*Various thematic maps were prepared on different soil parameters for delineation of farming situations and water resources planning of the *Kunkuri* Block.

Soil moisture depletion pattern of was plotted based on NDSI method, using Sentinel-2A data of year 2015, 2016, 2017 and 2018.The results revealed that during the year 2018 water depletion were more fluctuated as compared to remaining three years.The Multi Criteria Evaluation (MCE) approach is used for the characterization of farming situations. Various thematic maps such as NDSI, slope, LULC and soil texture were used for the characterization and delineation of farming situations. The result of MCE revealed that four orders of farming situation were categorized for the *Kunkuri* Block such as *Bhata*, *Matasi*, *Dorsa* and *Kanhar*. The area under *Matasi* and *Dorsa* was found to be highest (106km^2) followed by *Bhata* (98km^2) and *Kanhar* (84km^2).

On the basis of results water resources planning based on farming situation was suggested for the *Kunkuri* Block. Standard procedure was adopted to identified the appropriate locations for surface water storage, ponds and groundwater recharge structures. Total 41 places were identified for the construction of check dams for groundwater recharging, whereas 127 places were identified for the construction of farm ponds for water harvesting. The proposed plan involving better land use options and adequate water resources may help to increase the agricultural production in the study area.

Key words: Land use, land cover, water resource planning, groundwater recharge, water harvesting

Developing Land Resource Inventory-based Indices for Watersheds of Karnataka

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Watershed programmes are aimed at judicious management of natural resources for ensuring sustainable growth and development. Assessment of land resources with respect to their potentials and constraints are key to plan optimal management strategies. A science-based assessment through creation of watershed-wise land resource inventories (LRI) has been adopted by the Sujala-3 Project implemented by the Watershed Development Department of the Government of Karnataka. Analysis of LRI data helps in identifying land management units requiring similar management practices. Simplified information through maps and atlases were made available to the project implementation agencies for generation of watershed saturation plans as well as to create awareness among the farmers of the watersheds through training programmes and on-field demonstrations.

We conducted a study in thirteen watersheds in Hebbur *taluka* of Tumkur district in Karnataka for understanding the impact of LRI-based watershed planning and programme implementation on both environmental soundness and social acceptability of the project. For this purpose, two indices *viz*., LRI utility index (LRI-UI) and induced watershed eco-index were developed and their values were compared across watersheds. Both the indices were developed after interviewing more than 200 farmers of the watersheds and field functionaries. The LRI utility index, which signifies the value of LRI in land use planning, varied from 0.83 to 0.88 across the watersheds, indicating the correctness of survey number-wise LRI-based recommendations in all the watersheds resulting in the acceptance of the same by the farmers. Differences among the watersheds in terms of (LRI-UI) arise due to availability of resources like irrigation water for adoption and market considerations. Induced watershed eco-index (IWEI), which is a measure of the additional watershed area brought under vegetation cover due to crops, pasture and grassland development, and horticulture and forestry, varied from 0.06 to 0.14 across watersheds. Variations in values of IWEI are due to initial land use conditions prior to implementation of watershed plans, which in turn dictated the response of the watersheds to developmental activities.

Key words: Land resource inventory, LRI utility index, Induced watershed eco-index, Sujala-3 project

SESSION-V

Biodiversity Conservation and Strategic Soil and Water Management

Review and Prospect of Protection Forest System Construction in the Yangtze River Basin in the Past 30 Years

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The Yangtze River Basin shelterbelt system construction project is the first national key ecological treatment project in China. In order to improve the deteriorating ecological environment of the Yangtze River Basin, China has put forward the overall goal of building shelter forests in the Yangtze River Basin. It is planned to use 30-40 years to plant trees in the Yangtze River Basin, increase the area of forests, improve the situation of soil erosion, and ensure social and economic development. Through the implementation of the Yangtze River Basin shelterbelt system construction project, we will continue to push forward the watershed ecological management work. Promoting ecological management in the Yangtze River Basin with the model of ecological engineering has achieved remarkable results, and has achieved obvious ecological, economic and social benefits. Through reviewing the 30-year history of the construction of the protective forest system project in the Yangtze River Basin, this paper clarifies the development context of the Yangtze River Basin engineering control in China, summarizes the technical system and comprehensive control model of soil and water loss by biological measures such as afforestation, and extends the successful experience and typical achievements to other areas. We are looking forward to the future development trend of the Yangtze River Basin shelter forest construction in China.

Key words: Shelterbelt, Engineering construction, Yangtze River Basin

Ecological Restoration of Mangrove Forest in Southern East Coast of Andhra Pradesh, India

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The state's vast coastline is 1030kms and second largest in the country next Gujarat Andhra Pradesh has the longest coast line on the Eastern coast of India, Andhra Pradesh. Main characteristics which define the mangrove ecosystem are air and water, temperature ability to provide protection from wave energy, presence of salt water tidal range ocean current and shallow slopping shores from reaching other critical marine habitats such as coral reefs and sea grass beds. The health of these habitats is dependent in part on clean water so that sunlight is able to penetrate the water column. Total coastal area is spread over 92,906 sq.km sin nine coastal districts Potti Sreeramulu Nellore, Prakasam, Guntur, Krishna, West Godavari, East Godavari, Visakhapatnam, Vizianagaram and Srikakulam. The Mangroves occupy 352Sq.km.

A comprehensive survey along the 55 Sq. km. coastline of Nellore and Prakasam and Guntur districts of Andhra Pradesh was conducted to assess the present status of mangrove wetlands and their diversity. Total extent of mangrove cover in these three districts is 2541 ha occurring in 30 different locations of which 23 are in Nellore district and Eight are in Prakasam and Four in Guntur districts. Twelve true mangroves from six families and nineteen mangrove associates from eleven families were recorded in the present study. *Avicennia marina, Rhizophora mucronata, Excoecaria agallocha* and *Aegiceras corniculatum* are the dominant mangroves in the major wetlands of the three districts. The mangrove wetland is under threat like other parts of the world. The state stands fourth in the country for its mangrove area Nizampatnam brakish water wetland region studied and recorded 20species

Key words: Mangrove wetlands, Biodiversity, True mangroves,. Mangrove associates

Resource Conservation Technology for Jute based Cropping Systems: Issues and Prospects in Indo-Gangetic Plains

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Resource intensive agricultural crop production systems has caused negative environmental externalities and second generation problems like soil health deterioration, loss of nutrients, ground water depletion etc. To address this challenge, conservation agriculture (CA) involving minimal soil disturbances and retention of crop residue (>30%) have been practised increasingly and recognized to enhance soil health under climate change scenario. Jute (*Corchorus olitorius* L.), being an important fibre crop next to cotton, is eco-friendly, biodegradable and has much higher CO_2 assimilation rate mostly grown by marginal farmers in eastern parts of India. There is tremendous scope of CA under Jute based cropping systems with their unique crop physiology of leaf shedding in the field, which takes care of crop residue management under CA. Study conducted to evaluate the effect of tillage systems i.e. conventional tillage and no tillage with or without crop residue retention (+R/-R) on soil properties and crop physiology under most predominant jute based cropping systems (jute-rice-wheat, jute-rice-lentil and jute-rice-mustard). The SOC contents under No tillage with residue incorporated plots (NT+R) are much higher, maximum being in jute-rice-lentil (0.73 and 0.60%, respectively in 0-15 and 15-30 cm soil depth) followed by jute-rice-wheat (0.70 and 0.56%, respectively) and jute-rice-mustard (0.67 and 0.59%, respectively). Tillage practice, cropping system and their interaction had a greater effect ($P <$ 0.05) on the content of aggregate associated C for large macroaggregates (LM). After 3 year of crop cycle, soil carbon fractions are in the order: non-labile > very labile > less labile > labile for 0-15 cm depth. Nutrients availability and Soil microbial biomass carbon (SMBC) at surface soil (0-15 cm) were high under No tillage with residue incorporated plots (NT+R) as compared to conventional tillage practice. The tillage-cropping system interactions had significant impact on mean weight diameter (MWD) of air-dried aggregates at 0-15 cm layer. No tillage with residue incorporated plots (NT+R) showed higher aggregate stability (MWD: range- 0.51-0.83 mm and WSMA: range- 41.1-62.8%). Radiation use efficiency in terms of photosynthetically active radiation (PAR) was higher in no tillage in association with crop residue than conventional tillage. Similarly, the relative water contents (RWC; range: 73.9-88.3%) and chlorophyll contents (SPAD; range: 7.8-16.2) are significantly higher in no tillage+residue treatment than conventional tillage in all crop rotations. Evaluation of soil quality using soil quality index (SQI) under different tillage and cropping system showed that soil quality was better in Jute-rice-lentil (range: 0.42-0.62) under no tillage with residue (NT+R) as compared to the other systems. The higher index values implied that SQ under that management is better as compared to other treatments. Thus, minimum soil disturbances coupled with residue retention has resulted improved soil quality and provided better soil environment for sustainable crop production under jute based cropping systems in Indo-Gangetic plains.

Key words: Tillage, Residue management, Jute based cropping, Soil quality, Eastern India

Response Surface Modeling (RSM) and Optimization of Lead (Pb^{2+}) Removal from Spiked Aqueous Solution using Immobilized Biomass of Lead Resistant Bacteria

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The present study we had focused on Response Surface methodology (RSM) for prediction and optimization of lead (Pb^{2+}) removal from contaminated water by biosorbent based adsorption technique where Ca-Alginate based immobilized Pb resistant bacterial biomass was used as biosorbents. The biosorbents were characterized by X-RD and SEM for physic-chemical properties. A rotatable central composite design (CCD) and the response surface methodology were used to conduct and to analyze all the experiments, respectively. The adsorption process was investigated as a function of the three critical factors consisting of temperature, initial lead concentration and adsorbent dosage. The maximum Pb^{2+} adsorption capacity was obtained to be 364.28 mg/L (ppm) under the optimal conditions of 50°C, 670.26 mg/L, and 3.539% for incubation temperature, initial lead ion concentration, and the adsorbent dosage, respectively. The desirability function was used to find an optimum point where the desired conditions could be obtained. Using this biosorbent, the RSM generated maximum removal was predicted as 86.877% which was validated as 84.29% representing a capacity of 353.43 mg/L (ppm) Pb^{2+} removal from aqueous solution.

Key words: Lead removal, Response Surface Methodology (RSM), Central Composite Design (CCD), Ca-Alginate beads, Biosorption

Study on Flexural Mechanical Properties of 6 Plant Shoots during Non-Growth Period

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In this paper, Hippophae rhamnoides, Caragana Korshinskii, Tamarix chinensis, Salix psammophila, Thebranches of Hedysarum leave and Artemisia sphaerocephala) 6 in non-growth period were taken as objects, and the flexural strength of the branches of the six plants were tested indoors by YG(B)026H-250 fabric strength machine and self-made clamps, and the influence of branch length and diameter on the flexural strength index was analyzed, so as to provide a scientific reference for the selection of windproof and sand-blocking tree species and their hybrid configuration. The results showed that: (1) in the range of 0.5~2.5mm diameter, the bending strength of 6 kinds of plant branches increased with the increase of diameter, while the bending strength decreased in power function with the increase of diameter; (2) The breaking strength and breaking strength of Caragana korshinskii branches are the largest when the branch length is 60mm in the range of 0.5 - 2.5 mm, the values are 51.700N and 33.510MPa respectively, the breaking strength and breaking strength of Tamarix ramosissima branches are the largest when the branch length is 80mm, the values are 61.777N and 30.821MPa respectively, and the breaking strength and breaking strength of Tamarix ramosissima branches are the largest when the branch length is 100mm, the values are 62.237N and 33.156MPa respectively. The results showed that the values of breaking strength and breaking strength of branches among different plant species were also different when the branch length was different, which proved that only the restoration mode of combining multiple tree species was the best mode for realizing the function of water and soil conservation in ecological restoration.

Key words: Non growing period, Branch, Anti-folding force, Flexural strength

Species Functional Strategies Modify Biotic Interactions in Response to Increased Precipitation and N Deposition in a Desert Ecosystem

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Important global changes such as increased precipitation and N enrichment have altered and are continuing to change the structure of terrestrial ecosystems, especially resource-limited desert ecosystems. It is well known that the existing species may have contrasting responses to global change owing to their different adaptive strategies, and species with different functional strategies may have contrasting responses to biotic interactions within communities. However, the role of functional strategies in mediating species biotic interactions in response to global change remains unclear. We conducted an experiment in a site where 3-year water- and N-supplementation was already running in the Mu Us Desert of northern China, to explore the roles of functional strategies in regulating species biotic interactions in response to increased precipitation and N enrichment. The overall effect of the shrub *Artemisia ordosica* on the herbaceous community was almost neutral. This is because of the contrast in the responses to increased precipitation and N enrichment of groups with species varying in functional strategies: tolerant species groups responded negatively whereas competitive species groups responded positively. These hidden interactions contributed to community succession under the scenarios of increased precipitation and N deposition. Our findings highlight this important but easily overlooked mechanism underlying plant community dynamics in the context of global change. Knowledge of this mechanism would facilitate further understanding of cornerstone ecological processes and would help in the management of desert ecosystems.

Key words: *Artemisia ordosica*, Functional strategy, Hidden interactions, Mu Us Desert, Nitrogen decomposition, Species interaction, Water supplementation

An Overview of Mangroves for Protection of Coastal Areas

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Mangroves are salt-tolerant evergreen dense forests that grow in intertidal zones in tropical and subtropical estuarine regions and mud-flats. Additionally, mangrove forests provide many economical, ecological and environmental values to the people. The total mangrove forest area of the world in 2000 was 1, 37,800 square kilometres spanning 118 countries and territories. According to state forest report of 2015 of Forest Survey of India, mangroves spread over 4,740 sq. km which is about 3 percent of world's mangrove vegetation and 0.14 per cent of the country's total geographical area. Ecological valuation of the mangroves is mainly for its important role of protection and stabilization of coastal lands and estuarine. Mangroves are important means to control coastal erosion. They not only reduce erosion along the coast but also enhance sediment deposition which is essential to maintain their ecosystems. Several studies have been conducted using remote sensing and GIS which show that there is increased erosion rate in coastal areas where mangrove forests have died. Root architecture of mangroves is such that it traps sediments and prevents erosion from waves and storms. Mangrove forests also play an important role in many other edaphic functions which includes nutrient cycling, facilitation of plant nutrition, disease suppression, water purification, and biological attenuation of pollutants. The paper discusses different studies on coastal erosion, physico-chemical properties of soil, soil nutrition, soil organic carbon and relationship of soil with species composition and structure of mangrove forests in tropical mangrove environment. The study will help in exploring future research for reforestation of deforested mangrove sites, their management and conservation.

Key words: Mangrove forests, coastal lands, reforestation

Soil Remediation by Native Flora Grown in Metal Contaminated Soils

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Ecosystems are perishing as Industrial and Agricultural advancements are accelerating the pace of metal toxicity at all levels of biodiversity. Soil serves as the ground for the deposition of both air and water pollution thus adding more complexity and contaminants to its system. Phytoremediation can mollify the soil degradation sustainably using suitable plants for restoration of the contaminated land. Native plants are recommended over exogenous species as they may result in an undesirable modification of the ecosystem. The report published by Central Pollution Control Board on the Comprehensive Environmental Assessment of Industrial Clusters of India encircles the two major zones of Uttarakhand namely Haridwar and Udham Singh Nagar. The present study was conducted to assess the potential of 23 plant species growing on contaminated sites in the industrial cluster of Haridwar and to decipher the accumulation and transfer of the metal toxicity. Plants and associated soil samples were collected and analyzed for total metal concentrations. While total soil Cu, Fe, Ni and Zn concentrations varied from 2.29 to 5.89,8.16 to 11.78,1.42 to 9.83,2.32 to 5.34 mg/kg, those in the plant shoots ranged from 10.91 to 25.29,6.12 to 78.89,10.82 to 60.15,5.23 to78.20 mg/kg, respectively. Among the 23 plant species, it was observed that two native species (*Croton bonplandianum, Artemisia annua*) have greater potential for phytoremediation of Zn contaminated soils. The Zn hyper accumulation capacity of the three plants was found in order: *C. bonapaladium*>*A. annua*>*T. procumbens* in the investigated area. Suggested Hyper accumulators for overall remediation of Zinc, Nickel and Iron were *Amaranthus viridis* and *Croton bonplandianum*. The core objective was to determine the accumulation and translocation of metals independently in different species over a span of two year and evaluate phytoremediation efficiency of individual plant species. This investigation considered variations in soil properties of the specific site and emphasized on the native vegetation-enhanced phyto-remediation plan for the surroundings of industrially contaminated areas of Haridwar. Since metal uptake is dependent on species and emphatically collate with the tolerance efficiency of species, it becomes imperative to investigate and assess the potential of locally occurring plants in remediation of contaminated areas, so that the selected plants can be recommended as future tools of catharsis for contamination magnified due to industrialization and population affluence.

Key words: Hyper accumulator, remediation, degradation, ecosystem, *Croton bonplandianum*

Impact of Conservation Tillage and Intensifying Crop Rotations in Enhancing Soil Carbon, Microbial Cycling and Aggregation in Semiarid Agro-ecosystems: A Review

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Our increasing dependence on a small number of agricultural crops, is leading to reductions in agricultural biodiversity. Reductions in the number of crops in rotation or the replacement of rotations by monocultures are responsible for this loss of biodiversity. The belowground implications of simplifying agricultural plant communitiesremain unresolved; however,agroecosystem sustainability will be severely compromised if reductions in biodiversity reduce soil C and N concentrations, alter microbial communities, and degrade soil ecosystem functions. Increasing soil organic carbon (SOC) is a critical but daunting challenge in semi-arid agro-ecosystems. Management practices, such as conservation tillage and cropping system intensification have the potential to increase SOC, and microbial cycling but the drivers of this effect are unclear, and may change based on environmental conditions and management strategy. Tillage influenced SOC and microbial cycling but most effects were observed at 0–5 cm rather than 5–15 cm. Reduced tillage (RT) in a continuous monoculture increased SOC by 24% compared to conventional tillage (CT) at 0–5 cm, but tillage had no effect at 5–15 cm. Crop rotation increased soil C contents compared to continuous monocropping rotation under CT increased SOC by 28% at 0–5 cm compared to CT continuous monocropping. Reduced tillage increased soil microbial biomass C (MBC) by an average of 11 and 18% compared to CT continuous monocropping and the adoption of crop rotation, respectively, while microbial biomass N (MBN) for RT was 62% greater than for CT. NT (no-till with residue) and RTW (rotary tillage with residue) treatments significantly increased the proportion of macroaggregate fractions (>2 000 and 250-2 000 μm) compared with the MP-R (moldboard plow without residue) and MP+R (moldboard plow with residue) treatments. Averaged across all depths, mean weight diameters of aggregates (MWD) in NT and RT were 47 and 20% higher than that in MP+R. Aggregate stability in continuous rotations was about twice that in wheat-fallow rotations. Fungal biomass was three times greater in continuous rotations than wheat fallow, but was not significantly different from mid-intensity rotations.

Tillage systems can changes in soil organic carbon dynamics and soil microbial biomass by changing aggregate formation and C distribution within the aggregate. Wheat straw ditch-buried returning (WD) had significantly higher total organic carbon than did wheat straw returning with ploughing (WP) and no straw returning (CK) in wheat season. Soil dissolved organic carbon and easily oxidizable carbon contents were significantly increased by 21.3%, 24.3%, 38.6%, and 43.5% under wheat straw returning with rotary tillage (WR) than that under CK in rice and wheat seasons, respectively. Soil microbial biomass carbon (MBC) content was highest under WP in rice season, but in wheat season, WR had significantly higher MBC than WP and WD. However, higher SOC content of 8.14 $gkg^{-1}$of soil was found in reduced tilled residue retained plots followed by 10.34 $g\ kg^{-1}$in furrow irrigated raised beds with residue retained plots. Whereas, the lowest level of SOC content of 5.49 $gkg^{-1}$of soil were found in puddled transplanted rice followed by wheat planted under conventionally tilled plots.

Key words: Tillage systems, Agroecosystem, Aggregate associated C, Soil microbial diversity

Effective Utilization of Biofertilizers to Minimize Climate Change Impact

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Biofertilizers have important and long term environmental implications, negating the adverse effects of chemicals. They can add 20-200 kg N/ha year (e.g. Rhizobium sp 50-100 kg N/ha year; Azospirillum, Azotobacter : 20-40 kg N/ha /yr; Azolla : 40-80 kg N/ha; BGA :20-30 kg N/ha) under optimum soil conditions and thereby increases 15-25 percent of total crop yield. Azolla-Anabaena grows profusely as a floating plant in the flooded rice fields and can fix 100-150 kg N/ ha /year in approximately 40-60 tones of biomass produced. Long-term soil and crop management such as the excessive use of inorganic fertilizers and pesticides along with reduced organic manure amendments to the soil, simplified crop rotations and monocultures, the use of heavy machinery, and inadequate practices of soil management exert a considerable influence on soil quality by worsening the physicochemical and biological properties of the soil. The interactions of collective microbial community determine crop health in natural agro-ecosystem by providing numerous services to crop plants viz., organic matter decomposition, nutrient acquisition, water absorption, nutrient recycling, weed control and bio-control. The agriculturally useful microbial populations or plant growth promoting rhizobacteria (PGPR) cover *Azotobacter*, *Azospirillum*, *Rhizobium*, cyanobacteria, phosphorus and potassium solubilising microorganisms and arbuscular mycorrhiza fungi (AMF), whose inoculation to the soil ecosystem advances soil physicochemical properties, soil microbes biodiversity, soil health, plant growth and development and crop productivity.Besides playing role in nitrogen fixation through a variety of metabolic functions Azotobacter has the capacity to produce vitamins such as thiamine and riboflavin, and plant hormones viz., indole acetic acid (IAA), gibberellins (GA) and cytokinins(CK). Abiotic and biotic stresses are the major constraints that affect the productivity of crops. Many tools of modern science have been extensively applied for crop improvement under stress, of which the role of PGPRs as bioprotectants has become of paramount importance in this regard. *Trifolium alexandrinum* inoculated with *Rhizobium trifolii* showed higher biomass and increased nodulation under salinity stress conditions. *Pseudomonas aeruginosa* has been shown to withstand biotic and abiotic stresses. PGPRs as biological agents proved to be one of the alternatives of chemical agents to provide resistance to various pathogen attacks. Apart from acting as growth-promoting agents, they can provide resistance against pathogens by producing metabolites. The adequate use of biofertilizers helps in maintaining soil quality and thus provides a low-cost approach to manage crop yield along with protecting the environment.

Key words: Bio-fertilizer, Climate Change, PGPR

Minor Millets-based Agroforestry of Multipurpose Tree Species of Bhimal (*Grewia optiva* Drummond J.R. ex Burret) and Mulberry (*Morus alba*) for Resource Conservation and Production in North Western Himalayas -10 Year Study

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In Uttarakhand, Himachal Pradesh and Jammu and Kashmir minor millets constitute an important staple diet, but their productivity is low. The area is predominantly rainfed and monocropping is the common practice. The present studies are envisaged with a view to (1) Assess the productivity potential of traditional minor millets viz., finger millet (*Eleusine coracana*) and barnyard millet (*Echinochloa frumentacea*) along with traditional agroforestry multipurpose trees (MPTs) of *Grewia optiva* and *Morus alba* which are the major agroforestry tree species of the North western Himalayas primarily grown by small and marginal farmers for green tree fodder (2) Evaluating the performance of native multipurpose tree species (MPTs) in respect of growth parameters under different land use systems and quantify the tree-crop interactions for maximizing the productivity of the agroforestry system under rainfed situations.

The experiment was laid out in August 2009 by planting 324 saplings of improved provenances of *Grewia optiva* and *Morus alba* in one ha area. High yielding provenances of bhimal (viz. I.C. Bhaintan, I.C. Chamba and I.C. Malas) and mulberry (S1, S146 and S1635) 54 each, were planted in run off size plots (45x15 meter) with uniform plant and row spacing of 5.0 x 4.25 m. Survival percent of bhimal and mulberry was 75 and 96% respectively after one year of planting. The average plant height of bhimal and mulberry at the time of planting was was 77.1 and 73.3 cm which increased to 794.0 and 870.1 cm in ten years with the mean annual increments of 88.2 and 96.7 cm respectively. Like wise the average collar diameter of bhimal and mulberry was 1.63 and 1.33 cm which increased to 18.0 and 21.89 cm with the mean annual increment of 2.0 and 2.43 cm respectively.

The average productivity of improved varieties of finger millet and barnyard millet was 16.5 and 15.2 q ha^{-1} in comparison to 14.2 and 13.4 q ha^{-1} recorded in local varieties registering an improvement of 13.9 and 12.3 per cent respectively.

The average productivity of finger millet and barnyard millet under *Grewia optiva* was 12.1 and 11.3 q ha^{-1} while it was 11.3 and 10.0q ha^{-1} under *Morus alba*, showing considerable tree x crop interaction resulting in declining yield of field crops in the understorey of tree species. This necessitates management of agroforestry trees for successful crop cultivation.

The percentage of water stable aggregates (WSA) was the highest in *Morus alba* land use at 79.3 with the mean weight diameter (MWD)of 2.77 mm and different combinations of mulberry with crops, followed by *Grewia optiva* (WSA 62.9 per cent and MWD 1.07 mm). The field crops of barnyard millets and finger millet recorded 57.1 to 61.4 WSA with MWD of 1.12 and 1.01 mm respectively. The bulk density was the lowest in *Morus alba* + finger millet land use as well as cultivated fallow (1.40) at 0-15 cm soil depth It was followed by Morus alba land use and its combination with barnyard millet at 1.41. Field crops recorded a higher B.D. ranging from 1.42 to 1.45 (0-15 cm soil depth). Increase in soil fertility parameters was evident in different agroforestry land uses in comparison to field crops and tree based land use. The highest increase in organic carbon was recorded in *Grewia optiva* + Barnyard millet (0.75%) followed by *Morus alba* + finger millet land use (0.73%).

Based on 10 years average of studies pure field crop plots of finger millet and barnyard millet run off conservation efficiency ranged from 27-28 per cent respectively, while the combinations of mulberry trees with finger millet and barnyard millet reduced the run off from 31-40 per cent. The run off conservation efficiency due to trees ranged from 16-18 per cent only on 9 years average. The maximum soil conservation efficiency was noticed in *Morus alba*+ barnyard millet followed by *Morus alba* + finger millet at 39.8 and 35.8 per cent respectively. The soil conservation efficiency of field crops ranged from 22-23 per cent in Barnyard millet and Finger millet respectively. The soil loss reduction in trees was 11-16 per cent for *Grewia optiva* and *Morus alba* respectively.

Key words: Improved varieties, Finger millet, Barnyard millet, MPTs, Growth parameters, High yielding provenances

Performance of Halophilic Azotobacter and Phosphate Solubilizing Bacterial Isolates on Wheat Crop Grown in Sodic Soil

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Nitrogen and Phosphorus are two major essential macronutrients limiting the plants growth owing to its low bioavailability in sodic soils. The effect of halophilic azotobacter (Halo-Azo) and halophilic phosphate solubilizing bacterial (Halo-PSB) bioformulations on different growth parameters, nutrition characters and soil fertility were investigated in sodic soil during rabi season of 2016-17 at Krishi Vigyan Kendra, Dhaura, Unnao, India. The experiment was conducted in wheat crop, salt tolerant variety KRL-210 with and without bioformulations. Inoculation of bioformulation promotes the early germination of seeds. The occurrence of first germination was 3 days earlier and the germination percent was up to 12.0% higher as compared to control. Both bioformulations significantly increased the different growth parameters and yield of the crop as compared to control. The increase in grain yield was 12.9% higher with the inoculation of both the bioformulations as compared to 7.7% and 9.3% increase with the solo inoculation of Halo-Azo and Halo-PSB, respectively over control. Both bioformulations were able to improve nutrient content in the plants individually and in co-inoculation. Phosphorus content of the plant increased significantly in Halo-PSB treated plants. Co-inoculation of both bioformulations significantly improved the nitrogen and phosphorus content of the plants. Significant changes were also found in nutrient content of post harvest soil *viz.*, available nitrogen and available phosphors as compared with uninoculated fields. Bioformulation of halophilic isolates significantly increased dehydrogenase activity of soil by 14.9%, 19.72% and 25.5% over the control by the inoculation of Halo-Azo, Halo-PSB and co-inoculation with both bioformulations respectively. Dehydrogenase is an important enzyme for the energy production of organisms. This enzyme is indicator of biological redox systems and microbial activity in soil. Increase in dehydrogenase is indicator of increase in microbial activity due to its larger biomass.

The effect of both bioformulation inoculations together was more pronounced as compared to alone inoculation for improving the crop productivity and soil fertility under sodic stress. With the inoculation of both bioformulations, soil pH decreased substantially over control that shows the noteworthy improvement in the sodic soil. The bioformulation strains tested in the study have the potential for use as biofertilizer in sustaining the growth and yield of wheat salt tolerant variety in sodic soils and mitigating soil stress problem.

Key words: Halophiles, Wheat, Sodic soil, Halo-Azo, Halo-PSB

Microbes Mediated Salt Tolerance Management in Sugarcane and Plant Growth Promotion

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Sugarcane is a huge biomass generating crop and requires 10 to 12 months for maturity. It is being cultivated around 5.0 M ha area in the country and average cane productivity 74 t/ha. The crop is adversely affected by number of biotic and abiotic stresses. Among abiotic stresses, salt is one of them important limiting factor for sugarcane production in the country. In India, according to an estimate around 6.73 M ha area is salt-affected, of which 2.5 M ha is only available in the Indo-Gangetic plain (Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal). The Uttar Pradesh state has maximum sugarcane area and sugar production in the country. Salt affected area is increasing rapidly by an average of 10% per year and in the coming years; maximum cultivatable area will be affected. Soil salinization is mainly due to the poor irrigation management practices and natural causes. Increasing salinity and decreasing crop productivity are the two parallel serious concerns in agro ecosystems. The oxidative stress in plants occurred by higher salt concentration caused ion imbalance and osmotic stress. Salts have detrimental effects on plants such as damage to photosynthetic machinery, growth retardation and ultimately yield loss. Salinity also affects sugarcane plant growth and crop productivity as well. To minimize salt stress, the halo-tolerant plant growth-promoting rhizobacteria are being realized as alleviators of salt stress. These PGPR assist plants to withstand the increased concentration of salts by the production of different organic and inorganic compounds such as Indole Acetic Acid (IAA), ethylene, 1-Amino Cyclopropane-1-Carboxylate (ACC) deaminase, volatile organic compounds (VOC) and antioxidants activities etc.. For this purpose, we have isolated and characterized potential halo-tolerant microbial strains that may help sugarcane plants to survive under saline conditions. These halo-tolerant microbial strains may be the potential to work as defensive agents of plants by enhancing crop growth, productivity, tolerance and defense system in sugarcane agro-ecosystem.

Key words: Sugarcane, PGPR, Salinity

Soil Microbial Population is the Mirror of Soil Health

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An investigation was carried out to study the "Soil microbial population is the mirror of soil health" under incubation in the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar-pradesh. The experiment were laid out in Completely Randomized Block Design with twelve treatments replicated three times. N, P, K were applied through urea, single super phosphate and muriate of potash, respectively. While the total amount of organics were applied 14 days before incubation study. Microbial population of the experiment under incubation as bacterial population g^{-1}soil $x10^5$, control (T_1) treatment was show lowest at different days of incubation. There was an increase in microbial population of other treatments due to addition of organic and inorganic sources of nutrients at each days of incubation. Addition of fertilizers and manures either in combination or in alone has significantly shown as increase in bacterial population over control (T_1). The highest and lowest bacterial population was recorded at 90 and 0- days of incubation; whereas the treatments receiving 100% N through FYM were showed maximum population of bacteria through out experimentation periods. The at par values were observed in the treatments of T_3 to T_7 and T_8 to T_{12} except T_8 and T_{12} treatments at different days of incubation. All the treatments show superiority over initial value of bacterial population through out incubation periods. The population of fungi was maximum and minimum observed at 60 and 0- days of incubation due to different treatments under different periods of incubation. Incorporation of nitrogen through alone organic treatments (T_8 to T_{12}) increased significant fungal population over control (T_1). Similar, to the population of bacteria; fungal pupation has also showed maximum and minimum population in the treatments of 100% N through FYM (T_8) and control (T_1) respectively, through out the experimentation periods under incubation study. Among the treated conditions alone nitrogen through organic sources given better response over other treatments under incubation at different days. Most of the values were at par with each other in the treatment of integrated approaches (T_3 to T_7) and organic alone treatments (T_8 to T_{12}) in respective days of incubation. Declined trend was started from 90 days of incubation in all the treatments in fungal population over 60 days of incubation. Application of N through organic manures / wastes alone treatment (T_8 to T_{12}) were recorded maximum population of actinomycetes over other treatment under incubation study at deferent days. Similar, to the population of bacteria and fungi the highest and lowest population of actinomycetes were recorded in the treatments receiving FYM alone (T_8) and control (T_1), respectively at different days of incubation. Among the different days of incubation the maximum and minimum values were observed at 60 and 0- days respectively. Most of the values were at par with each other in the treatment T_3 to T_7 and T_8 to T_{12}; except T_8 and $T_{10.}$

Key words: Organic sources, inorganic sources, microbial population under incubation study

Nutrient Dynamics and Enzyme Activities during Enriched Composting with Low Grade Rock Phosphate and Native Nutrient Solubilising Microbes

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Agriculture plays a critical role in the economic development and poverty alleviation in developing countries. Also, agricultural sustainability is imperative for a sustainable agriculture. There must be a positive link between its supply and demand. Unfortunately, this linkage has been disturbed by many factors from which the deficiency of the nutrients particularly that of phosphorus (P) has been a major one. Moreover, its application to the soil in developing countries has been slowed down due to alarming increase in its price. Of the three major plant nutrients, phosphorus (P) is exclusively sourced from geological materials. The nutrient is mined and processed to give fertiliser products but the quality mineral/ores are often limited in India. Instead we are endowed with various low-grade mined ores in different part of country. The eco-friendly and safe utilization of such low-grade mineral/ores is a concern of government.

A viable option for various bio-degradable wastes is composting, which is a biological process that uses native microbes to convert bio-degradable organic matter into a humus-like material commonly known as compost. The process has numerous advantages including bulk volume reduction and waste utilization. Generally composts prepared from farm wastes have low nutrient content, particularly P (0.2-0.4%). A possible means of improving the nutrient content in compost is to prepare enriched organo-mineral fertilizers by addition of low-grade materials such as rock phosphate (RP) (<20%). An experiment was conducted to study the changes in various major nutrients during preparation of enriched organo-mineral compost using farm waste (weeds and crop residues), low grade rock phosphate (18.9%P) and *Femitopsis melei* that has potential to solubilise both P. Composting reduced the total carbon (C) but increased total N content as it progressed over time. This was reflected in the decrease of the C/N ratio. Significant increases in total P was also observed where rock phosphate was added individually and combined along with native microbes. Microbes solubilise more of P (2.8-3.6%). High alkaline and acid phosphatase activities were high in the poultry manure piles from the beginning of the test, reaching maximum activity by the end of the testing period. Overall, a moderate level of fluorescein diacetate (FDA) (esterase, lipase and protease) was observed at the beginning of composting. The activity of FDA increased as composting progressed. This composting process represented a combined activity of a wide succession of environments in the compost pile as one microbial group/enzyme overlapped the other and each emerged gradually as a result of the continual changes in temperature as well as moisture content, O_2 and CO_2 level, and progressive breakdown of complex compounds to simpler ones.

Key words: Nutrient dynamics, Enzyme activity, Enriched composting, Nutrient solubilising microbes

Reclamation of Cement Dust Contaminated Soil using an Exotic Earthworm Species *Eisinia fetida* under Laboratory Condition

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Contaminations of soil with cement dust have been reported to cause alteration of physicochemical properties of soil, accumulation of heavy metals and loss of fertility.The present study aims to investigate the effect of earthworm sps (*Eisinia fetida*) in reclaiming the cement dust contaminated soil. LC_{50} value of the cement dust was determined through an acute toxicity testing using probit analysis. Toxic effect of cement dust below sub-lethal on *E. fetida* was studied following exposure for 7, 14, 21 and 28 days. Reactive oxygen species level, lipid peroxidation and changes in catalase activity *E. fetida*were assessed using standard methods. Alteration of soil properties and heavy metal (Pb and Cd) were performed following incubation of *E. fetida*in cement dust amended soilfor 28 days to assess its reclamation potential. Cement dust found to be highly toxic to *E. fetida* with LC_{50} value 2.08g/kg BW and induced oxidative stress in earthworm. Incubation of earthworms for 28 days modulated soil pH, increased OC and OM content, increased nitrate and phosphate content in a duration dependent manner. *E. fetida* was highly effective in removing Cadmium from cement dust amended soil but did not uptake lead (Pb) from the soil. *E. fetida* improved soil health by increasing soil amylase activity. The present study demonstrates that Soil invertebrate like *E. fetida* can partially reclaim the contaminated soil if contamination is sub- lethal and remove heavy metals selectively from contaminated soil.

Key words: Cement dust, Heavy metals, Soil reclamation, Toxicity

Resistance and Resilience of Soil Microbial Groups in Long-term Fertilizer Experiment against Moisture Stress

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The ecological stability of soil biota under stress atmospheres can be assessed by two aspects *i.e.* resistance and resilience. We investigated the effect of long-term (47 years) application of chemical fertilizers and farm yard manure (FYM) on soil microbial groups (*bacteria*, *fungi, Actinomycetes* & *ammoniaoxidisingbacteria*) and dehydrogenase activity (DHA) and their resistance and resilience against moisture stress in Alfisol. To accomplish this, soil samples (0-15 cm depth) were collected from seven selected treatments (control, N, NP, NPK, NPK+hand weeding, NPK+FYM & NPK+Lime) under soybean (*Glycine max*) crop in 2018 from the on-going Long-term Fertiliser Experiment (LTFE) of Birsa Agricultural University, Ranchi. Samples were exposed to moisture stress (air dry soil moisture) and incubated for 60 days at 28 ºC with optimal moisture content (2/3rd water holding capacity). Soil microbial population and DHA were analysed at 1, 15, 30 and 60 day(s) after moisture stress.The results indicated that, long-term application of FYM significantly alter soil microbial groups and DHA. Balanced application of NPK along with hand weeding recorded significantly higher values of soil parameters over balanced application of NPK with weedicide. Moisture stresses significantly decreased the DHA and different microbial groups.The magnitude of reduction varied between 25-88% among studied parameters. The extent of reduction of different soil microbial groups due to moisture stress was highest in N alone (100% N) and NP (100% NP) treatments. Interestingly, continuous hand weeding with balanced fertilization helped in build-up of higher resistance and resilience of soil microbial groups as compared to weedicide with balanced fertilizer application. Among the soil microorganisms, resistance and resilience of ammonia oxidising bacteria was lowest, while fungi and actinomycetes were at par and higher than those of bacterial population.Relationships between different microbial groups (bacteria, fungi, actinomycetes and AOB) and resistance and resilience of DHA revealed that, resistance index of dehydrogenase activity was more consistently associated with initial level of bacterial (r^2=0.45) and AOB (r^2=0.45) than *Actinomycetes* and fungal population under stress. However, under similar abiotic stress, resilience index of dehydrogenase activity at 15th day was correlated well with actinomycetes (r^2=0.80) and bacterial (r^2=0.77) population in soil. It can be concluded that, application of farmyard manure with balanced NPK was the most effective in improving the microbial population as well as resistance and resilience of capacity of soil against moisture stress.

Key words: Soil function, Abiotic stress, Soil microbes, Manuring and fertilization

A Brief Inventory on the Soil of Orchha Wildlife Sanctuary, Madhya Pradesh

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Orchha wildlife sanctuary is located between the Jamni and Betwa rivers in Niwari district of Madhya Pradesh, extending up to 44.91 square kilometre. The area remains relatively unexplored and calls for recording of both soil and floristic data to ensure better management and conservation. This research deals with analysis of physical and chemical properties of the soil present in and around various sites of the Orchha wildlife sanctuary. The slightly acidic soils present in different locations in the sanctuary are predominated by sandy loam texture and reddish to red colour of soil. Soil moisture, soil organic carbon and available nitrogen were found to be in low range. Available potassium, calcium, magnesium and sodium were found in moderate range. In micronutrients, iron was present in marginal concentration, zinc was found to be deficient, copper in high concentration and manganese ranged from marginal to high. This account holds importance in context of floristic assessment of the area.

Key words: Soil, Orchha, Physico-chemical properties

Study on the Hydrological Characteristics of Biological Soil Crusts in Different Desertification Ecosystems

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Biological soil crusts serve as a vanguard for improving the ecological environment in arid, semi-arid desertifification desertification areas. It is a good indicator of the level of improvement which the local ecological environment is undertaking. In desert areas, water condition is a key factor ofin improving the ecological environment. As a fifirst first layer protection, biological crusts play an important role in local vegetation succession due to their abilities to conserve and maintain moisture. Study on hydrological characteristics of biological soil crusts in different desertification ecosystem areas results shows that: (1) Biological soil crusts had effects on stopping soil water infiltration. And along with rainfall increasing, the ability of infiltration barrier by biological soil crusts was lower. With the development of biological soil crusts, biological soil crusts thickness increased the ability of infiltration barrier by biological soil crusts increased. In addition, the ability of biological soil crusts blocking the water in Mu Us sandy land was better. (2) Biological soil crusts on the performance of evaporation were carried out by analyzing the variations of daily and cumulative evaporation. Different types of biological soil crusts and site conditionsdetermine the effect of biological soil crust on the moisture to evaporate when the rainfall is small (< 25mm). Biological soil crust had an inhibitory effect on moisture evaporation in the condition of largerprecipitation (25 mm). (3) The average and quantity of condensation water were increasing with the development of biological soil crusts. And the average and quantity of condensation water in Mu Us Desert was larger than that in Ulan Buh Desert. The formation of the condensation water was affected by the change of air relative humidity, surface and air temperature, and the difference between atmospheric temperature and surface temperature. Study on biological soil crusts hydrological characteristics in a different desertification ecosystem, which can provide theoretical basis and technical support for the effective utilization and biological crusts scientific management for the soil water content in desert area, desertification area of biological crusts become a new way to control soil loss of biological put forward scientific hypotheses, the biological crusts better recovery for the ecosystem area and the ecological environment construction services.

Key words: Biological soil crusts; Water infiltration; Water evaporation; Desertification Areas

Role of Plant Extracts in Sustainable Agriculture: A Brief Review

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The overzealous and indiscriminate use of most of the synthetic pesticides has created different types of environmental and toxicological problems. The optimum growth of agricultural crops has been hampered by a number of factors such as attack of insects and disease infection. Plant pathogens account for about 20% reduction in the principal food and cash crops produced worldwide. Recently, in different parts of the world, attention has been paid towards exploitation of different types of plant extracts as novel technique in green agriculture. The popularity of botanical pesticides is once again increasing and some plant products are being used globally as green pesticides. Pyrethroids and neem products are well established commercially as botanical pesticides and recently some essential oils of higher plants have also been used as antimicrobials against storage pests because of their relatively safe status and wide acceptance by the consumers. In the context of agricultural pest management, botanical pesticides are best suited for use in organic food production in industrialized countries but can play a much greater role in the integrated pest management of agricultural crops. A large number of synthetic chemicals have been developed for the control of plant diseases, but due to growing awareness of their hazardous side effects, more and more emphasis is being placed on the use of bio-control agents. Consequently, researchers from all over the world now pay more attention to the development of alternative methods which are environmentally safe, non-toxic to humans and animals, and rapidly biodegradable. Plants are natural laboratories in which a great number of chemicals are biosynthesized. Many of the resulting plant extracts are non-polluting, cost effective, non-hazardous, biodegradable and can be safely used as alternative to synthetic pesticides. Numerous plant extracts have been identified for applied purpose such as onion (*Allium cepa*), ginger (*Zingiber officinale*), Neem (*Azadirachta indica*), garlic (*Allium sativum*) papaya (*Carica papaya*), independent weed (*Chomolaena odorata*), bitter kola (*Garcinia kola*), miracle tree (*Moringa oleifera*) etc. Plant extracts are cheap, environmentally friendly, readily available, and are therefore recommended for sustainable agricultural and horticultural production.

Key word: Agriculture, Plant extracts, chemicals, fungicides, Pests

Impact of Climate Change on Biodiversity

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Many investigations in recent years have studied the effects of climate change on the future of biodiversity. The relationship between climate change and biodiversity has long been confirmed. From a general perspective, the rapid change in climate and alarming biodiversity loss risks human livelihood (e.g. a mega change in the food chain, change in quality and quantity of water sources, decline in medicines and other bio-resources from biodiversity. Climate change is having a significant and potential impact on biodiversity, and is predicted to become a progressively more alarming threat in the near future. Loss of Arctic sea ice threatens biodiversity damage across an entire ecosystem and beyond. The related pressure of ocean acidification, resulting from higher concentrations of carbon dioxide in the atmosphere, is also already being observed and documents.The inter-connected nature of ecosystems and biomes means that the loss of species can have knock-on and very detrimental effects upon a range of ecosystem functions. Climate change is affecting the habitats of almost all species on this planet, which must either adapt or migrate to areas with more favourable conditions. Even small deflection in average temperatures can have a remarkable impact on ecosystem diversity. Some species may benefit from climate change (including, from a human point of view, an increase in diseases and pests) but the rapid nature of the change suggests that most species will not find it as beneficial as most will not be able to adapt. Thus, there is an urgent need for monitoring of impacts, specifically targeted to assessing the impacts of climate change would support the most effective adaptation responses possible under highly uncertain circumstances. There are still many gaps in our knowledge to correlate the impacts of climate change on biodiversity. An interdisciplinary research programme could possibly focus only on one or few of the identified research issues, and should generate input data for predictive models based on climate change scenarios.

Key words: Climate change, Biodiversity, Carbon dioxide, Global warming

Assessment of Climate Smart Agricultural Practices in North East India

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The domains of Adaptation, Mitigation and Food Security apropos of Climate Smart Agricultural (CSA) practices and its dimensions need to be ascertained before its dissemination and hence it requires appropriate examination. There need of appropriate study in order that research institutions and government mechanisms augur well in understanding farmer's behavioral intention to adopt CSA Practices, to disseminate information, ensure broad participation and harmonize policies. Therefore, considering the above essentials, the present study was conceptualized to assess and ascertain CSA practices in North East India into the domains of Adaptation, Mitigation & Food Security. The study followed descriptive research design. Multi-phase convenience sampling has been adopted in the study. The respondents in the study were agriculture and allied professionals having at least two years of experience in climate change research and extension services in the states Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland and Tripura. The study unveiled that under the domains of Adaptation, Mitigation and Food Security, the CSA practices *viz.*, *'Agri-horti-duckery-fishery based farming system, Farming system model for food & nutritional security and Fish-pig-tuber crops based farming system'* have been ranked the most important CSA practices respectively. On administering the *Jonckheere-Terpstra* Test for testing the conformity in the ranks given by respondents, it was divulged that the CSA practices in the domains of Mitigation and Food Security were significant @ 1% level of significance with *p*-values of 0.001 and 0.006 respectively; however CSA for the domain of Adaptation was found insignificant having*p*-value 0.786. The research strongly advocates that more research and refinement are needed to generate champion CSA options for effective adoption by farmers.

Key words: Climate Smart Agriculture, Adaptation, Mitigation, Food Security, North East India

Persistance of Pretilachlor and Pendimethalin Residues in Rice – Mustard – Sesbania Sequence under Conservation Agriculture System

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Weed management is one of the major considerations for realizing higher productivity. Yield loss due to uncontrolled weed growth in transplanted rice ranges from 16 - 86%. Herbicides are being used to ensure the production of enough supplies of food, fibre and protection of human and livestock health. Chemical control of weeds is often preferred due to its economic and efficient control compared to manual and mechanical methods. However, the potential hazard of herbicide residue in soil is a great concern to all quarters. Accordingly, a study was initiated during 2016 with tillage practices viz. conventional and minimum tillage along with application of Pretilachlor and Pendimethalin as pre emergence weed management practices at Instructional-cum-Research Farm, Assam Agricultural University, Jorhat-13, in rice – mustard - sesbania system. The experiment was comprised of five treatments in rice viz. T_1 and T_2 – Conventional Tillage (Transplanted) ; T_3 – Conventional Tillage(Direct-Seeded); T_4 - Minimum Tillage(Direct-Seeded),T_5 – Minimum Tillage(Direct-Seeded) with plant residue incorporation.However, in mustard the treatments were - T_1 and T_3 – Conventional Tillage ; T_2 - Minimum Tillage, T_4 and T_5 – Minimum Tillage with plant residue. Basundhara was used as the rice variety both in transplanted as well as direct seeded rice and NRCHB – 101 as the mustard variety. The soils of the experimental field was sandy loam, acidic (pH 4.5) with CEC 6.18 cmol(p^+)kg^{-1}. From the study it was observed that the Pretilachlor residue detected in soil on the day of application was in the range between 0.334 – 0.386 microgram g^{-1} and observed till the range between 0.008–0.124 microgram g^{-1} on the 30th day of application of pretilachlor. Similarly, Pendimethalin residue detected in soil on the day of application was in the range between 0.936–0.992 microgram g^{-1} and observed till the range between 0.008–0.075 microgram g^{-1} on the 30th day of application of Pendimethalin. Results revealed that herbicide residue detected at below detection limit in soil from 60th day of application of herbicides with minimum tillage in rice and mustard crop. However, conventional tillage recorded herbicide residue at below detection limit in soil at harvest in rice and mustard crop.Significantly lower amount of herbicides residue was resulted from the combination treatments of minimum tillage with direct seeding rice and residue incorporation. The half life recorded with Pretilachlor was (5.0–9.0) days and with Pendimethalin was (4.0–7.0) days. Appropriate weed management through application of herbicides are important for efficient control of weeds, increasing nutrient use efficiency, improving and sustaining soil health and ultimately crop productivity while maintaining residue of applied herbicide in soil and crop at minimum level.

Key words: Weed Management, Pretilachlor, Pendimethalin, Herbicide residue, Half life

Enhancement of Productivity in Rice-Wheat Cropping System through Climate Smart Agriculture

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Rice-wheat cropping system is the predominant cropping system followed by farmers of the entire Indo-Gangetic plains. In the midst of climate change scenario, the productivity of this predominant cropping system has become vulnerable to erratic monsoon rainfall during rice growing season apart from occurrence of high temperature stress that the wheat crop faces during flowering to maturity. In order to achieve potential productivity, it is essential to assess the sowing window of rice-wheat crop through field experimentation and assessment of crop weather suitability. Efforts have been made to pre-pone transplanting of high yielding, long duration rice varieties by utilizing available rainwater along with various climate smart interventions (*e.g.* 3 HP single phase motor pump/ tractor mounted solar pump/solar pump). The experiment has also been conceived for better understanding and prediction of relationship between two or more weather parameters and grain yield of crops for yield prediction before actual harvesting of the crop. Thus, optimum sowing time needs to be standardized for every agro-ecological situation for success of Rice-Wheat cropping system in the State. Accordingly four high yielding rice varieties, which have been selected on the basis of first year experiment, were planted on four different dates (05.06.2018, 25.06.2018, 15.07.2018 & 05.08.2018) in split plot design and their performance was assessed on the basis of various agro-meteorological parameters. The results showed that first date of sowing (15.05.2018) and transplanting (05.06.2018) was found to be highly productive. Among rice varieties, Rajendra Mahsuri outperformed all other varieties giving an average yield of nearly 62-65 q/ha. All the irrigation parameters like IWP, AIWP and WUE exhibited highest value for Rajendra Mahsuri establishing the fact that it can achieve highest yield potential when sown on 15th May and transplanted on 5th June. Varieties transplanted on 5th June were harvested around 10-15th October. Similarly, seven high yielding wheat varieties including both timely and late sown were sown on four different dates. The first date of sowing (10th November) was found to be highly productive based on all parameters employed in case of rice. Among wheat varieties, HD 2967 performed best giving an average yield of 45-48 q/ha. Varieties sown on 10th November were harvested on 23rd March, 2018. Harvesting of wheat varieties by 20th - 25th March may save the crop from hailstorm, westerly winds and terminal heat stress.

Key words: Rice-wheat, sowing time, stress

Sustainable Agriculture for Natural Resource Management and Bio-diversity Conservation

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The growing use of off farm production inputs means that largely closed systems are being increasingly opened up. Almost all existing fertilizers such as phosphorous and nitrogen based fertilizer are produced using energy-intensive methods involving the use of oil and gas. In addition, phosphate based fertilizers relies on the using of phosphate, a finite and unsustainable resources and a production process using various toxic chemicals. Sustainable agriculture is regenerative and self sustaining. It produces its own inputs (crop based manure) in a closed loop cycle and contribute to soil fertility, clean water system, biodiversity and other ecosystem services, rather than depleting the natural resources. This practice increases organic matters in soil, sequester carbon and support diversity. One of the major benefits to the environment is that sustainable agriculture use 30 per cent less energy per unit of crop yield in comparison to industrial agriculture. This reduced reliance on fossil fuels results in the release of less chemical and pollution into the environment. It also benefits environment by maintaining soil quality, reducing soil degradation and erosion, and saving water. The agriculture community is thus setting up hopes on sustainable agriculture which will maintain the cycle of input-output and ecosystem balance.

Key words: Industrial agriculture v/s sustainable agriculture, natural resource management, bio-diversity conservation and eco-system balance

The Bio-computational Models in Flowering Plants of Agricultural Applications towards Sustenance

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Today there may be concern in rising of temperature globally. May be more in tropical climate. Due to which instances of male formation in plant, restricted plant flowerings are found in summer months. Temperature may not be only factor that determine such mal happenings. On the other side prevalent soil moisture helps in plant flowerings adequately. This is the reason when we follow most preferable cropping system surrounding fisheries peripheral spaces for crop assurance and more sustenance. Authors felt a few computational models that may help in plant biotechnological applications and with some specific evidences in tropical climates. Now-a-days, this may be easy to estimate total plant-biomass existing in certain geographic farm using remote sensing. This communication have estimated that total biomass of a plant may not be indicative to the amount of flowering or fruiting in any orchard or certain geographic vegetation, however, the mere stem-cells either in mass or volume are indicative the proportionate amount of flowerings. Whereas total canopies in mass or volume may proportionately relates to amount fruiting of vegetation, specially in agricultural crops of any climate. Co-efficient of flowerings with respect to effective stem-mass is very much constant for specific plants of certain geography. Hence it can be concluded that more the effective stem-mass, more may be the proportionate flowerings of the same plant. Co-efficient of fruiting with plant canopy may also be constant for a certain plant in specific geography. Moisture in plant tissue, naturally, specially in effective stem makes more mass or volumes to produce flowerings and fruiting in agricultural crops, with assurance,

Key words: Plant biotechnology, Effective stem-mass, Stem-volume, Proportionate model, Plant flowering and fruiting

Floral Diversity in the Nongpok Ningthou Chingu Panganba Sacred Groves of Andro, Imphal East, Manipur

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Nature worship is an age old traditional tribal belief based on the premise that all creations of nature have to be protected. The traditional practice shows the symbiotic relation between the human beings and nature. Indigenous communities all over the world lived in harmony with nature and conserved its valuable biodiversity. Due to such beliefs, some forests have been preserved in pristine forms which are called "Sacred groves". These Sacred groves are the only remnants of the original forests and are often part of the heterogenous landscape intermingled with agricultural field, plantation, barren land, water bodies as well as villages.

The study was carried out in the Nongpok Ningthou Chingu Panganba Sacred groves, located in the villages of Andro, Imphal East Districts. These sacred groves has an area of approximately 4.04 acres of land, protected by Chakpa community of Andro. Floral diversity of these sacred groves were surveyed during 2017-2018. A total of 17 random quadrat was laid down through random sampling. A total of 28 tree species, 5 species of herbs and 13 species of herbs belonging to 25 families was reported. Among the tree species, the highest frequency of tree species was recorded in *Quercus serrata* and *Pasania pachyphylla*. The lowest frequency was reported in *Flacoutia jangomas*, *Lannea grandis, Stereospermum chelenoides, Xylosma longifolia, Albizzia lebbeck, Celtis timorensis, Amoora wallichii, Psidium guajava, Phoebe hainesiana, Eucalyptus spp*., *Cedrela toona, Erythrina indica* and *Meyna spinosa*. Highest density of tree species was reported in *Quercus serrata* and lowest density was reported *Flacourtia jangomas, Lannea grandis, Stereospermum chelenoides, Albizzia lebbeck, Celtis timorensis, Amoora wallichii, Phoebe hainesiana, Eucalyptus spp*., *Cedrela toona, Erythrina indica* and *Meyna spinosa.* The Important Value index (IVI) of tree species was highest in *Quercus serrata*. The IVI of shrubs was highest in *Lantana camara* and that of herbs was highest in *Panicum sphaerocarpon.* Sacred groves play an important role in maintaining the local micro climate as well as in mitigating climate change by acting as sink of carbon. So, conservation of sacred groves is a must for every citizen.

Key words: Sacred groves, Diversity, Chakpa, Andro, Manipur

Evaluation of Antagonistic Potential of Certain Plants against Root-knot Nematode *Meloidogyne incognita*

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In the present investigation, an effort was made to evaluate antagonistic potential of some plants against root-knot nematode *Meloidogyne incognita* through sustainable farming. Instead of using chemical fertilizers for control of root-knot nematode, intercropping of susceptible plants with root-knot nematode antagonistic plants were done at field level. In a screening trial, nine different antagonistic plants viz. marigold, garlic, mustard, chrysanthemum, strawberry, periwinkle, sesame, broccoli and castor were tested against *M. incognita*. All these antagonistic plants produce very low number of galls, resulting low root-knot index compared to the susceptible control. Among these plants, marigold, periwinkle, garlic were found to be in the resistant category, while Broccoli was found to be moderately resistant.

In a root-knot infested field, these four plants were intercropped with root-knot susceptible tomato to see the antagonistic effect of these plants on root-knot nematode. All the treatments with these four intercrops were found to be effective in reducing number of galls, egg masses and final nematode population in soil subsequently increasing plant growth parameters. The treatment with periwinkle was found to be most effective in increasing the growth parameters viz. shoot length, shoot weight, root length and root weight of tomato with corresponding decrease in number of galls, egg masses, final nematode population in soil. The increase in yield of tomato per ha was maximum when tomato was intercropped with periwinkle, followed by marigold.

Key words: Antagonistic plants, Root-knot nematode, Management, Intercropping

Vegetation Affects Collembolan Population of Home Garden Agroecosystems of a Rural Area

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The home gardens are agroecosystems of biodiversity significance. They provide food, fodder and medicine in addition to ecosystem services. The soils in home garden agro ecosystems harbor a large numbers of micro and macrofauna. Among these soil fauna, microarthropods are considered to be indicators of soil pollution in home garden agro ecosystems. Compared to other microarthropod groups, collembola are well studied and have been used as indicators of soil health and soil disturbance. The vegetation in home garden agro ecosystems has influence on collembolan population and influence their abundance and spatial distribution. The study examines the effect of vegetation cover and plant functional groups on spatial distribution of collembola in home garden agro ecosystems of a village in Kerala. Soil microarthropods were sampled from 25 home garden agroecosystems, and identified upto group level collembolans were selected and abundance was estimated. The seasonal abundance of collembola was compared. Simultaneously vegetation cover in the home gardens and number of plant functional groups per home garden were estimated. The results showed that vegetation cover and plant functional groups showed significant positive correlation with collembolan abundance in the home garden agro ecosystems. This point to the fact that increased canopy cover and plant species diversity can have a positive effect on the soil quality of home gardens by enhancing the presence of collembolans in the soils, which can be a simple practice that can be adopted by common people irrespective of their scientific knowledge.

Key words: Abundance, Canopy cover, Functional group, Home garden management, Soil quality

SESSION-VI

Socio Economic Issues in Resources Management for livelihood Security

Socio-economic Dimensions in Soil and Water Conservation

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Despite years of study and substantial investment in remediation and prevention, soil erosion continues to be a major environmental problem with regard to land use in India and elsewhere around the world. Furthermore, changing climate and/or weather patterns are exacerbating the problem. Ranjan Bhattacharya *et al. (2016)* found that to achieve success in soil and water conservation policies, institutions and operations must be coordinated using a holistic approach. Watershed programmes have shown to be one of the most effective strategies for bringing socio-economic change to different parts of India. Within dryland and rainfed areas, watershed management has quietly revolutionized agriculture by aligning various sectors through technological soil and water conservation interventions and land-use diversification.

A participatory approach has been adopted in watershed management during the last decade in many developing countries. Participatory Watershed management is meant for growing biomass, the pipeline for prosperity of the people for bridging the gap between poverty line and per capita income. In achieving this objective, the people's part is awareness, participation and response. The state should revise the methods and methodologies as frequently as possible as long as they are appropriate and economical. Whatever may be the value of a plan, the impact of participatory watershed management depends on effectiveness of the technology in the background of needs, priorities, cultural practices and community participation.

The major issues of social dimensions in soil and water conservations particularly for watershed development consists of lack of scientific knowledge regarding severity of soil erosion and its impact on crop productivity, lack of community management, social stratification and inequality, lack of ownership feeling in farmers, etc. Fragmentation of land in small pieces due to increasing population is one of the major constraints in community watershed development which limits the scientific treatments of soil and water conservation due to its feasibility in such a small piece of land. Traditional disputes amongst farmers always are always proven hurdles in such activities. In Deccan plateau of Maharashtra, shallow groundwater acquirers having early recharging and early drying characteristic do not give sustainable results for water availability. Adequate funding from scientific soil and water conservation treatments also limit the adoption of technology. In spite of this, there are many successful examples of community watersheds and its impacts like Kadwanchi in Maharashtra.

The Kadwanchi watershed in Jalna district of Maharashtra implemented during 1997-2002 covering an area of 1888 ha was re-visited during 2012 after a gap of 10 years to draw lessons from the success and understand the drivers of sustainability. The in-situ conservation measures in the form of field bunding and ex-situ through check dams complemented each other and improved both surface and ground water availability. As a consequence of water resource development, a shift in the land use, cropping pattern and conversion of fallow and culturable wastelands to cultivable land was observed. All the crops registered higher productivity and the production was doubled during the kharif and rabi season while increase in horticultural production was several folds mainly due to cultivation of grapes. The post-project scenario also noticed change in composition of livestock with more number of cross-bred cows, which is attributed to increase in availability of fodder due to higher cropping intensity (from 132 to 175%) and cultivation of fodder. The success of watershed led to the improvement in physical assets, individual farm houses and created an exemplary model of construction of internal roads to a length of 42 km by farmers themselves. The schemes of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), thrift by SHGs and subsidized electricity for agriculture were found to be of little significance. Farmers are willing to mobilize the funds to pay the cost of electricity as per the norms of industry. The post-project sustainability is attributed to the factors such as proper facilitation by the implementing agency, active participation by the community, judicious use of water, convergence with other schemes and collective leadership.

Good leadership and community participation led to the success of watershed programme and similar replication is possible in other areas by following the key drivers of success namely transparency in implementation of the programme, active participation by the community and improved availability and access to both surface and ground water. The watershed has amply demonstrated that the sustainability of NRM works relies on capacity building of the community and their hand-holding. There are several successful watersheds, but Kadwanchi is one of the light houses in the country for donor agencies, implementers, scientists and farmers as well for studies on "what next after watershed".

Key words: Community watersheds, capacity building, watershed programme

Socio-Economic Issues of Sustainable Soil Management - Hilly Area of Serbia

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According to the natural characteristics, Serbia is predisposed to erosion processes. However, both worldwide and in Serbia, a large percentage of erosion processes are contributed by anthropogenic factors. The activity of man can be both negative and positive, depending on the degree of awareness of the importance of using natural resources on the principles of sustainability.

Preventing the degradation of torrential floods and erosion processes contained in the sustainable management of land resources, which includes the use of participatory methods. The paper presents the participation of the community in the management of natural resources (CBNRM), according to which the community becomes the primary implementer, with the assistance and under the supervision of professional services. In the case of public participation in the sustainable management of land resources Grdelica shows the socio-economic and ecological approach of the local population.

This paper also presents a model of sustainable management of land resources, adapted to the conditions of hilly-mountainous areas of Serbia, which includes the planning of production on sloping terrain from the aspect of land resources, then the needs of the population for certain localities particular production, and profitability of planned production. Regarding ecological effects of the model of SLM, soil loss is reduced under the level of tolerance in the researched area. Economic effects of the established model of SLM, proved by Benefit-Cost Analysis, are on the satisfactory to significant level. These reasons are enabling people to stay and survive in these regions.

Key words: Land degradation, Sustainable management, Economic effects, Environmental effects

Future Trajectory: Climate Resilient, Profitable and Equitable Conservation Farming

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Focused endeavor for sustaining humanity, economic activities and environment is now a compulsion for our future. Seven decades of Soil Conservation in India has provided good insight. Imparting climate resilience, profitability and equity has to be inclusive of Community; Production possibilities; Market and Natural Resources both Terrestrial and Aquatic. Resource conservation and production systems have to be managed within the frame work of Farm Holdings; Agro-ecosystems; Village; Watershed and Region. Efforts made on imparting agro-ecosystems specificity and application of harvested water led to increased production of 5t, 6t and 8t per ha over only 3 t/ha. Scaling up to village level with 37 farm families; it could integrate fruits, vegetables and fisheries. Diversification reduced climate effect and raised income by INR 130 thousand/ha/yr eq. over only < 60 thousand.

Scaling up to regional scale over 3,500 farm families; components of drainage line treatments, water harvesting and perennial vegetation to non-arable land over 485 ha, imparted climate resilience and assured livelihood to landless farmers. Adoption of water harvesting, protected cultivation, fisheries, poultry, vegetables and diversified farming over 570 ha, resulted high profitability. Harvested water of > 90,000 m^3 resulted higher income of INR 2,368 th /yr. Allied activities of service providers and generated employment to youth. Total of 14,800 man days of employment per yr could be generated for 3,500 farm families.

Nationally, models evolved with natural resource management, high productivity, high pay-off production systems, logical intensification and diversification, applied resources, energy, value addition and marketing from 102 disadvantaged districts (ICAR) by author.

Challenge remains for soil and water conservation to be way of farming and what prevents their adoption? Resource Augmentation need paradigm shift by Improving the gains, reducing the losses and aiming at augmented status of water, nutrients, vegetation, and soil quality, productivity and cost reduction. Integration of traditional with modern knowledge is a key factor for its success and wider adoption. Soil Conservation Business Model can offer an inclusive frame work -

Eco region / Resource Conditions / Support/ Applicability

Production Systems/Allied Activities/ Domestic and Market needs/ Processing/Client specificity

Agenda next involves - Making resource conservation as a way of farming; Quantification, Applicability; Bankability; and necessary skills as an enabling policies; Market intelligent, climate smart farming systems; Required Research, Technology, Infrastructural support and hand holding and Farming as a preferred profession.

Key words: Climate resilience, Inclusivity, Conservation farming, Business model, Scaling up

Efficient Resource Management for Sustainable Forage-Food Production in Bundelkhand Region of India

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In central India, Bundelkhand region is characterized by a semi-arid climate experiencing recurrent drought once in 3-4 years. Due to soil & water related constraints, the agriculture in this region is mainly mono cropped and subsistence type fails to support huge human and livestock population and remains to be low productive, less profitable and high risk activity. *Annapratha* (free grazing by livestock) has been setback for crop production and also the reason for migration of rural mass for search of job. Analyzing this situation and based on field survey, the issues and constraints were deliberated upon to take up project on devising problem based concepts and developing scientific intervention and technologies for food – fodder security. The project on climate resilient resource conservation approaches for sustainable crop production from rainfed areas was carried out. The findings of the research project clearly exhibited that under climatic aberrations of rainfed semi arid region, diversification of existing cropping system through inclusion of hedge rows of perennial shrubs like sesbania and subabul and seasonal legumes as intercrop under ICMP (Integrated crop management package) along with mulching with available plot waste and loppings of hedge rows of perennials once in a season performed better and gave higher yield, more economic return, efficient utilization of energy and maintains soil health. For rainfed ecosystem of Bundelkhand efficient cropping systems viz., Dual purpose sorghum + Cowpea – Chickpea + Mustard, Sesame + Green gram – Barley + Linseed, Dual purpose sorghum + Guar – Barley + Chinese cabbage and Sorghum + Cowpea – Batra + Chinese cabbage along with hedge rows of perennial shrubs (Sesbania/subabul) with a spacing of 4.5 m row to row and 1 m plant to plant are identified. Inclusion of perennial bushes under hedge row concept (4.5 m row to row and 1 m plant to plant) in different cropping systems of rainfed semi arid region can provide substantial and assured green fodder (12.5 – 15.2 t/ha) from rainy season to summer season thus able to sustain 1-2 adult cattle units (ACUs)/ha. During rabi season under rainfed condition, early supply of harvested rain water or early rabi season rainfall (up to Dec.) pulse/oilseed crops and under late water supply or winter rains condition cereals especially barley gave higher yield and better economic return. Mulching coupled with one irrigation for establishment play very important role in growth and development of rabi season crop since it gave 15.8 to 90.1% higher yield and higher economic return (B: C ratio 3.02) than irrigation alone.

Key words: Diversification, Forage, Cropping system, Hedge row, Rainfed

Evaluation of the Environmental, Economic, and Social Impacts of the Grain for Green Project on Loess Plateau of Northern Shaanxi Province in China — taking Mizhi County Case Study

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The overall of the paper furnished frame of the system method assessing environmental, economic, and social impacts effects of Grain for Green project from 1999 to 2010. We took classification of the soil (0-20cm) of cropland converting to forest carbon sequestration, benefits structural changes in household income and the impact of social harmony employing approach of the ecological economic, questionnaires, and fundamental orientation theory and fuzzy membership coordination coefficient this study investigated the environmental effect of changes on soil organic matter nearly 10-years back in forest-grass ecosystems and sloping of cropland. Soil organic matter content of Forest-grassland was higher than 0.315 percent of sloping farmland, and then the average soil organic carbon density increased 0.39 kg/m^2, begetting in soil (0-20cm) ecological and economic benefits of carbon sequestration value of 1.61 million yuan. We surveyed 50 family in 2010 to learn their revenue structure and quantify their opinions of grain for green project, 69%of family net income rose 2 to 5 times, 56% of the family net income of the agricultural industry improved from 0 to 1 times, 70% of family had migrant workers,which 63.6% of family of migrant labor households earning was more than 50% in overall of the family income. Based on amendment of fundamental orientation theory, social had been a primary coordination state measuring fuzzy membership coordination coefficient value of 0.81.further indicated that the grain for green project is working to improve the regional ecological environment, increase farmers income with optimizing the revenue structure of income, and promote harmonious development society.

Key words: Grain for Green project, Environmental, Economic, and social, Loess Plateau

Socio-Economic Factors Influencing on Soil Conservation Technologies Adoption in Western Hills of Tamil Nadu

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Hill areas have serious problems of landslides, torrents and slips. In Nilgiris district of Tamil Nadu 110,000 hectares of land are affected by soil degradation. The study was conducted in the Nilgiris District of Tamil Nadu. To examine the nature of conservation technologies adopted by the farmers and to study the impact of crop damage on productivity and income at farm level. The study also aim to examine socio-economic factors influencing the willingness to pay for soil conservation technologies adopted by the crop farmers and constraints in soil and water conservation technologies adoption by farmers. Sample respondents were selected using multistage purposive sampling from the five categories of watersheds very high, high, medium, low and very low, priority watersheds at the rate of 50 in each priority watershed. The samples were post stratified into marginal, small, medium and large farmers based on land holding pattern. NPV, BCR and IRR were used to study the technical feasibility and economic viability of the different conservation technologies. In tea plantation, stone wall had the highest NPV of Rs.74335 and the staggered trench had shown the lower NPV of Rs.19237 in tea plantation among all conservation structures. The bench terrace had the highest IRR of 34% for carrot. The BCR, NPV and IRR for both annual and perennial crops were found to be encouraging. In willingness to pay (WTP) regarding, 188 farmers of the sample respondents were willing to pay for soil conservation technologies against 62 who were not interested to pay for internalising soil related externality. The average wiliness to pay was Rs.4687/ha. That about 42 per cent of farmers had stated that they were willing to pay in the range of Rs.5000 to Rs.10000/Ha. Increase in age by one per cent would decrease the willingness to pay by Rs. 248, indicating that old age farmers were conservative and not willing to pay much for conservation investment due to conservatism.The constraints experienced by the crop framers were the high cost of conservation technologies was the prime reason hampering the adoption decisions of the farmers, followed by the non-availability of subsidy, high cost credit and lack of long lasting conservation methods. Poor technical support and lack of security of tenants were the less perceived problems of the hill region farmers.

Key words: Soil Conservation, NPV, BCR, IRR, Willingness to Pay, Constraints

Effect of Water Resources Development and Technology Interventions on Livelihood of Farmers in Eastern India

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Water resources development and agricultural technology interventions were carried out in two clusters of villages in Dhenkanal Sadar and Odapada blocks of Dhenkanal District in Odisha under the eastern Indian plateau region. Ten water harvesting structures (WHS) were constructed in the farmers' field on participatory basis in which farmers contributed a part of the expenditure. Multiple use of water in the WHSs was done in terms of agriculture, on-dyke horticulture, fish culture, vegetable cultivation, dairy, poultry, duckery and mushroom cultivation to develop them as integrated farming system models. The integrated farming system models comprised mostly four land types, i.e. pond area, bund area, paddy area and upland area. The pond area was used for fish culture, bund area for on-dyke horticulture and the upland area for poultry, dairy, mushroom and vegetable cultivation. The economic analysis of the IFS models indicated that the net income from individual models varied widely between Rs. 16,078/- to Rs. 2,50,624/-. Poultry farming in the uplands and intensive cultivation on the embankments of the pond were more effective in increasing the net income form IFS models. It was observed that a farmer needs to be very enterprising and sincere for developing a successful integrated farming system model. Impact analysis of the water resources development and technology interventions at the study sites was done by analyzing comparative position of physical, social, financial, human and natural assets of the farmers before and after adoption of the interventions. The overall standard of living of the study farmers increased from 13.5 to 17.1 in a scale of 5 to 25, respectively.

Key words: Water harvesting structure, Multiple use of water, Livelihood of farmers, Impact analysis

Natural Resources Management based on Delineation of Farming Situations of Narharpur Block of Kanker District

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Land and water are the most important parameters for agricultural production. Farming situations catering same type of soil, slope, land use and management practices were delineate using the high resolution satellite data and other generated thematic maps for providing vital information for efficient utilization of the precious natural resources. Farming situation provides the key information about the soil order, soil health, slope, land use along with availability of moisture for the crop. The present study was carried out at Narharpur block of Kanker district of Chhattisgarh. The water body and forest areas of the blocks were separated classifying the geocoded digital satellite data into six different classes based on the spectral signature variations using unsupervised classification technique. A total of 160 representative soil samples from the remaining four classes of unsupervised classification were identified and collected from the field and were analysed using standard procedures along with the support from few existing samples collected from the soil health card portal. Based on Normalized Differenced Soil Index (NDSI) method, the soil moisture depletion of the Narharpur and Bhanupratappur blocks was evaluated and five index ranges was worked out depicting the soil moisture status. The soil moisture variation was classified into the five classes on the basis of its nature. The “very low” soil moisture variation class shows represents the forest and water body, “low” soil moisture variationclass shows the clay soil, “moderately low” soil moisture variationclass shows the sandy clay loam to silt loam soil, “medium” soil moisture variationclass shows the loam soil, and the “moderately high” soil moisture variationclass shows the occurrence of sandy loam soil in the study area. In the present study, Multi-Criteria Evaluation (MCE) technique was used to delineate the farming situation map of the study area. The farming situation apart from the forest covering the 394.7 sqkm (44.10%) of the total area was categorised into four classes viz. *Bhata, Dorsa, Matsi and Kanhar* for Narharpur Block having the highest agricultural area of *Dorsa* 190.64 sq km (21.3%) and *Bhata* covered the least area of 74.11 sqkm (8.28%). Whereas, *Matasi* covered 85.20 sqkm (9.52%), the *kanhar* covered the 150.36 sqkm (16.8%). To develop the water and soil status of the area, recharging structure and water harvesting structure were proposed with the help of farming situation map prepared using approach of Multi-Criteria Evaluation (MCE) technique. The generated thematic maps were superimposed and 58 check dams and 149 farm pond were proposed for soil and water conservation and development in the block.

Key words: Farming situation, NDSI, Classification, Soil and Water Conservation

Women Empowerment, Rehabilitation, Environment Protection, Employment Generation, Energy Utilization, Soil Solarization, Hill Cultivation, Micro Flora and Fauna

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In agriculture, women are involved in almost all aspects of crop production, however their role in decision making is reduced along the agriculture value chain. This has largely been due to the limited role of women in governance and decision-making structure in rural society. It is widely acknowledged that women play a key role in collection and safeguarding of water for domestic and - in many cases - agricultural use, but they have a much less influential role than men in management, problem analysis and in the decision making process related to water resources.

Women have the potential to play a critical role in this process, as they use and manage land and other natural resources, while meeting water, food and energy needs in households and communities. While women are the backbone of farming systembut are often the ones who suffer more. Deforestation, monoculture practices in agriculture, loss of groundwater, flooding, landslides and destruction of biomass have worsened the situation of the women and increased their workload.However, women are no longer viewed as mere victims, it is increasingly recognized that women can play key role in natural resources management as they have the knowledge and experience gained from working closely with their environment. Attention to gender is essential to sound development practice and at the heart of economic and social progress.Gender needs should be part of the overall policy framework which can ensure that policies, programs and projects address the differences in experiences and situations between and among women and men.

There have been initiatives in other initiatives in the rural landscape, where women have been able to contribute to economic development and financial wellness through livelihood projects across the country. Similar initiatives may be initiated to offer a solution to enhance involvement of women in natural resource management. This paper intends to identify role of women in agriculture value chain in India and successful initiatives where women have been able to establish themselves as key contributors and use that learning to offer a possible direction to increase contribution of women in environment protection, water conservation in a socially inclusive and economically viable manner.

Key words: Decision making, Policy framework, collective efforts

Assessment of Micro Irrigation Potential for Extending its Coverage in India

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Water play critical role in agriculture production. In country, agriculture is predominantly dependent of groundwater and consumes more than 90 per cent of its draft. This will have repercussion on demand of other sectors of economy. Recognizing the gravity of water scarcity in many part of the country, government have started formulating its water policy pivotal to micro irrigation. With concerted efforts of government, 10.25 million hectare cumulative area has been brought under micro irrigation across Indian states till March, 2018. Coverage of micro irrigation area across states has immense variation. Sates like Punjab and Uttar Pradesh which have started facing water scarcity but have very low penetration of micro irrigation. To estimate potential area for micro irrigation, crop suitability and crop currently being grown by its adopter, have been considered. Further, two indices based on source of irrigation have been constructed to arrive at estimate. Estimate of potential area for micro irrigation came to be 65 and 80 million ha following both scenarios. Based on that estimate, micro irrigation penetration was highest in Andhra Pradesh, followed by Karnataka and Maharashtra. Concentration of micro irrigation over the period of time has much variation; state like Andhra Pradesh started with very low base in 2006-07 and reached highest in year 2018. But in many state penetration of micro irrigation, is much lower especially in area which faces water scarcity like Punjab. So, there is need to look into why adoption of micro irrigation is not picking up in some states despite having large potential area and facing water scarcity.

Key words: Water, Micro-irrigation, Potential, Penetration

Spices, Medicinal and Aromatic Plants an Alternate Remunerative Option under Edaphoclimatic Stresses

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A conversion of problems or adversities into opportunity is an essence of ecological adaptations of any species not only for its survival but to its flourishing under those conditions. These conditions may be an abiotic or biotic. Therefore, it is utmost essential to study the Autecology and Synecology of crops for concern problems. Drought, heat, frost, radiation salinity/sodicity, a shortage of nutrients and chemical pollutants are major edaphoclimatic stress and their influence will increase worldwide as a result of climate change. Plants are said to be stressed if their growth or reproductive ability is affected. This leads to yield losses and reduced quality in general agricultural crops. Plants react to stress factors with morphological, physiological and biochemical adaptations designed to increase their resistance to the stress. Some spices are adaptive with anticipated climatic change (rising temperature and CO_2 level). However, there may a shift towards the northern hemisphere from the southern with rise in temperature. Salinity found beneficial even for some crops like lemongrass and Java citronella up to EC 5 dSm^{-1}. German chamomile, vetiver, jamarosa and citronella eucalyptus have wide ranges of salinity tolerance. Some of the aromatic plants are salt includer type salinity tolerant has potential for hyper accumulation of salt resultant helps in reclaiming the saline soil such as palmarosa. Palmarosa, lemongrass, vetiver, jamarosa, citronella, ambrette, chamomile, fennel, dill, lavender, Japanese mint, mint, ocimum, celery, isabgol, senna, periwinkle, liquorices, *Lepidium*, *Salvadora*, ashwagandha, *Abutilon, Calotropis,* datura, and Jojoba are adoptive in saline alkali and sodic soil and water. Fenugreek, cumin, coriander, nigella and rose scented geranium, davana, lavender and geranium are suitable for nutritionally eroded soil and some of them have association with VAM leads to effective utilization of available nutrients and water. Some of the crops are fairly tolerant to moisture stress like dill, ammi, anise, fennel, *Cymbopogon species*, *Ocimum,* Eucalyptus, lavender, rose, aloe, *Calotropis*, *Pedelium*, *Tribulus* and *Papaver*. Some of the crop varieties like coriander (RCr-20, RCr-436, RCr-446, CS-6, Sadhana, Swathi, Sindhu, Co-1, Co-2, Co-3, Co-4 and Azad Dhania-1), cumin (RZ-19, RZ-209 and RZ-223, GC-3 and GC-4), fennel (RF-125, GF-1 and GF-2), fenugreek (RMt-305, CO-2, Rajendra-Kranti, HisarSuvarna, HisarMadhavi and HisarMukta), Ajwain (RPA-68, Ajmer-AA-1, Ajmer-AA-2 and Lam Sel-1) and dill (Ajmer-AD-2 and Guj. Dill-2) are fairly tolerance to moisture stress. On the other side, *Acoruscalamus,* cardamom, clove, kewada and menthe could withstand under high water table and regular water logging or submerged conditions. Medicinal rice is also an example of this category. Most of the cases edaphoclimatic stresses improve the active principles in medicinal plants and essential oil quality of aromatic plants up to a certain level. Therefore, underutilized natural resources can be utilized profitably by these crop diversification.

Key words: Moisture stress, spices, aromatic plants, essential oil

Techno Economic Study of Summer Sesame Crop Grown in Saurashtra Region of Gujarat

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The study investigated the techno economic feasibility of summer sesame crop under drip irrigation with various irrigation interval and thermal regimes. The experiment was designed with four levels of thermal regime (four different dates of sowing 1st February, 16th February, 1st March and 16th March, 2012) and three levels of irrigation interval (viz., 3 days, 4 days, 5 days) with drip irrigation and 7 days with surface irrigation, with and without mulch as common to all treatment. The results of the experiment revealed that the highest and lowest net return with water saving value was found as Rs. 100877.67/ha and Rs. 4072.90/ha without mulch under treatment 16th February and 5 days irrigation interval with mulch and 1st February and 5 days irrigation interval without mulch respectively. The highest Incremental Cost Benefit Ratio for drip irrigation adoption over surface irrigation was found as 10.98 without mulch and 8.44 with mulch respectively under the treatment 16th February and 5 days irrigation interval. Conclusion derived from the results that drip irrigation will be beneficial for summer sesame crop grower for both, economical as well as water saving parameter.

Key words: Summer sesame, Economics for crops, Drip irrigation

Assessing the Impact of Technology Dissemination of Fennel Primary Processing on Income and Employment Opportunities for Tribal Women

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For improving socio-economic status of tribal women through primary processing of fennel the Krishi Vigyan Kendra, Sirohi organized need based skill oriented training programmes (5, one day; 2, three days; 1, seven days) for selected 200 tribal women (fennel producers) during last years (2014 to 2015) in small groups (25-30 trainees), with an aim to develop their skills regarding harvesting of umbel at post-mature stage, grading of produce (A, B & C grades), drying of fennel in modified shade house made up of local indigenous material to obtain desired green color and flavor, threshing on RCC floor or polyether sheet and packaging in polythene lined bags for retaining colour, texture and marketing of the final produce to fetch higher prices by eliminating the role of middlemen. The skill oriented trainings had a positive impact on tribal women and about more than half of the total area (83%) has been transformed in primary processing. By primary processing of fennel, additional employment of about one lakh ten thousand mandays have been generated and empowered tribal women as this work is mostly done by the tribal women only (88.16%) in district Sirohi. By this intervention, additional monitory returns of around Rs. 32.0 crores year^{-1} have been generated in the district as estimated by the KVK scientists. In the district, trained tribal women is getting Rs. 500-550 day^{-1} for harvesting and primary processing of fennel, whereas other unskilled women are getting only Rs. 300-350 day^{-1}.

Key words: Tribal, Self-employment, Livelihood, Primary processing, Economy

Resource Conservation by On-farm Use of Manual Paddy Drum Seeder in Unnao District

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Paddy drum seeder is very imperative tool for direct seeding of rice (DSR) in paddy cultivation. It can save labour, water utilization for paddy sowing/transplanting, mechanical work in bed preparation subsequently it increases the yield thus effect the cost of paddy cultivation as well as the income of farmers. A front line demonstration (FLD) was carried out to evaluate the on-farmconservation of resources by the use of manual paddy drum seeder (PDS)and its impact on farmer's incomeas compare to the prevailing rice transplanting (TR) methodology as farmers practice. Fourteen farmers having 0.50 hectare (ha) land were selected from 11 villages of Unnao district (Uttar Pradesh) for conducting the FLD. 0.25 hectare (ha) land was selected for PDS and the same for transplanting TR with the same variety of paddy in each trail. The parameters taken to assess the effectiveness were 1) Water pumping hours, 2) Labour requirement for sowing/transplanting as man-hour, 3) Tractor running in hours, 4) Yield in quintal/hectare, 5) Input cost 6) benefit and cost ratio (BCR). Observations of the study revealed that about 24-32 hr/ha pumping was saved in PDS during the field preparation in comparison of TR which is approximately 2073.6 m^3 to 2764.8 m^3 groundwater pumping against 173 mm rainfall (2018-19) during the sowing and transplanting season (0 to 40 days). Tractor involvement in rotavating and puddling in TR, it had to run 8-10 hrs/ha extra for the field preparation as compared to PDS. 5-7 man-hr/ha labour was required for paddy drum seeder whereas TR required 196-224 man hr/ha labour at the time of nursery sowing/transplanting. Further 1.14 to 1.9 q/ha increment in paddy yield was recorded by the PDS technique in comparison of TR. By considering all above parameter, cost of paddy cultivation were calculated to be reduced Rs. 9097.00 Rs/ha on an average by the use of DSR technique. With the yield increment data, the economic benefits by the use of PDS were 11719.00 Rs/ha averagely. Further, proper practice of PDS, farmer can reduced the cost in paddy cultivation upto 23858/-Rs/ha along from Rs 34228/- Rs/ha in TR with the miscellaneous expenditure in plant protection, micronutrients and herbicides. 3-5% increment of paddy hiked benefit cost ratio (BCR) value to 2.74:1 in PDS as compared to TR i.e. 1.91:1. Thus results revealed that the use of PDS, farmer's major input resources like labor, water, and diesel can largely be reduced. PDS is very beneficial tool to the farmers and there would be no exaggeration to say that paddy drum seeder is a dominant tool for the conservation of farmer's resource in the paddy cultivation in Unnao district.

Key words: Manual Paddy Drum Seeder, Resource Conservation, Water Saving, Benefit-Cost ratio

Role of INM in Increasing Oilseed Production and Improving Rural Livelihood in Bundelkhand Region of India

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A range of oilseed crops viz., groundnut, rapeseed-mustard, soybean, sesame, sunflower, safflower, niger, linseed and castor are cultivated in the country. The cultivation of oilseed crops has been considered as less remunerative by farmers because of low productivity of crops due to injudicious use of fertilizers.Oilseeds, the second largest agricultural commodity after cereals in India, plays a significant role in India's agrarian economy, sharing 14 percent of the gross cropped area and accounting for nearly 5 percent of the gross national product and 10 percent of the value of all agricultural products.

The need for providing balanced fertilization for realizing optimum seed and oil yield of oilseeds is the urgent requirement. Sustainable oilseed production requires efficient use of inputs through adequate and balanced fertilization, including organic manures, secondary and micronutrients, bio-fertilizers, cropping system-based fertilization, green manuring and site-specific nutrient management to avoid wastages and harness positive interactions of nutrients and growth factors.

Integrated plant nutrient system is known to ensure better crop yields, crop quality and farm profits. It also corrects soil nutrient deficiencies, and helps restoring fertility and productivity of the land that has been degraded by wrong and exploitative activities in the past.

In Uttar Pradesh Bundelkhand is rainfed oilseed growing region. Oilseed crops mainly grown by farmers in this area are groundnut, mustard, sesame and caster. Keeping in view the importance of oilseed in Bundelkhand agrarian economy and role of IPNS in boosting the crop production,effort has been made to compile the role of IPNS in oilseeds crop production.

Key words: Oilseed, balanced fertilization, manures, IPNS

Assessment of Interventions in Agri-Horti Systems under Rainfed Conditions

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An attempt was made to assess the effectiveness of agri-horti system under rainfed conditions of Jammu region. On-farm trial was established from *rabi* 2015-16 to *rabi* 2017-18 in existing four year old citrus orchard. At the citrus orchard various interventions like- construction of rain water harvesting structure, growing field crops in the inter row spaces of fruit trees, application of recommended fertilizer and manures to the fruit trees as per their age, *etc.* were carried to study the benefits of agri-horti system. Traditionally, intercropping in fruit orchard was practiced under irrigated situation, but with the harvesting of rainwater it was possible to utilize the land unit efficiently by putting it under cultivation of field crops, which helped in increasing both production and productivity. In general, farmers develop orchards for fresh fruit production and do not consider it for intercropping. The study indicated enhanced yield of citrus fruit trees along with intercrops (wheat and mustard taken in *rabi* season and maize and bajra taken in *kharif* season). The mean increase in fruit yield due to interventions, after three years of study was to the tune of 23.0 percent The production of fruits significantly increased due to intercrops and it was maximum in citrus in association with wheat and mustard (4920 q/ha) during *rabi* 2017-18. Mean yield of inter row crops increased by 33.0 percent for wheat, 32 percent for mustard and 45 percent for maize, due to various interventions. Benefit cost ratio increased to 6.2 after three years of study as compared to 4.68 before interventions. System profitability was also worked out and it was seen that Citrus-Maize-Wheat showed maximum profitability of Rs 414/ ha/year, followed by Rs.371/ha/year under Citrus-Bajra-Wheat. It was confirmed that citrus based agri-horticultural systems were effective in bringing about improvement in the soil properties as reflected by the significant increase in organic carbon, available nitrogen, phosphorus and potassium.

The study showed that intercrops did not exert adverse effect on the growth and productivity of citrus. The field crops intercropped (raised in the interspaces of the fruit trees) in the orchard provided seasonal revenue to the farm family. Intercropping in citrus was effective in bringing improvement in the soil fertility, leading to a sustainable production system.

Key words: Agri-horti system, Water harvesting, Benefit cost ratio, Farm profitability, etc.

A Survey on Socio-Economic Status and Awareness on Soil Fertility, Soil and Water Conservation Practices in Lakya Sub-watershed of Chikkamagaluru District of Karnataka

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The survey was carried out at Lakya Sub-watershed of Chikkamagaluru district under Sujala III watershed project which was designed by Government of Karnataka and implemented by Watershed Development Department of Karnataka Government. This project was funded by World Bank, aimed for soil and water conservation, land resources inventory through integrating Socio-Economic data. Purposive sampling method was used for 100 per cent enumeration for data collection and data was collected from 179 respondents of Lakya Sub-watershed consists of Dasarahalli-2 and Dasarahalli-1 micro-watersheds which covers Laxmipura, Devarahalli and Kanive Dasarahalli villages respectively. The statistical components such as frequency, percentage and ranking were used to analyze the data. Major findings of the study are, more than fifty per cent (57.14%) of the respondents were falls under 36-55 years, 22.16 per cent were having primary school education followed by 20.45 per cent high school and 18.18 per cent middle school level of education, majority (98.30%) of the farmers were doing agriculture as a primary occupation and 73.86 per cent of the farmers following subsidiary occupation, 48.30 per cent of the respondents had marginal size of land holding followed by small (31.25%) and medium (14.20%). The total average annual income of the sampled households was Rs. 3,40378. The results indicated that, 66.48 per cent of the farmers are opined that there was soil and water erosion problems in their fields, 30.11 per cent of the farmers were tested their soil earlier, 93.18 per cent of the respondents were interested in soil testing, 78.98 per cent of the farmers were adopted the conventional soil and water conservation practices. However out of 78.98 per cent of the farmers adopted conservational practices, majority (97.16%) of the households have adopted field bunding followed by summer ploughing (82.39%) and countour bundings (60.80%). About 81.25 per cent of respondents opined that their soil fertility status was medium. The results indicated that, majority of the households have shown interest in soil testing and keen to have knowledge on soil fertility aspects. Hence, awareness need to be created among the farmers about the importance of soil testing, soil fertility and conservation of soil and water. In this regards concerned line departments and institutions need to be conduct various programmes related to above aspects *viz,* Awareness programmes, training programmes, participatory programmes (PRA, RRA) etc., and different extension activities for betterment farmers and their land resources.

Key words: Socio-Economic status, Soil fertility, Soil and Water conservation

Managing Soil without Fertilizers for Rainfed Agriculture in 3 Rural Farming Villages of the Jos-Plateau, Nigeria: Implication for Sustainable Soil Resources of the Area

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There have been several studies on different aspects of soil studies on the Jos-Plateau, Nigeria. However, a comprehensive assessment of the different indigenous soil management practices other than the conventional application of organic and non organic fertilizers has not been carried out. The study therefore, identifies and assesses the different soil management practices, practiced by farmers, other than the traditional application of organic manure and chemical fertilizers to the lateritic soil by farmers in the area. Three principal methods were used to collect the required data for the study - questionnaire survey, focus group discussion (FGD) and field observation. 258 farmers were surveyed. The result revealed that sweet potato, maize, irish potato, hungary rice, beans and soya beans are the crops commonly grown rainfed crops among the farmers. Land preparation is done with burning of bushes and crop residues, while tillage is done with the use of locally fabricated big hoe, which are nutrient depleting. Weeding is commonly done twice which permits competition of weeds with crops. The crops grown are mostly non-leguminous and their mixing patterns are not soil nutrient-giving. Mono-cropping, and continuous cultivation without rotation with legumes, which permit weeds, pests and less soil nutrient-giving and conserving, are common practice among the farmers. Soil fertility problem, among other factors, was rated to constitute severe limitation to sustainable food production in the area. An integrated management package involving soil test and soil management education are recommended for sustainable management of the soil resources of the area for sustainable crop production by the farmers.

Key words: Indigenous soil management practices, traditional, orgnaic manure, weeding, legume rotation

Kinnow Cultivation: Economic Evaluation under Different Irrigation Systems in Rajasthan

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The present study was conducted in Sri-Ganganagar and Bikaner districts of Rajasthan. Kinnow cultivation under diûerent irrigation system *viz.;* solar, diesel and electric irrigation system was found to be popular in the state. Therefore, study on economic evaluation of kinnow cultivation under diûerent irrigation system in Rajasthan has been conducted to evaluate kinnow orchard orchards under different irrigation system. Total 240 respondents were selected for the study. Standard techniques like NPV, BC ratio, IRR, Break-Even point and Payback period were employed. The investment in kinnow orchard has been seen as profitable business. In the study area, the net present value was work out to be Rs 842521 per ha under solar irrigation system Rs 798964 per ha electric irrigation system and Rs 762808 per ha under diesel irrigation system. Internal rate of return was found to be 38 per cent, 37 per cent and 35 per cent under solar irrigation, electric irrigation and diesel irrigation system. Beneft-Cost Ratio was at 2.36, 2.23 and 2.08 under solar, electric and diesel irrigation system. Break–Even point was 5.82 ton, 4.79 ton and 6 ton under solar, diesel and electric irrigation system. Payback period estimated to be 7.1 years, 7.2 years and 7.3 year under solar, electric and diesel irrigation system. Hence, the kinnow orchard with solar irrigation system has been found to be very economic feasible and it should be realized to the farming community for attraction towards use of renewable energy in fruits production in the state.

Key words: NPV, IRR, BCR, Kinnow, solar, and Rajasthan

Integrated Farming System in Sisal Plantation for Enhancing Farm Income and Sustainable Production

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Sisal occupies 6th place among fibre plants, accounting for around 1.0% of the production of natural fibers in volume terms and around 0.2%in terms of value. However, the sisal farmers are mostly resource poor farmers. Under the present scenario of climate change, there is an urgent need to increase the productivity and profitability of sisal growing farmers by providing employment generation throughout the year including sustainable production by increasing land and water productivity. Keeping this view in mind, an experiment was taken up in Sisal Research Station, Bamra to study the feasibility of Integrated Farming System under organic management practices in the sisal.The animal component enterprises such as dairy, poultry, rearing of rabbit apiary, pisciculture, mushroom cultivation, Azolla culture, vermicomposting, along with crop components like growing of field crops, fruits, vegetables, timber, raising of fodder etc. was taken up. The animal waste was used as manure in the field including the vermicompost, sisal waste, oil cakes and biofertilizers. The plant protection measure was taken using neem-based product. The poultry litters also used as feed for fish. It was found that weed and pest infestation was less due to integration of different IFS components. The efficient use of available resources helped to generate adequate income due to integration of various farm enterprises recycling of crop residue and by product within the farm itself for which there was increase in profit by 72%. The employment generation was also enhanced by 248 man days/ha. There was also significant increase in water use efficiency and improvement in soil physical properties and reduction in soil erosion.

Key words: Integrated farming system, Sisal, Water use efficiency

Effect of Establishment of Vermicompost Units and Training on Soil Fertility, Productivity and Socio-economic Status of Small and Marginal Farmers of District Sirohi, Rajasthan

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Dominance of chemical agriculture from last few decades has deteriorated the soil health and created problem of disposal of agricultural waste in rural areas. It is important to maintain environmental and agricultural sustainability without reducing productivity. Vermiculture technology has been considered as a sound and viable option to regenerate the soil health through recycling the agriculture waste. For the promotion of vermiculture technology in rural as well as tribal areas the Government of India and Government of Rajasthan launched different national and state level programmes. During recent past COA, Sumerpur, AU, Jodhpur under RKVY project,working in the tribal area of Sirohi district, has encouraged small and marginal farmers to take up vermiculture technology, to regenerate soil health by using vermicompost and reduce the use of agro-chemicals, to boost up the crop, fruit & vegetable production, increasing income and socio–economic condition through sustainable agriculture.

Key words: Soil fertility, vermicompost, income

Impact and Constraints Analysis of Tribal Farm Women Adoption of Nutritional Kitchen Gardening

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Kitchen garden plays an important role for rural families to provide diversified vegetables in their daily diet. Most of the families having kitchen garden of different sizes but they are interested to do scientific cultivation of vegetables in their kitchen garden. In this view TWTC Narmada had demonstrated the kitchen gardening in tribal area. Since last three years about 200 kitchen garden demonstration kits were given to tribal farm women for cultivation of vegetables in their kitchen garden. To know the impact of the technology along with constraints faced by tribal farm women the attempts were made. Demonstrations on kitchen gardening have paved the way of healthier, long, prosperous and biodegradable life of the tribal families. The results seen the overall knowledge of kitchen gardening indicated that the low, medium and high level of knowledge before contact with TWTC was 83.00 per cent, 11.00 per cent & 06.00per cent, respectively. It was altered up to high, medium and low level of knowledge 09.00 per cent, 14.00 per cent and 77.00 per cent after contact with TWTC. At the end we can suggest these demonstrations in the region found an important for increasing the income, improving the family health, soil fertility and productivity and also to raise the standard of living of the tribes. However, some constraints were also faced by tribal farm women in adoption of scientific cultivation of kitchen gardening. The input constraints were the most important constraints and were ranked in first position which needs to be solved for betterment of the tribes in the region.

Key words: Impact, Nutritional Security, Adoption, Constraints, Scientific Cultivation of Kitchen gardening

Socio- Economic Constraints of Soil and Water Conservation in Mustariwadi Micro watershed, Raipalli Sub-watershed in North Karnataka

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An investigation was undertaken to assess the socio-economic constraints affecting the soil and water conservation in the Mustariwadi micro watershed of Raipalli sub-watershed located in Humnabad taluk of Bidar district, Karnataka state. The information was collected from 77 sample farmers by personal interview method representing different soil units in the watershed obtained from the land resource inventorization work under Sujala-III project. The micro watershed is covering an area of 555.52 ha and the sample farmers are spread across three villages *viz*., Mustariwadi, Mustari and Udbal. The interpretation of results revealed that, the adoption of soil and water conservation practice by all size groups of farmers (marginal, small, medium and large land holdings) were only to the extent of 24.65% out of which 10.38% adopted compartment bunding, 7.79% used loose bolder checks, 5.19% undertook deep summer ploughing and 1.29% followed contour cultivation. With respect to the assessment of extent of adoption of soil and water conservation across the size groups it was found that, medium size group farmers adopted to the extent of 40% in compartment bunding and 20% each in loose boulder checks and summer ploughing. The reasons for not adopting soil and water conservation practices by the farmers were due to non availability of sufficient financial support (68.83%) and lack of knowledge and awareness about soil and water conservation (62.33%), small land holdings (7.79%). However, the perception and willingness of farmer's participation in watershed development programme for soil and water conservation activities pointed that farmers are prepared to contribute their labour power to the extent of 37.66% without sharing of any financial burden. Hence, there is need to provide financial support and an awareness drive from government to the farming community to take up soil and water conservation activities in the watershed area through integrated watershed development approach for enhancing better farms productivity and natural resource conservation.

Key words: Socio economic constraints, Micro watershed, Soil and water conservation

Preferences and Social Values for Ecosystem Services in Local Ecological Management: A Case in Karst Basin Yunnan Province, China

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Previous works have made great progress in assessing ecosystem services (ES) that are directed toward exploring various aspects of ecological changes and economic values. These preferences, however, might neglect the important role of people who are the direct beneficiaries in this ecosystem. Therefore, including these stakeholders in ES assessment identifies their relations and perceptions between ES and society. In order to quantify and map these relations, we designed and implemented an analytical framework based on the Public Participatory Geographic Information System (PPGIS) method to explore local stakeholders' (farmers, government managers/experts, and company employees) similarities and differences in recognition of preferences and social values for ES in a typical Karst basin. Our results showed that remarkable differences appeared in preferences for ES across three groups. Farmers gave more preferences to provisioning services, government managers/experts to regulating and cultural services, and company employees did not show any important preferences. The spatial distributions and relations of social values for ES also showed great differentials. Provisioning services were always related to specific natural conditions, regulating services to forests, and cultural services to specific locations around tourism localities, forest, and wetland parks. The local stakeholders' surveys can improve the enthusiasm of the local people to participate in environmental management and provide more socio-ecological information to help the managers alleviate the conflicts among different stakeholders.

Key words: Ecosystem services, Stakeholders, Preferences, Social values, Karst Basin

Bio-Physical, Environmental and Socio-economic Impact of Integrated Watershed Management Programme in Karma Micro watershed of Balarampur: A Case Study from Eastern Plateau (Purulia district) of India

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An increasing population, lack of technological intervention, lack of knowledge may increase in demand of various natural resources and causes degradation not only on the quality of productive natural resource base but also the quality of environment specially for semi arid tropics which is characterized by water scarcity, land degradation, productivity loss, poverty and food insecurity. For conservation and management of natural resources integrated watershed management programme is implemented at Karma micro watershed in Balarampur using the holistic system approach. The impact of watershed development programmes have been outlined in terms of biophysical aspect which includes crop productivity, cropping intensity, water availability and environmental aspect which includes soil erosion control by minimizing surface run off and use of vegetative cover and Socio economic aspect which includes Literacy, per capita Income, people participation, employment. Results indicate that due to in situ and ex situ watershed interventions there is a significant positive impact on crop productivity, cropping intensity, ground water recharge, rain water harvest and soil erosion control. In order to sustain increase in crop productivity, ground water recharge, rain water harvest and soil erosion control watershed management programme should be economically viable, socially acceptable, technologically feasible while saving natural resource base with livelihood security.

Key words: Bio-physical impact, Environmental impact, Socio-economic impact, Eastern plateau, Semi arid tropics

Optimization of Land and Water Resources for Maximizing Farm Income for Central Narmada Valley

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Continuous Irrational utilization of water and land resources, decreasing its quality and standards. This study attempts to propose a new aspects for the optimization of available good quality of land and water resources to maximize the net farm revenue of Central Narmada Valley.Central Narmada Valley covers two districts namely Hoshangabad and Narsingpur (M.P.). A feasible and precise model for the allocation of these resources was developed by embedding crop water use effect on land allocation, which is generally on demand mainly under agriculture sector.The objective function was to maximize net annual farm return with decision variable of seasonal cropping pattern. The model consist of mainly two constraints Land and water for optimization. The study shows that the total water availability for utilization was 728644 ha M and the net sown area of the valley of Rabi and Kharif was 753890 ha and 733943 ha respectively.The net annual return from the vally was increased by 10% of existing data under optimal allocation model. The model results shows decrease in rice, gram and mustard crop area against increase area of pea, wheat, sorghum areas. The developed model can be used as an accurate decision support tool for taking farm level decisions to allocate optimal land and water resources and may be responsible to mitigate the water and land deficiency in the area.The outcome of the study can assist the policy makers in taking decisions to develop a sustainable plan of land and water resources for the available area.

Key words: Water & land resources, demand, Allocation, Optimization, Annual return, Decision support, Policy makers

Role of Women in Environmental Protection and Sustainability of Natural Resources

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Women have an integral relation with the environment. Therefore, women are essential for any measure aimed at environmental protection and sustainable development. In fact, women have contributed greatly to the conservation movements in the past. The best example is the Chipko movement, when women lead by Gaura Devi protested determinedly against the commercial mistreatment of the Himalayan forests. The issue she led was of saving trees and planting ecologically appropriate trees. Elsewhere also, women were active in agitations against deforestation, construction of large dams and mining activities. All wild animals were nourished with food and protected from intruders by the women of Bishnoi community. Medha Patekar is the leading personality in 'Narmada Bachao Andolan'. Arundhati Roy is also linked with Narmada Bachao Andolan. Women have always played a significant role in the environmental protection. Furthermore, too women can help control population explosion which has been one of the major factors in environments dreadful conditions. Women are in the best position to make maximum contribution in family planning.

Women have always played a critical role in meeting household and community energy needs. With adequate environmental education and awareness women can conserve energy resources far more efficiently as compared to men. Women are responsible for the cleanliness of the household, on which depends the health and wealth of the family members. With proper education and training one can minimize the experiences and incidences of most of the water, food and airborne diseases. Traditionally women were kept away from the powers of decision making. Their unequal access to education and lack of decision-making authority at all levels has lowered their position in the society. As a result, it has had adverse effects on income, nutrition, health, social support networks and domestic knowledge. Women have direct contact with natural resources like fuel, food, fodder, forest, water and land especially in rural areas where 70% of Indian population reside. Before 18th and 19th century, it was considered that women had role in environmental protection as they were neglected and given a back seat in all spheres of social life. But now, times have changed. As discussed above, women have played critical roles in managing natural resources on family and community levels. From the high level to the grassroots, the 1992 UN Earth Summit, India's Chipko Movement and Kenya's Green Belt Movement all highlighted the role of women's voices and perspectives in sustainable development. Similarly, nowadays Medha Patekar, a social worker, Menaka Gandhi, an environmentalist and politician are playing key role for the conservation and promotion of the environment. Therefore, conservation of natural resources and promotion of environment cannot be done without involving the women in planning and training for promoting the values for conservation and promotion of environment.

Key words: Women, education, decision making, management of natural resources

Fertilizers Use Status and Performance of Improved Technologies in relation to Socio–economic Situation of Farmers in Waterlogged Sodic Soil of UP

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The productivity of food grains mainly of rice – wheat cropping system of waterlogged sodic soil of U. P. is very low and need to enhance, so that the requirement of food grains for growing population of country is meet out. A study was conducted among 100 families to assess the socio- economic status of the farmers in the villages of Patwakheda, district Lucknow. Eighty three percent of family of the village was found under below poverty line category. 53 male and 75 female were illiterate. Educational position of the Patwakheda village was also very poor. As 141, 27, 12 and 8 persons were study up to 8^{th}, 10^{th}, 12^{th} and others, respectively. Land holding of the farmers was very small such as 95 farmers were marginal and 2 farmers were found in small category. Utilization of Fertilizers was very low by the farmers in the village was documented. They mainly use urea and DAP as fertilizer to the all crops. In case of urea application 4, 7, 62 and 10 farmers and 5, 20, 63 and 14 farmers were using only 0-5, 5-10, 10-15 and 15-20 kg per ha in wheat and rice crops, respectively. In case of DAP application 2, 15 and 56 and 14, 15 and 48 farmers were using 0-5, 5-10 and 10-15 kg per ha in case of wheat and rice crops, respectively.

Field demonstrations were conducted to study the effect of improved technologies developed by CSSRI for waterlogged sodic soil to compare with conventional farming practices by the farmers. Field demonstrations of salt tolerance rice variety CSR 36 with improved agronomical practices were conducted in 4 village i.e Patwakheda and Lalaikheda in Lucknow districts and Marks Nagar and Sirsakheda of Unnao District. Sixteen marginal farmers were selected for field demonstrations having soil pH_2 varied from 8.86 to 9.82. Recommended package of practices for waterlogged sodic soils were followed and the crop conditions was monitored throughout cropping period. Crop yield was recorded and compared with traditional method of rice cultivation and cultivars grown by farmers. The range of grain yield was recorded as 3.90 to 4.99 and 3.23 to 4.62 ton per ha in improved and traditional method respectively. Maximum 32.5% grain yield was found in the Marks Nagar village of Unnao district and minimum 8.14% in Sirsakheda village of Unnao district. Average grain yield enhancement of salt tolerance rice variety with improved practices was recorded 18.24% higher over the traditional varieties.

Key words: Waterlogged sodic soil, socio- economic status, salt tolerance, field demonstration

SESSION-VII

Policy Interventions in Soil and Water Management for Global Food Security

Soil and Water Conservation Policy and its Relating to Human–Environment Context in the Yellow River Basin since 1949

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Abstract: Policy plays an increasingly important role in natural resource management as it lays out a government framework for guiding long-term decisions, and evolves in light of the interactions between human and environment, especially in soil and water conservation that has some great off-site impacts. This paper focuses on soil and water conservation (SWC) policy with a case of the Yellow River Basin (YRB), China. The soil erosion and its negative impacts on the soil, rural poverty, sediment loads and high flood risks, are analyzed using the Driving force–pressure–State–Impact–Response (DPSIR) framework to analyze the evolution of SWC policy. Four stages are identified in which SWC policy interacts differently with institutional, financial and technology support. The natural condition, soil erosion, economic, as well as the main tasks, technologies and supporting manners are described in detailed in each stage. Over the historical period considered, with the implementation of the various SWC policies, the rural economic and ecological system improved continuously while the sediment load and flood risk decreased, and the SWC policy changed with the change of natural, economic and institutional condition.

Key words: Soil and water conservation, Policy, Human–environment context, The Driving Force–Pressure–State–Impact–Response (DPSIR) framework, The Yellow River

Sustaining Crop Production using Poor Quality Waters-Challenges and Opportunities

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Current fresh water use in arid and semiarid lands is not sustainable, as use exceeds replenishment and demand for water continues to increase. The primary use of fresh water in arid and semiarid regions is for irrigation; approximately 70-90% of water use is by agriculture. Sustainable management of the water resources is, therefore, an international priority to meet the demands of future population for food and fiber. Increasing competition for water due to rapid urbanization and industrialization is greatly affecting the fresh water allocation for irrigated agriculture. Further, the productivity of irrigated agriculture is low in many parts of the world because of the use of poor quality of ground water such as saline and sodic water. Increasing demands for fresh water for municipal and industrial use are coupled with increasing world food needs, leaving less water available to agriculture. Thus, agriculture will either need to reduce acreage under irrigation, which is undesirable since it will reduce food supply, or irrigate with alternative water sources such as saline and marginal quality waters which is possible but sustained use requires consideration of the impacts of these waters on both crop production and soil health. In different states of India, 32-84% ground waters surveyed are brackish in nature. However, injudicious use of sodic and saline waters poses grave risks to soil health in terms of deteriorating soil physical, chemical and biological properties. Development of salinity, sodicity and toxicity problems not only reduces crop productivity but also limits the choice of crops. It is, therefore, imperative that irrigation development plans are carefully drawn and executed to sustain crop production and minimize salinization and deterioration of soil physical conditions over the long-term.

The commendable contribution of Indian Punjab in spreading and adopting new technologies during Green Revolution, which transformed the food security scenario of the country, is a well-known fact. However, this revolution was accompanied by overexploitation of natural resources mainly soil and water. In Punjab, 42% of the aquifers are poor in quality posing serious threat to sustainable crop production especially in the south-western region of the state. To prevent degradation of state's land and water resources while meeting country's increasing demand for food, adoption of relevant and emerging technological interventions for optimally using poor quality waters for supplementing irrigated agriculture are of paramount importance. In this context, the long-term research work conducted by Soil Salinity Laboratory, Department of Soil Science, PAU, Ludhiana with regional stations located at Faridkot and Bathinda focused on managing and developing strategies for safe and judicious use of saline and sodic waters in agriculture for sustaining crop productivity and maintaining soil health in these challenging environments. Although emphasis was on managing these saline and sodic waters in the Indian Punjab, the developed practices are appropriate for many other arid and semi-arid regions where irrigated agriculture is confronting similar challenges.

***Key words*:** Sodic water, Poor quality water, Management of sodicity, Crop productivity, Punjab

Understanding the Legacy Effect of Different Tillage Farming Systems with Crop Residue Input on Carbon Mineralisation and Available Nutrient Supply in Contrasting Soils

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Understanding the legacy effect of tillage-based farming systems on soil organic carbon (SOC) mineralisation and nutrient [nitrogen (N), phosphorus (P) and sulphur (S)] supply after crop residue input is critical to appropriately manage plant available nutrients at the farm scale. To enhance this understanding, fresh crop residues [canola (*Brassica napus*: δ^{13}C 124‰) or wheat (*Triticum aestivum*: δ^{13}C 461‰)] were added to Luvisol and Vertisol from two long-term (16–46 years) field experiments and incubated under a controlled environment for 126 days. The practices in the Luvisol were conventional tillage (CT) and reduced tillage (RT) under mixed crop-pasture rotation, and no-till (NT) under continuous cereal-cover crop rotation. The practices in the Vertisol were CT and NT under wheat-wheat rotation. The residue input significantly stimulated SOC mineralisation via "positive priming", which was greater ($p < 0.05$) in the CT than RT/NT in the Luvisol only. The SOC mineralised after 126 days was 3.1–4.2 and 1.6–2.5 times higher in the canola and wheat residue-amended soils, respectively, than the unamended soils. Although the CT or RT versus NT had higher net N availability in the Luvisol only, the residue input did not increase plant available N in both soils, possibly due to stronger residue-induced N immobilisation than mineralisation. The results showed a significant release of available P and S in both residue-amended soils (canola/ >/ wheat) after 26–50% of residue-C was mineralised over 126 days, and the Vertisol had greater net available P than Luvisol. Our results suggest that considerable quantities of available P and S may release from the soil reserves via SOC priming, and possibly via dissolution/desorption reactions in the soils, in addition to their direct release from the residues. In conclusion, fresh crop residue input to historical farming systems enhanced the supply of available P and S, which varied with tillage, crop residue and soil type.

Key words: Soil organic carbon, priming, plant available nutrients, Canola and wheat residue, ^{13}C isotope

Can Anti-erosion Measures be Proposed in Such a Way as to also Increase the Biodiversity of the Country Side?

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The most serious degradation factor affecting soil quality in the Czech Republic, as in other countries, is water erosion. In the Czech Republic, water erosion is a threat to more than half of the agricultural land.One of the major factors in accelerating water erosion is the structure of agricultural land and landscape, with a significant increase in arable blocks in the post-war period during land consolidation.On the other hand, there has been a significant decline in landscape elements, including greenery. The current, fragmented landscape forms a mosaic of much larger pieces than in the first half of the 20th century. The average size of blocks of arable land is now 11 hectares (compared to the earlier mosaic with segments of about 1 hectare). Blocks larger than 100 hectares are not an exception. With these changes in the landscape, where some 2/3 of the landscape elements have been lost, there is also a significant decline in biodiversity. In this presentation, we give a new approach to soil protection, which also increases biodiversity in the countryside.

Based on raster modelling of erosion processes, and landscape connectivity in GIS and statistics, we propose measures that will reduce the overall risk of erosion and other related degradation changes,while also increasing functional connectivity to the landscape, resulting in increased biodiversity in the area of interest. This approach is based on our certified methodology for the calculation of raster functional connectivity, which allows us to determine locations in a country where the implementation of remedial measures would contribute to an increase in biodiversity. The resulting raster layer can be combined with erosion modelling techniques to precisely locate places where corrective action would have a synergistic effect, reducing soil vulnerability and increasing biodiversity.

Key words: Landscape optimization, Erosion, Landscape connectivity

Soils of Arid and Semiarid Environments: Major Challenges and Potential Opportunities

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Arid and semiarid environments occupy around 37% of the earth land areas area and are inhabited by about 16% of the world's population. Soils in these environments differ from those in humid zones due mostly to scant moisture conditions. They are characterized by harsh climatic conditions such as very high temperature, low rainfall, strong wind, and sand storms are common. Besides, the presence of salt-affected soils and lack of fresh water. Characterizing and classifying the soils of these environments allows international and regional knowledge transfer, as similar soils can easily be identified and successful management practices can be adopted without conducting long-term trials on local soils. The present study aims at characterizing and classifying the main soils of arid and semiarid environments and their physicochemical properties and behavior. Further objective is to discuss the main challenges facing theses environments including land degradation, water scarcity that threaten agricultural productivity, overpopulation, urbanization which contribute to rapid social change, rising temperatures, unemployment, degradation, and desertification. The study is concentrated in the arid and semiarid environments of the Middle East with two pilot areas, one from Abu Dhabi the United Arab Emirates representing hyper-arid environments, and the other from Fayoum Depression Egypt representing arid and semi-arid environments. The United States Department of Agriculture system of soil classification (USDA Soil Taxonomy) was used to classify the soils up to the family level. The results of the study reveals that soils of both pilot areas are broadly categorized as sandy, sandy calcareous, gypsiferous, saline, saline-gypsiferous, and hard pan soils. Out of 12 soil orders in the world, three orders of Aridisols, Entisols and Inceptisols have been identified. Entisols are the most commonly occurring soils, followed by Aridisols to a relatively lesser extent, and the least common order is Inceptisols. These soils are described in the context of their formation, temperature and moisture regimes, properties and occurrence. The main physical and chemical characteristics will be presented and discussed and major challenges facing these environment will also be discussed.

Key words: Arid, Semiarid soils, USDA Soil Taxonomy

The Twenty Years Retrospect and Prospect of Water and Soil Conservation Plan for Production and Construction Projects in China

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This paper conducted a systematic review of the past twenty years on the authorized strength, examine and approve, the acceptance of special facilities of water and soil conservation program report for production and construction projects, as well as the enactment of related laws and regulations0standards0specifications, analyzed the problems, characteristics and development trend of different stages, in order to provide technical support for "delegate power, fair supervision and efficient services" reform of the production and construction projects. To collect relevant data of river basin institutions, the water administrative department of the government and the water and soil conservation program compilation agencies by searching the periodical database and the official website of the water and soil conservation monitoring center of the Ministry of Water Resources, then carry out sorting and analysis and summary. Through review and analysis found that due to related policy, the water and soil conservation program for production and construction projects has experienced early stage, stable development stage and the ongoing "delegate power, fair supervision and efficient services" stage, The editing techniques of water and soil conservation program had been basically perfected, but there is a misalign between the authorized strength and acceptance, which leads to complicated procedures in the acceptance process. Over the past twenty years since the implementation of the water and soil conservation program for production and construction projects, more than 300,000 projects nationwide have compiled and implemented the water and soil conservation program. the area of preventing and controlling water and soil loss exceeds 150,000 km^2, reducing water and soil loss effectively. Implemented "delegate power, fair supervision and efficient services" to the water and soil conservation work can not only improve the work efficiency, but also greatly enhance the subject responsibility consciousness of the construction unit.

Key words: Production and construction projects, Water and soil conservation plan, Review

The Tradeoff between Soil Erosion Protection and Water Consumption in Revegetation: Evaluation of New Indicators and Influencing Factors

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Soil conservation and soil water storage are two of the main ecosystem functions affected by revegetation programs. However, the effects of revegetation on these variables have traditionally been studied separately, and there have been few efforts to assess their responses to revegetation in an integrated way. This paper evaluates the tradeoff between these responses by introducing two new indicators: the accumulation of the ratio between soil erosion protection and water consumption over a prescribed time period (EEWA) and the time specific ratio of the reduction in soil water to the reduction in erosion by vegetation (EEW). Micro-plot experiments involving different vegetation types, clipping treatments, and rainfall intensities were conducted, revealing that analyses based on EEWA identified different dominant factors and optimal management strategies than would be obtained by considering either soil conservation or soil water contents in isolation. The vegetation type, clipping, and rainfall intensity all affected soil erosion by changing the level of soil protection and the driving forces of erosion. Vegetation type and clipping affected soil water storage during and after simulated rainfall but the impact of rainfall intensity was limited because even the mildest rainfall treatment exceeded the soil's infiltration capacity. The results confirmed that it is possible to retain the soil conservation benefits of revegetation programs while avoiding detrimental soil water consumption by manipulating factors such as the vegetation type and clipping regime. These findings will provide useful guidance for increasing the sustainability of revegetation programs, particularly in arid areas where soil water is often a limiting factor for vegetation survival.

Key words: Revegetation, Soil erosion, Soil water shortage, Tradeoff; Vegetation type

Artificial Intelligence-boon for Future Agricultural

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With the help of artificial intelligence, farmers are now able to grow better crops and look after their animals while saving time and energy. The combination of artificial intelligence and big data will move this industry towards digitalization. But our farmers' awareness of artificial intelligence was found to be almost negligible. Only few farmers were aware about artificial intelligence aspects like drones and robotics etc. It implies need to generate awareness and create infrastructure to meet this imperative technological need to revamp Indian agricultural sector.

Through digital transformation in agriculture, the information like environment, soil fertility, moisture content in the soil, crop growth and their health status and occurrences of weeds will be gathered. Acquisition of this real-time information would occur through the use of artificial intelligence and big data analytics and the data would be stored in a cloud database. Drones monitor the condition of the soil and determine whether it needs watering or seeding, while sensors in and around the cattle check their health and nutrition. Cameras monitor vegetables and fruits are being taught to recognize irregularities or problems such as dehydration and unwelcome insects. Secondly, we get the prediction for future action for farming and its management. It forecasts future conditions/problems by taking into account previous year's data and current weather conditions which are already stored in the cloud database.

The new agricultural technology strategy, artificial intelligence, integrated telematics, data management systems and auto-guidance solutions together, have the potential to make farming much more productive and profitable. The precision farming technologies help customers to become more efficient and saves resources. Producing quality, nutritious and affordable food will be a huge challenge before the world. It is predicted that even with the limited resources, the smart ICT, a new hi-tech era need to be ushered in where automation and data can help farmers address the many challenges of the future. The Artificial Intelligence (AI) application in farming will bring revolution, sustainability and vibrancy in future farming. Through digital agriculture, where technologies such as Artificial Intelligence (AI), Cloud Machine Learning, Satellite Imagery and advanced analytics are empowering small-holder farmers to increase their income through higher crop yield and greater price control. Artificial intelligence can boost the efficiency of daily operations in a traditional farm and maximize production volume and minimize the possibility of failure due to natural disasters, system errors, and other factors by acquiring data on growth, the weather, and agricultural equipment.

Key words: Cloud computing, Satellite imagery, Precision farming, Internet of things, Smart farming

Aspects of a Legislative and Policy Framework to Manage Soil Carbon Sequestration

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Before human-caused CO_2 emissions began, the natural processes that make up the global "carbon cycle" maintained a near balance between the uptake of CO_2 and its release back to the atmosphere. However, existing CO_2 uptake mechanisms, called CO_2 or carbon "sinks", are insufficient to offset the accelerating pace of emissions related to human activities. It is argued that successful adaptation to climate change impacts will include advances in international and national environmental law particularly in the areas of institutional, technological, education, research, and regulatory practices that concern soil carbon sequestration. This paper discusses the environmental law and policy framework for the management of soil carbon. Aspects of the legislative and policy framework important to this process include its ability to recognise carbon sinks, expand existing sinks, and the procedures available to return and store carbon in soil reservoirs. In this context, the legal framework to manage soil carbon is similar to the framework to prevent and control land degradation. International law provides global standards and guidelines and national legislative systems provide the substantive and procedural legal mechanisms to manage soil carbon. The United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement are the primary international legislative instruments but other international instruments and strategies have a significant synergistic role. Various approaches are presented for framing national legislation or to reform existing legislative frameworks to improve the procedures to manage soil carbon.

Key words: Land degradation, Land degradation neutrality, Legal framework, Legal element, Sink, Soil carbon, Sustainable soil management

Artificial Intelligence in Relation to Agriculture

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Artificial intelligence refers to machines ability to imitate human cognitive abilities like problem solving and learning. These skills require understanding of language and speech and strategic thinking e.g. self-parking or cruise control features. It is of paramount concern to think how the farmers could be benefitted from artificial intelligence (AI) technology that are using or planning to use it in future. The AI in agriculture has various applications ranging from rural automations, facial acknowledgements, computerized water systems frameworks and driverless tractors. These applications are employed in relationship with an alternate sort of sensors, GPS frameworks and radars etc. AI in agriculture is emerging in 3 major categories viz., agriculture robotics, soil and crop monitoring and predictive analysis. Also, it finds applications in supply chain efficiencies, monitoring crop conditions like water stress, nutrient condition, plant population, soil moisture content etc. However, other applications in agriculture include predicting disease outbreaks using relevant data, automated irrigated conditions / systems that take weather conditions into account, drones capable of delivering customized fertilizers and pesticides based on requirements of crops and autonomous GPS guided harvesting systems. However, domination of agricultural complex in 21st century will require 2 things such as biological data sets and engineering talent to apply AI to them. Lately as Professor Hawking said that AI could spell the end of human race but it could also serve us. The farming process will be smarter; there will be more data, more AI technologies to be used for agriculture. It is new world order.

Key words: Disease forecasting, Drones; Smart agriculture, Soil and crop monitoring

Irrigation Planning with Conjunctive Use of Surface and Groundwater Using Linear Programming

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Optimal use of available surface and groundwater, in any canal command area would result in their better utilization by maximizing the benefits from the crop production. Shortages of surface water supplies have increased the need of groundwater development in many canal commands. In the present paper, the feasibility of conjunctive use management is analyzed using a mathematical model in the Tungabhadra side channel irrigation command area of Krishna western delta in Andhra Pradesh, India The water demand and available water resources in the study area are evaluated considering surface water and groundwater. In the present paper, a simple optimization model is presented to explore the possibilities of conjunctive use of surface and groundwater using linear programming with various hydrological and management constraints, and to arrive at an optimal cropping pattern for optimal use of water resources for maximization of net benefits. To arrive at optimal allocation plan of surface water and groundwater, 'solver', an Add-in from MS office excel was used. The results indicate that conjunctive use options are feasible and can be easily implemented in the area, which would enhance the overall benefits from cropping activities.

Key words: Surface water, Groundwater, Conjunctive use, Linear programming, Excel solver, Cropping pattern

Guiding the Ecological Construction of Soil and Water Conservation with Jinping Xi's Ecological Civilization Thought

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Jinping Xi's ecological civilization thought is a powerful ideological weapon, fundamental compliance and action guide to guide the development of China's ecological civilization construction. In the new requirements of the new era, there are some problems in the soil and water conservation ecological construction, such as inadequate institutional system, the basic support cannot keep up, the regulation of soil and water loss is not in place and in sufficient soil erosion control. In order to do a good job in the ecological construction of soil and water conservation in the new era, it is imperative for us to strengthen political responsibility, practice the concept of ecological civilization, optimize the layout of work, fill shortcomings in development. Meanwhile, it is necessary for us to do a good job in the supervision of production and construction activities, focus on regional governance, build a monitoring and evaluation network, promote informatization construction, and improve institutional mechanisms.

Key words: Jinping Xi's thought of ecological civilization; Soil and water conservation; Soil and water loss

Assessing Farmers' Perception, Vulnerability and Coping Strategies to Climate Change in Hot Semi-arid Eco-region of Rajasthan, India

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A study was carried out to assess farmers' perception, awareness, and extent of knowledge on climate change and what coping mechanism they are using to mitigate the effects of climatic change. Using responses from a survey questionnaire for randomly selected sample of 150 farmers from three villages of Baran district of Rajasthan state indicate different perception levels. 82% of the respondents perceived climate change is a real problem and 50% of the respondents disagreed with the contention that this problem exists in their region. 54 per cent of the farmers reported that frequency of drought has increased during last 10-20 years. However, 67% of the farmers were optimistic about reduction in frequency of droughts in future. 80% of the respondents also foresee that the availability of water will reduce in future while 78% have the opinion that monsoon, when compared to past, receded earlier in the region. 59% of the respondents had the opinion that maintaining ecological balance is solely lies on the government but 31per cent thought that community has a more significant role than government for taking initiatives to check ecological degradation in the area. About 74% of the respondents have the opinion that scientists are capable to find solutions to counter the problems of climate change. 83% (34% strongly agreed) with the statement "I do worry about the loss of flora and fauna of my area" which indicates that they are aware about the possible loss as a result of climate change. In contrast, 28% respondents disagreed with the statement that it is hard to change their habits for more environmental friendly practices. To sustain their livelihood and to withstand with climate change effects on agriculture some of the farmers adopted soil and water conservation measures especially bunding (37%) followed by loose boulder check dam (11%) either with the help of watershed programme implemented long back or self construction for enhancing moisture conservation in the field. To escape climatically bad years the farming community has been using a wide range of inbuilt coping mechanisms which were not specific to the climate hazard type. Farmers' most important strategies to cope with the erratic rainfall and the occurrence of frequent droughts were to change the cropping pattern (75%) followed by installing borewell (57%). Other major coping strategies by the farming community in the study area included, working as casual labour (69%), selling of field trees (40%), selling livestock (38%).Vulnerability to climate change is the degree to which a farmer is susceptible to, and unable to cope with, adverse effects of climate change, including climate extremes.Hence, study worked out the farmers vulnerability index and found that majority of the sample farmers fall in the category of highly vulnerable (44%) or vulnerable (55%) categories.

Key words: Adaptation, Climate change, Perception, Vulnerability index

Water Productivity in Rainfed Agriculture: Status, Challenges and Paradigm Shift

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Indian agriculture broadly categorized into two types namely, Irrigated and Rainfed. Of those, rainfed agriculture has a prominent role to play in India's agriculture and economy. India ranks first among the rainfed countries in the world in terms of area, but counts amongst the lowest in rainfed yields (about 1 ton/ha). Rainfed agriculture which accounts for about 52% of the net sown area is contributing only about 35% of the food grain production as the productivity is much lower than that of irrigated areas. While observing the characteristics of irrigated agriculture, it is seen that the growth in productivity is very marginal in the recent past which indicates that scopes of enhancing productivity rainfed agriculture is tremendous which can be best accomplished by improving rain water productivity. Water productivity enhancement is one of the most important strategies for meeting the growing food grain requirement in a sustainable manner amidst the challenges of climate change.

Moreover, India's average crop water productivity is low when compared to few selected countries in Asia and Pacific. For example, the overall rice water productivity in India is relatively low (0.24 kg/m^3 to 0.57 kg/m^3) in comparison to rice growing areas of other countries like China (1.84 kg/m^3), Nigeria (0.59 kg/m^3), Philippines (1.39 to 1.61 kg/m^3), Australia (0.70 to 0.75 kg/m^3) and United States of America (0.88 to 1.44 kg/m^3). This scenario is further worse in rainfed areas when compared to irrigated regions.

In this study attempt has been made to analyze state wise coverage of major crops cultivated under rainfed condition, its productivity compared to available rain water, effectiveness of rainfall for crop production and water productivity of major rainfed crops. The results indicated a wide variation in rainfall effectiveness and water productivity across states and type of crops in rainfed regions. There is great scope to improve water productivity by suitable crop diversification, crop alignment, water harvesting, in-situ moisture conservation, on farm water management, appropriate soil health management, optimal use of available water synergizing production system etc. Overall, improvement in water productivity at rainfed regions can be achieved through creating synergies across scales and between various agricultural sectors and the environment, and by enabling multiple uses of water and equitable access to water resources for different groups in society.

Key words: Rainfed agriculture, Water productivity, Water management, Water resource conservation

The Urgent Need for a Global Agreement for Sustainable Food and Farming

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With 95% of the world's food coming from soil and 33% of our global soils already degraded it's not surprising that the theme of this year's World Soil Day 2019 will be 'Stop Soil Erosion, Save our Future?!' Almost every week we see a new report illustrating the devastating impacts of human activity on the environment; not least the knowledge that we now have less than 12 years to limit climate change. Soil degradation gives us a finite number of harvests left before we are unable to produce the food we need. Antibiotic resistance, lifestyle diseases, malnutrition, air and water pollution, wildlife declines and huge pressures on resources including drinking water paint a bleak picture for human survival.

For every issue outlined above, a reform of our global food system is an essential part of the solution; an imperative requirement for human survival and the key to meeting globally agreed SDGs and the Paris Climate Change targets. For example, the food system is responsible for a significant share of greenhouse gas emissions (GHGE), up to 30%, with livestock making 14.5% GHGE. The potential benefits of changing our food system are huge; it is an essential building block to deliver enough nutritious food for the growing population, and a re-generation of the natural world - soils, climate, biodiversity across land and sea, and cleaner air and water.

Industrial Agriculture, as part of the broken food system built on diets high in meat and dairy, must end in order for there to be a hope of solutions. For example, the FAO has said intensive livestock "reduce the food balance" as they consume human-edible carbohydrates and protein and convert them into a smaller quantity of energy and protein for human consumption. A 50% reduction in the use of human edible crops as animal feed with livestock's primary role becoming the conversion of materials that we cannot consume into food we can eat would helpmeet SDG Goal 2 (Zero Hunger). Moving away from industrial agriculture with its huge demand for feed crops for confined livestock would allow cropland to be farmed less intensively with reduced use of monocultures and chemical fertilisers and pesticides. This would enable soil quality to be improved through the use of rotations, legumes, green manure and animal manure. Changing our attitude to sources of protein, together with new food technologies and rediscovery of plant-based foods, could transform the food system. A global problem needs a global solution. A global agreement to transform food and farming systems, along the lines of the UN Framework Convention on Climate Change, could yield crucial benefits including a major reduction in food and farming's contribution to climate change, soil degradation and the destruction of wildlife habitats. A new global agreement could underpin sustainable and ethical approaches to food and farming for the benefit of global food security, human and animal health and welfare and livelihoods.

Key words: Industrial agriculture, Livestock production, Food systems, Animal feed

Conservation Measures for Resource Conservation and Sustainable Production in Central India

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About 53% area comes under rainfed agriculture and nearly 70% of the total geographical area in the region has been affected by varying degree of erosion hazards. The red soils comprise 50% area and found mostly on higher elevation in uplands consequently adversely affected with the problem of soil erosion, low productivity and even crop failure. On the other hand black soils are found on low lands and pose the problem of drainage and workability. About 80% of total annual rainfall is received during monsoon season but water stress conditions are commonly experienced by crops even in rainy season due to long dry spells and short monsoon seasonfurther aggravate the situation. High intensity rains in monsoon season cause considerable soil erosion. On account of frequent droughts, the region traditionally faces scarcity of water for drinking as well as agricultural purposes. The crop intensity in the region is about 115%. The yield potential of crops is low and agriculture is not economically viable until scientific management of land and water is undertaken for sustainable agriculture. The results of different field studies carried out on soil and water conservation aspectrevealed that growing of legume crops in pure or suitable intercropping system on contours on slopy land not only provide sustainable production but also minimize erosionduring rainy season.Improved tillagecoupled with *in-situ* surface mulching of sunnhem precorded 34% higher rainwater conservation and 47% higher grain yield of sorghum over farmer's practice (conventional tillage and no mulching) in the red soils. Green manuring of sunnhemp during *kharif* season not only minimized erosion but also increased the yield (35%) of succeeding wheat during *rabi* season over allowing traditionally land fallow during rainy seasonin red soils.The vegetative barriers of different grass species at 0.7 m vertical interval were found effective in reducing runoff and soil loss and nutrient loss from slopy agricultural lands. Rainwater harvesting and recycling was also found effective in mitigating the effect of drought and augmenting crop yield. Contour bunding in sorghum at 3% slope in red soils conserved higher rainwater (42%) and recorded higher grain yield of sorghum (11%) over farmer's practice (no bunding).The V-shape micro-catchment was found best for resource conservation, enhancement of the yield of inter crops and growth and yield of *aonla* under agroforestry system on sloping lands in red soils.The results of different soil and water conservation studies suggested that growing of legumes during rainy season, improved tillage coupled with *in-situ* surface mulching, suitable intercropping systems, green manuring, vegetative barrier/contour bunds and rainwater harvesting and recycling and *aonla* based agroforestry were found effective in soil and water conservation, mitigating the effect of climate change and achieving sustainable production in semi-arid conditions in Central India.

Key words: Micro-catchment, sloping land, mulching, intercropping

On Ecological Water-Soil Science

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Water and soil resources is the substance basis of vital movement of ecological system, and its distribution and change directly influence the structure and function of ecological system. Under the background of increasingly serious resource and environment issues, "ecological water-soil science" is put forward and developed. The ecological water-soil science could be called "ecohydropedology" according to the rules of English word formation. Its basic contents include the relationship of vegetation and water and soil resources, ecology-oriented water and soil pattern, process and its mechanism, as well as conservation and sustainable utilization of water and soil resources with coordinated production, life and ecological service. The new basic discipline is of important practical significance for deepening the relative disciplines. Additionally the establishment of this new discipline is hopeful to promote and directly serve the theoretical research, technical development and application practice for soil and water conservation. The ecohydropedology refers to the interdiscipline among ecology, hydrology and water resources, soil science and land science. As a discipline, the object of study, theoretical system and methology of the ecohydropedology are mainly influenced by water, soil and living things, as well as the relationship among the three factors.

All the land ecological systems are associated with issues of ecological water and soil, and are the specimen to be studied in ecohydropedology. Research in the fragile ecological environmental area with apparent issues is helpful to carry out ecological repair and environmental protection. The space-time process, utilization and regulation of water & soil resources for the Loess Plateau are special and complicated due to the combined action of its soil erosion and climate drought. The important content about carrying out the theoretical innovation and practical application of ecohydropedology in the Loess Plateau is to investigate spatio-temporal characteristics of water and soil resources with vegetation under the condition of erosion and draught, to analyze the interaction between vegetation and water & soil resources, to clearly determine moisture, nutrient, carbon balance and circulation characteristics of the ecological system of agriculture, forestry, grass land in different regions, to analyze the response mechanism of water-soil process of multiple and composite ecological system on climate change and human activities, and to evaluate the influence of agricultural production and ecological construction on regional water & soil environment, so as to put forward the coordinated and sustainable management countermeasures. Consequently, the research achievements on ecohydropedology will be enriched, and the discipline development will be promoted. Green development concept has gradually been consensus in this times. People are longing for green mountain, clean water, and harmonious coexistence of human and nature. Under this background, using the advantages of multi-disciplinary crossing and deepening the research on water-soil-vegetation relationship, promote theoretical innovation of ecohydropedology. What is further needed is application of the theoretical achievements to the great practice of green development and ecological civilization construction, to realize conservation and sustainable utilization of water and soil resources. While the process is a long way.

Key words: Soil and water conservation, Chinese Loess Plateau, Ecohydropedology

Natural Resource Conservation Planning Education: Engaging the Next Generation

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Natural Resource Conservation Planning in the United States is carried out primarily by the USDA Natural Resources Conservation Service. This federal agency employs conservation planners who are trained primarily through in-house training programs consisting of a combination of on-line and classroom courses coupled with mentoring by more experience employees. The NRCS, as well as other resource conservation agencies worldwide struggle to attract motived employees with adequate background to become the future planners of the agency. This paper presents specifics of a college course developed at the University of Hawaii to provide a detailed orientation and hands-on experience in conservation planning. The course is offered on-line to allow participation by students throughout the state of Hawaii and emphasizes the application of the conservation planning process in actual management situations.

Conservation planning is a holistic approach to natural resource problem-solving and management that considers ecological (natural resources), economic, and social factors in an integrated fashion to address human needs and resource protection. A conservation plan presents and analyzes the major natural resource management issues or problems and proposes action plans for the maintenance and protection of an ecosystem and its components.

The class focuses on the field application of the USDA-NRCS iterative and adaptive conservation planning process grounded in the SWAPAH (Soil, Water, Air, Plants, Animals, Humans) resource description and analysis framework. Students are exposed to both the theoretical underpinnings and the field application of inventory and assessment tools and techniques for these resource areas as well as to the process of developing and accessing management alternatives. Students select a farm or other land area to studyand develop the key components of a conservation plan using on-line data, procedures and guidance documents provided on the NRCS website.

Students work individually to learn how to identify and assess resource concerns and to develop conservation management alternatives,conduct background research, sketchmaps, and assessing the bio-physical history and condition of the site. All students gather weekly in an on-line video conference to compare experiences, share insights and learn new procedures. Once the site's characteristics and importance for conservation is clear, the problems and susceptibility of the site to disturbance (natural and anthropogenic) is identified. These are the basis for drafting solutions and recommendations for development. The final student product is"mini-conservation plan" which is well presented, easy to read and informative, yet not too long as to include unimportant details. This course is presented as a potential model for introductory training in conservation planning and as means to attract the next generation of planners. While it is specific to the resources and procedures used in the United States, the basic components of the course should be of relevance for similar training worldwide.

Key words: Conservation planning, Education, Conservation training, Staff recruitment

Conservation Agriculture: A Tool for Saving Natural Resources with Food and Livelihood Security in Bangladesh

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A 15 years' long term study was conducted on conservation agriculture at the Regional Wheat Research Centre, Rajshahi, Bangladesh as a warmer area to compare the effects of four straw retention (SR)/tillage treatments (30% SR of all crops+ Permanent raised beds (PRB), 0% SR +PRB, 30% SR+ Conventional tillage practice (CTP) and 0% SR+ CTP in an intensified RW systems. Another five tillage options such as DSR in Zero, Strip. PTOS and unpuddled TPR in Permanent raised bed and farmer practice (FP) were also used in rice-wheat systems both in on-station and on-farm for saving natural resources and get higher yield with proper utilization of inputs. After five years when used 30% straw retention under raised bed system produced the higher productivity compared to conventional practice. Water use efficiencies improved 25, 23 and 29% in wheat, rice, and mungbean crops, respectively when 30% SR with PRB system. Soil organic matter and infiltration rate in surface soil layers of the PRB had increased by 0.82% & 47% while bulk density decreased 10-12% after 15 years (15 rice-wheat-mungbean crop cycles) with 30% straw retention both from wheat and rice and full straw retention from mungbean. Less global warming potential (GWP) in direct seeded rice and wheat on permanent beds& zero tillage and more in conventional both puddle transplanted rice**.** Compared to the conventional practice all RCTs reduced the GWP by 13 to 37%..PRB with 30% SR saved 42 litre/ha/year fuels with 44% less CO_2 emission in the atmosphere in rice-wheat-mungbean system. Compared with all experiments, conservation tillage system with residues retained appears to be a very promising technology for saving natural resources and improve soil and crop productivity for sustainable intensification of RW systems as well as reduces global warming in Bangladesh.

Key words: Soil, crop and water productivity, Conservation agriculture, Natural resources, GHG emission, and Rice-Wheat systems

Collaborative Purification Technology of Field-Ditch-Wetland System for Non-Point Source Pollutant from Paddy Rice Irrigation Area

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Unreasonable fertilization, irrigation and drainage in farmland are the main causes of non-point source pollution and water eutrophication.In rice irrigation area, farmland block, weirformed wetland, and the connecting irrigation channels and drainage ditches, constitute a unique pattern of farmland landscape, which is not only the main channel of farmland non-point source pollution migration and transformation, but also the important place of the pollution treatment.According to the above characteristics of rice irrigation area, a model of collaborative purification technology based on "field-ditch-wetland" systemfor non-point sourcepollution treatmentwere proposed in this research. Key technical parameters were set and calibrated. The in-situ test in Huoluobang irrigation area of Pinghu City shown that, the technology could effectively reduce the water amount and the pollution concentration ofthe drainage water.In the farmland area, adopting the water and fertilizer regulation technology of "rain-storing and low-dew irrigation + rational fertilization", compared with the traditional irrigating and fertilizing mode used by the local farmers, the annual average water-saving rate of irrigation was 27.5%, and the discharge of COD, TN and TP pollution load was decreased by 20.8%, 21% and 27.9%, respectively.In the drainage system, the utilization of the ecological ditch treatment technology of "compound ecological ditch system + rational hydraulic regulation" could effectively intercept and treat the nitrogen and phosphorus and other non-point source pollution from the drainage water, reduced the pollution load of COD, TN and TP by 27.6%, 25.8% and 39.8%.At the end of drainage, the treatment technology of "aquatic cash crop wetland system + rational hydraulic regulation" was adopted to further purify the farmland tail water, and the removal rate of COD, TN and TP pollution load reached 60%, 83% and 72%.The results could provide technical guidance for the prevention and control of non-point source pollution in rice irrigated area.

Key words: Rice Irrigation, Farm land non-point pollution source, Field-ditch-wetland purification system; in-situ test

Community Participation in Water Resource Management: A Case Study of Local Water Storage Structures in Gujarat State of India

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Different management regimes exist in the governance of water resources world over, though, traditionally societies have managed to harvest, conserve and manage rainfall and runoff through water storage structures to meet their various needs. Community participation in water resource management has been considered crucial for effective and sustainable management of the resource. However, management of local water storage structures, as common property with a set of rules to govern access to and allocation of resource, is perilous in terms of resource efficiency and sustainability. In fact, studies on traditional water resource management in rural India focusing on the institutional design have emphasized on contextualization and specificity as crucial for success of traditional water resource management regime. With this background, the present study examined community owned water storage structures in Gujarat state of India with village ponds as case study. Data collected on social aspects and technical details of 22 ponds were analyzed to examine the existing management structures, the interactions of social and technical design factors and its effect on resource management. The study revealed that strength of Panchayati Raj Institution (PRI), and the water management society, not only governed the financial strength and functionality of the water resource but PRI success in managing the water source was also affected by the functionality of the resource. Factors such as location and design structure of water resource affected its functionality and this, in turn, affected the financial strength of the resource management society in managing the community water resource. In addition, the strength of the institution in managing the resource was also affected by the institutional design. Representation of the poor and weaker section of the society, particularly women, who largely depended on the community water resource for routine domestic chores, was weak, leading to water resource management issues being either given less importance or ignored. This design failure resulted into vicious circle of poor resource management, poor water storage capacity of resource, poor water charge collection ultimately leading to poor water resource management due to financial constraints. The study suggested policy interventions in terms of scientific design of the community water resource, strengthening institutional design by improving representation of the relevant shareholders in resource governing body and measures to improve financial strength of the water resource which could sustain the storage capacity of these water storage structures and their social and technical viability.

Key words: Community participation, Water storage structures, Management, Sustainability

Determinants of Adoption of Soil and Water Conservation Measures: A Systematic Review for Policy Makers' Perspective

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Land degradation due to soil erosion is a serious environmental and socio-economic problem. Among different adaptation and mitigation strategies, soil and water conservation (SWC) measures are of prime importance due to their synergetic positive effects for sustaining natural resource and enhancing resilience. Meta-Analysis of factors affecting the adoption of SWC technologies from extant studies was conducted to identify the key factors influencing the adoption of SWC measures, in order to provide useful insights to policy planners for facilitating design of effective and efficient programs. Critical analysis indicated the following key findings: Firstly, it has been observed that in most of the studies, as a set of explanatory variables a host of factors such as socio-economic, access to market, access to information have extensively been used. However, many studies failed to account for other significant variables such as social networks/social structures, plot level features, perception and attitude relating to risk, perception relating to soil erosion severity and level of fertility and climate variability, effect of capacity building in soil and water conservation measures, incentives other than economic etc. Exclusion of variables could be due to lack of agreement on relevant factors, budget constraints, higher degree of locational and technological specificity of soil and water conservation measures, which is mainly based on the type of soil, slope of plot and rainfall of the locality. Secondly, the interdependence of SWC measures in the adoption behaviour have not been taken into account. This implies that adoption of SWC measures were treated mutually exclusive, which is not the case in conservation efforts. Thirdly, and most surprisingly, in most of studies, employed models were based on the axiom of maximation economic incentives, and failed to factor-in the environmental/ecological benefits of SWC measures. Lastly, in most of cases, adoption of SWC measures has been treated as one-time activity. However, for realizing the potential benefits, continuous adoption of SWC measures with proper maintenance is required/recommended. To conclude, it can be suggested that in analysis of adoption behaviour, if some key adoption factors are ignored, then it can lead to inappropriate design of programmes leading to low and disappointing rate of adoption of SWC measures. Policy implication is that program designers and field functionaries must factor-in variables such as psychological, self-motivation, social networks, actual profitability (discounted using appropriate rates) etc. for enhancing the adoption rate of soil and water conservation measures to moderate the effect of climate variability, and for sustaining the crop production in drought prone areas.

Key words: Soil and water conservation measures, Meta-analysis, Econometric models

Need for Water Resources Management at Micro Level and Necessity for an Alternative Legal Frame Work with Specific Reference to Agriculture

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Water is the most critical element of Natural Resources, which is essential for both human and other living organism. It is also important component for social and economic growth of human society. As per National Environmental Policy, 2006; water has to be protected and conserved, made equally accessible to all the sections of the society, and also should leave sufficient quantity for present and future generation. Also National Water Policy, 2012 emphasises on enhancement of water available for use, demand management, water use efficiency and water pricing. It is a matter of fact that Agriculture sector consumes maximum share of water and also less controlled. Even if price incentive encourages farmers for indiscriminate use of water. Within Agriculture, Rice and Sugarcane are the two crops which consume maximum water. There are empirical evidencesthat areas where these two crops are cultivated have been experienced water stress. The increasing use of fertilizers and pesticides are affecting largely water and air quality. It has affected the ground water quality severely. The non-point pollution needs strict monitoring through effective mechanism. Secondly a major portion of rain water goes runoff to the sea. So there is no effective measure for water balancing mechanism. In spite of sufficient provisions in law and good number ofjudicial pronouncements for conservation, preservation and judicious use of water; the present situation has become alarming. As per Niti Aayog Report, 2018; 600 million people face high to extreme water stress, 75 percent of house hold do not have drinking water on premises, and 70 percent of water is contaminated.

In this paper an attempt has been made to examine the present status of water use efficiency in different sectors with specific reference to Agricultureand also projection for future. Water requirement for different crops and their water use efficiency. Existing legal provision, efforts made by different states for regulating and proper distribution water resources. Existing gap in effective implementation of policy and compliance to statutory provisions. It is suggested that an alternative model can be thought of regulating water resources at the Central level and bring a self-regulating provision for achieving water positive at micro level and also bring sustainability for administration of the unit through cost recovery mechanism. Precautionary principle should be guiding factor for legal frame work. Importance of peoples' participation for efficient use of water through crop rotation, use of technology and water budgeting are also equally needed. The water table fluctuation assessment should also be measured more frequently so that crop planning and water budgeting can be done before the commencement of the season.

Key words: Water use efficiency, Water pricing, Stress, Non-point pollution, Legal frame work

Level Evaluation Method Study on Design Unit of Soil and Water Conservation Plan for Production and Construction Projects

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In recent years, With the acceleration of urbanization process in China, all kinds of new construction and constructing projects in the country have surged. The soil erosion caused by the production and construction project is becoming more and more serious, which has become an important reason for the soil erosion caused by man-made. It is an effective means to control the soil erosion by standardize manage the design unit of soil and water conservation plan for production and construction projects. On the basis of investigation and research, by comprehensive index methodÿthis paper puts forward a set of scientific and based on self management thought design unit level evaluation method, which provides the basis for the development of the "Level Evaluation Management Measure on Design Unit of Soil and Water Conservation Plan for Production and Construction Projects".

Key words: Production and Construction Projects; Design Unit of Soil and Water Conservation Plan; Level Evaluation Method; Management measures

Combating Land Degradation by Land Levelling; Implications in Semi-Arid Chambal, India

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Gully and ravine erosion across the world is a major land-degradation process, which is predominantly susceptible to the effects of land-use change, crop productivity, cropping pattern change and overall development of a region. The semi-arid Chambal region is known for its vast and intense ravine network. The Chambal region is severely dissected by narrow gully heads which have been at places gone underneath more than 60 meters. This underdeveloped populated region's 80 per cent of the total rural population is dependent on agriculture. Ironically the available agricultural land is not enough to support the need of the people of this region.

To combating land degradation, land levelling is one of the widely used land reclamation processes in Chambal ravine. Several methods have been applied to level the ravine land, such as using bulldozers or infilling gully lines. The last couple of decades, multi-levelling of topsoil removal by the farmers has shown a distinctive process of sustainability at some places. The objective of this paper is to understand the land levelling dynamics and its implications for the socio-economic development of this region. To fulfil the objective different years of various satellite images along with SOI toposheets have been interpreted and mapped which have been verified with the physical field survey. The change history of ravines scenarios also been constructed using a cross profile from ALOS PULSAR and Cartosat DEM. The implications of reclamation activities have been analysed through physical field survey, FGD, and from literature along with a longitudinal household survey of three selected villages based on the ravine erosion and land levelling history.

It has been observed that the total ravine land has been reduced substantially (~ 600 km2) in the last 40 years due to the high rate of land levelling practices by locals. However, it has been found that ravine formation processes are still active in many catchments. It has been reported that the productivity of levelled land is not sustainable for a long time. The impact of land levelling has significant off-site consequences too. Besides the loss of productivity and change in cropping pattern, shifting of villages, social segregation and loss of common property resources are the problems in Chambal Region. The river systems also getting affected and lost its natural flow due to the result of high siltation. Due to loss of natural forest rising man-animal conflict and disturbing ecological balance. There is environmental impact too as the degraded area will not only result in disrupt social harmony but also intensify the conflicts and cause distress migration. A more holistic approach towards this degraded region will certainly limit the effects of soil erosion and land loss.

Key words: Land degradation, Land levelling, Chambal region

Role of Residue Farm Machinery in Maintaining Soil Health and Ecological Balance

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The post-harvest agricultural residue mainly paddy straw is still considered as discarded owing to its minimum utilization, storage and disposal relating problems. As agriculture in India is gradually progressing, more stresses are laid on the crop yield and productivity. But in existing scenario, the post-harvest agricultural residue management is cumbersome and needs more momentum for its effective utilization. With this issue, the farmers still have their most appropriate option of burning residues in farm field as a part of its disposal. To address these trepidations, the in-situ agricultural residue management machinery can prove to be a practicablesubstitute which not only restricts indiscriminate open field burning but also provides judicious management of paddy residue in addition to improvising soil health thereby promoting agricultural sustainability. These machineries encompass chopping and more uniformly spreading the residues as mulch with sub-surface retention or incorporation. The surface retention option encompasses the application of (i) super SMS, for finely chopping and evenly spreading the paddy residue as soil mulch (ii) happy seeder for uninterrupted sowing operation of wheat into heavy paddy residue sub surface mulch without conducting mechanical manipulation of soil. The combination of these two implements has given pertinent results in enhancing crop yield. The option of surface incorporation includes the utilization of mulcher or chopper for effective chopping of straw followed by spreading it in the field and wet mixing by rotavator. These technologies helps in enhancing soil physical properties, improving organic and moisture content and edaphic factors offering effective weed management affecting economy, saving energy and consequently eradicating unnecessary residue burning. These farm residue machineries form the resilient foundation of in-situ paddy residue management and are gaining momentum with its feasible and viable approach.

Key words: Residue management, surface retention, surface incorporation, super SMS, happy seeder

Assessment of Soil Health Card Scheme with a Participatory Approach –A Case Study of Palaskhel Village, Maharashtra, India

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Soil is a crucial enabling resource, central to the creation of a variety of goods and services integral to ecosystems and human well-being. Maintaining good soil health is an essential factor for sustainable production of crops and for, the most wanted, high productivity. The farmers' experiential knowledge about their soil is a valuable resource and needs to be integrated with scientific knowledge for better soil management practices. Soil Health Card (SHC) scheme is an initiative by the Government of India, used to assess the current status of soil health which in turn is used to recommend judicious use of chemical fertilizers with a combination of bio-fertilizers and organic manure. A study was undertaken in Palaskhel village in Sangli District, Maharashtra, to understand the implementation and dissemination of the SHC scheme on the ground level. A soil mapping exercise with the participation of over 100 farmers was conducted to understand the soil pattern in the village and the soil map of the town was developed with the help of farmers' knowledge. Structured interviews were conducted with 40 farmers to understand their perception of the SHC scheme and to fetch information on water resources, water availability, and cropping pattern. Based on these studies, it was found that lack of awareness and infrastructure are major shortcomings in the implementation of the SHC scheme. The locations of samples tested during the year 2018-19 cycle under the SHC scheme were mapped using GIS, to understand the adequacy of samples tested under SHC and spatial distribution. In the developed soil map, multiple soil types were observed within an area of 10 hectares while in other areas of the village it was observed that the same soil type has spread over more than 300 hectares. The existing grid sampling technique may skip smaller sized soil types while few samples may represent the same soil type repetitively, and thus this method does not represent the actual soil variation in the village. Soil samples from the same farmers in the village were collected and tested in two different soil testing labs, and the soil test results were analyzed, compared, and found inconsistent. Soil mapping can be improved by considering soil variation with farmers' knowledge as complementary to the current grid sampling method of the SHC scheme. To ensure consistency of the soil testing results, there is a need for standardization of sampling & testing procedures and certification of soil testing labs. Water sources, water availability, cropping pattern, farm practices, and native crops are a few other important parameters which need to be taken into consideration in the SHC scheme while recommending fertilizer dosages.

Key words: Soil mapping, Soil Health Card (SHC) scheme, Soil variation, Participatory approach, farmers' perception

Sustainable Natural Resource Management through Organic Agriculture in North-East Region of India: Scope and Constraints

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Keeping the hazardous effects of inorganic fertilizers and the agro-chemicals on environment as well as on the human health, it is an urgent need for the developing country like India to shift to the organic agriculture. There is lot of scope for promotion of organic agriculture in the North Eastern Region of India which accounts 7.64% of the total area of the country. Agriculture is by far the most important occupation of the people of this region. Majority of the farming community is resource poor and purchase of fertilizers and chemicals in adequate quantities is beyond their capacity, therefore, the use of inorganic fertilizers and chemicals is meager in this region. The farmers in general and hill farmers in particular are also having apathy towards use of agro-chemicals. Secondly, the region has not tested the fruits of green revolution and is, therefore, by default organic in nature which can be easily converted in organic agriculture. It is assumed that the difference in production gap due to adoption of organic agriculture is expected to be negligible; rather there is scope for enhancing productivity with good organic management, the organic premiums would boost earning of the hill farmers. Thirdly, it is an added advantage that all the households are maintaining livestock producing sufficient quantity of on-farm manures, which could be efficiently used for organic agriculture. Moreover, the north-eastern states being the one of the mega biodiversity receiving very high rainfall (2000-11000 mm per annum) leads to profuse production of biomass. Some of these species could be efficiently used in organic production. The major constraints associated with promotion of organic farming in the region are the identification of the potential areas for organic food production; research, development and extension strategies for promotion of organic cultivation; human resource development in production of organic inputs like bio-fertilizers, vermi-compost, botanicals for pest management, etc.; assistance to farmers in post harvest handling, processing and value addition, identifying certification agency within the region, and reduction of certification cost and creation of infrastructure and mechanisms for marketing of organic produce.

Key words: Organic agriculture, North-East India, scope and constraints, etc.

Study and Application on Conservation Tillage Technology of Rice (*Oryza sativa* L.) Southern China

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For a long time, with the increase of mechanized farming and chemical fertilizer input in southern China, the rice yield has increased, but the problems of soil degradation, rising operating costs and non-point source pollution have become more and more prominent. Unreasonable tillage and fertilizer input are prone to secondary soiling and other problems in paddy soil. In recent years, the traditional no-tillage cultivation of rice in southern China has been widely applied in some places. From the perspective of planting methods, the main forms are: no-tillage direct seeding, no-tillage throwing, no-tillage transplanting, etc.; it has improved soil physical and chemical properties and rice field habitat, The advantages of reducing the cost of farmland operation, facilitating planting and managing mechanical operations, but there are: the base fertilizer can only be applied, the fertilizer utilization rate is low, the rice yield is reduced under the same fertilization amount, the manual transplanting is difficult, and the survival rate after planting is low. It is difficult to cast no-till and throw seedlings, and it is difficult for rice straw to return to the field in full, burning straw in some places, many manpower operations, and high labor costs.The project changed the artificial table to apply the base fertilizer to the synchronous machinery to deepen the base fertilizer, improve the fertilizer utilization rate, increase the rice yield, reduce the pollution of the fertilizer to the environment; change the artificial insertion (throwing) and spread the seedlings into mechanical transplanting and mechanical precision drilling (water) the drill sowing and the dry drill sowing can reduce the labor intensity of manpower planting and save the labor cost. The rice seedlings in the rice paddy field can be used as rice dry seeds, which not only protects the vegetable sprinkler irrigation facilities, but also saves irrigation water, and can also use the sprinkler irrigation to reduce high temperature stress and improve rice yield and quality; the manual topdressing and spraying are mechanical fixed-track topdressing and spraying, which solves the problem of rice management mechanization. Together with the mechanization of planting and mechanization of harvesting, the whole process of mechanized production of rice is realized; the use of mites and herbicides to achieve full return of straw is achieved.

Key words: Rice, Conservation tillage

Intercropping in Sugarcane a Profitable Venture among Farmers

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Population density is rising rapidly and supply food to such a growing population is a big challenge for farming community resultantly agriculture people should optimize the use of resource especially soil. Krishi Vigyan Kendra is working for the transfer of technologies like inter cropping for the optimum use of soil and other resources. A survey was conducted with the objective to assess the adoption of intercropping by the farmers. The total 150 Farmers from 5 villages namely Padri piperpati from block Bishunpura, Piperaghat from block Seorahi, Purena Katiya from block Tamkuhi Raj, Premwalia from block Kasia and Manjharia from block Dudahi was interviewed. The result revealed that in one year cropping pattern 37.99% farmers were doing intercropping in main(base) crops of Sugarcane, Banana and Bitter gourd. The oilseed crop toria, pulse crop green gram, vegetable crop cauliflower,coriander and spice crop turmeric were the selected intercrops. It was observed that by adoption of intercropping the yield / ha can be increased from 2.25% to 52.92% and net return can be increased from 16.67% to 93.59%. Therefore, it may be concluded that in the one year cropping pattern inclusion of one intercrop can increase the substantial profit of farmer's and availability of food and nutritional security

Key words: Intercropping, cropping pattern, soil, sugarcane, banana and bitter gourd

An Underutilised Space: Role of Gram Sabha in Watershed Development

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To analyse the implications of two extreme of roles assigned to Gram Sabha in the Guidelines of watershed development issued from 1994 onwards by the Central Government to the states. The first was assigning the role of Project Implementing Agency in the Hariyali Guidelines, 2003 based on the recommendations of Hanumantha Rao Committee Report. The second was followed by WARASA-Jansahbhagita guidelines of Ministry of Agriculture which continued to govern the management of National Watershed Development Projects in Rainfed Areas until 2008. The Gram Sabha in this guidelines was merely a contact point of watershed community within the Gram Panchayat. In between the two extremes is the Common Guidelines for Watershed Development, 2008, which was formulated after Neeranchal Committee Report, 2006 that gave its opinion on the performance of Gram Sabha in a span of three years after the Hariyali Guidelines launch. It made Gram Sabha, a forum with "responsibility for all and benefit to few. " The Center-Statehas not assigned role to Gram Sabha in a continuum of its capacity and power assigned by the state level initiatives in the direction of PRIs over a period of time. The guidelines rather created a role for Gram Sabha based on "perform or perish model" for the Gram Sabha which was not in coordination with the statutory position assigned to it.

Methodological/ Conceptual Approach: This uneven role in the Centrally Sponsored Schemes indicate incremental approach of policy making when we analyse the policy process. It indicates that the policy has not taken into cognizance the ground realities and has overlooked it. This approach has harmed the platform to come up as a unit of collective actions and decision making thus impairing the empowered platform for people's participation in development.

Key Findings: The field level realisation from Kerala, a state which is considered as bench mark in strengthening PRIs has also not been able to keep Gram Sabha engaged actively in watershed development projects due to limitations created by the guidelines. Gram Sabha remains an underutilised space in policy scenario where government retain power sharing with the common people.

Key words: Centrally Sponsored Scheme, Watershed Development, Gram Sabha, Community participation

Entrepreneurship Development through Irrigation System Development –A Case Study of Runni Saidpur Block of Sitamarhi District of North Bihar

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Agriculture today suffers from multiple crises and one of the worst crises is pertaining irrigation and water resources. It is a crisis of poor management of water resources leading to deeper crisis in terms of both availability as well as quality of water. Smallholder irrigation in eastern India is strategically recognized as an important sector in addressing rural poverty, food insecurity and rising youth unemployment. However, despite the government's efforts and huge investment, the sector has failed to make a meaningful contribution to overcoming these challenges. Ground water has rapidly emerged to occupy a dominant place in India's agriculture and food security in the recent years.

This is a case study of Saidpur Ghat village of Runni Saidpur block of Sitamarhi district. Saidpur ghat village is located in Sitamarhi district of North Bihar. The district forms part of the Indo- Gangetic Plains and is primarily a flat alluvial terrain with a masterly slope towards south and is devoid of any major topographic irregularity. A complete irrigation System, consisting of tubewell, Pumping set, pump house and underground pipeline system have been installed in Saidpur Ghat village of Sitamarhi district under Tribal sub Plan of AICRP on Irrigation Water Management. More than 12 tribal families of Dhangar community benefited from this system. Earlier these group of farmers were paying very high price for irrigation water to the tune of Rs 200/hr. After installation of modern irrigation system along with underground pipeline has reduced the cost of watering to Rs 70/hr. The duration of irrigation has also reduced drastically. With the installation of this system duration of irrigation for their one acre plot has reduced upto 3 hrs from 6 hrs. Due to assured and cheaper irrigation cropping intensity has been increased to about 200%. The productivity of the crops with diversified cropping system has increased which has ultimately increased their income. This complete irrigation system has created and an opportunity of Entrepreneurship development for rural youth. Reasonable proportion of the farmers identified increased income, wanting autonomy and desire to succeed as the key drive to entrepreneurship development in the area.

Key words: Irrigation, underground pipeline, enterpreneurship

Open and Distance Learning (ODL) in Agriculture

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More than half of Indian population is engaged in agriculture for their livelihood. Proper education in agriculture is an essential component to improve the practice of crop production and animal husbandry. The education in agriculture not only imparts knowledge but also skills simultaneously. In this country, at higher education level, the agriculture education is being imparted through 75 State Agricultural Universities (SAUs), 03 Central Agricultural Universities, 03 General Universities with Agriculture Faculty and 281 colleges. But their full capacity contributes to less than one percent in country's Gross Enrolment Ratio (GER). Moreover, for educating the farmers and rural youths (who cannot afford a seat at these Higher Education Institutions (HEIs), no specific institutions exist for them. Open and Distance Learning (ODL) is a technology based education system, has capacity to cater masses at a given point of time. It has proven its capacity of transacting knowledge and building skills among various stakeholders in the domain areas of agriculture. The school of agriculture, IGNOU has been striving to build human resource in agriculture and allied sectors through Open and Distance Learning (ODL) since 2006. A number of Awareness, Certificate, Diploma and Post Graduate Diploma and Certificate programmes have been developed. Each of programmes (wherever applicable) consists of 50 percent theory and 50 percent practical components. Every year, the school enrols 2000-4000 learners in its different programmes. The teaching, learning and evaluation mechanism are unique and comparable with the conventional system of education.

Key words: Knowledge, educating farmers, human resource development

Grain Yield of Maize as Influenced by Irrigation Levels and Maize Genotypes

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A field experiment was conducted during summer 2018 and 2019 to study the effect of drip irrigation levels on yield performance of maize genotypes at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The experiment was laid out in strip plot design with three replications comprising of sixteen treatment combinations. The treatments included were four irrigation levels such as drip irrigation at 0.6 ETc, 0.8 ETc and 1.0 ETc and furrow irrigation at 0.8 IW/CPE ratio and four maize genotypes such as NK-6240, Pinnacle, CP-818 and RCRMH-2. The two years pooled data revealed that, effect of irrigation levels differed significantly with respect to grain yield of maize. Furrow irrigation at 0.8 IW/CPE ratio (75.8 q ha^{-1}) and drip irrigation at 1.0 ETc (71.4 q ha^{-1}) were found statistically on par with each other. However, significantly higher grain yield was noticed as compared to drip irrigation at 0.8 ETc (54.4 q ha^{-1}) and 0.6 ETc (38.8 q ha^{1}). The genotypes differed significantly, NK-6240 recorded significantly higher yield (66.4 q ha^{-1}) as compared to the rest of the genotypes tried. Significantly the lowest grain yield was recorded with Pinnacle (55.1 q ha^{-1}). The interaction effect due to irrigation levels and maize genotypes was found significant with respect to grain yield of maize. The combination of furrow irrigation at 0.8 IW/CPE ratio with NK-6240 genotype recorded significantly higher grain yield (80.8 q ha^{-1}) as compared to other treatment combinations. However, this treatment remained statistically non significant with drip irrigation at 1.0 ETc with NK-6240 (77.9 q ha^{-1}), furrow irrigation at 0.8 IW/CPE ratio with CP-818 (77.4 q ha^{-1}) and Pinnacle genotype (73.8 q ha^{-1}). Significantly the lowest grain yield was obtained with the combination of drip irrigation at 0.6 ETc with Pinnacle (32.0 q ha^{-1}) and CP-818 (39.5 q ha^{-1}).

Key words: Drip irrigation, Furrow irrigation, Genotypes, Grain yield, Maize

Global Policy Framework for Ensuring Food, Energy and Livelihood Security

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Irrigated agriculture is the main source of water withdrawals, accounting for around 70% of all the world's freshwater withdrawals. The development of irrigated agriculture has boosted agricultural yields and contributed to price stability, making it possible to feed the world's growing population. Rapidly increasing non-agricultural demands for water, changing food preferences, global climate change, and new demands for biofuel production place increasing pressure on scarce water resources. Challenges of growing water scarcity for agriculture are heightened by the increasing costs of developing new water, soil degradation, groundwater depletion, increasing water pollution, the degradation of water-related ecosystems, and wasteful use of already developed water supplies. This article discusses the role of water for agriculture and food security, the challenges facing irrigated agriculture, and the range of policies, institutions, and investments needed to secure adequate access to water for food today and in the future. The scope for increasing water-use efficiency in agriculture is large-simply because agriculture uses the largest volumes of water. At the same time, enhancing water-use efficiency is a highly complex task because much of the apparent losses at the system level is reused elsewhere in the hydrologic basin. Conserving water ideally should be achieved without adversely affecting third parties who rely on return flows or downstream water reuses; without simply taking water away from farmers, thereby reducing crop yields and farm incomes; without causing long-term adverse impacts on water quality and farm soils; and by taking into account the full scarcity value of water for all the ecosystem services this resource provides. Irrigation is, and will remain, the largest single user of water, but its share of world water consumption is projected to decline. Growing scarcities of water and land are projected to progressively constrain food production growth, slowing progress toward the goals of food security and human well-being. In the absence of policy and investment reform, water for the environment and for food production will increasingly conflict in many parts of the world. Water pollution will affect growing populations in developing countries, harming both agricultural and economic development. Economic incentives for water management include prices, taxes, subsidies, quotas, and ownership/rights. These incentive measures, when implemented appropriately, can affect the decision-making process and motivate water users to conserve and use water efficiently in irrigation and in other uses. At the zero or low levels of current water prices, irrigation water use is highly price inelastic; however, in many cases, prices high enough to induce significant changes in water allocation (or recover capital costs) can severely reduce farm income. Water is allocated through a variety of mechanisms, ranging from complete control by the government to a mixture of market and government allocation, to predominantly market allocation. The structure of any particular system of water allocation is influenced by the existing institutional and legal frameworks as well as the water resources infrastructure.

Key words: Conserving water, farm income, water reuses, infrastructure

SESSION-VIII

Bio-industrial Approaches to Watershed for Food and Livelihood Security

Bio-Industrial Watershed for Sustainable Bio-Economy through Innovative Bio-Industrial Crop – Coconut Palm (*Cocos nucifera* L)

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World over efforts are being made to promote 'Bio-economy' to the extent possible to eliminate or mitigate the harmful effects of non renewable fossil fuel economy. Bio-Biased economy encompasses the production of renewable bio-resources and their conversion to food, fibre, bio-energy, bio-industrial products through innovative efficient technologies generated by meaningful research with practical application. It offers vast development opportunities and solutions to the increasing population. It also ensures environmental stability, economic stability, climate change, food security and conservation of natural resources. Agriculture is one of the major sources of Bio-mass production. Operational structure of the bio-industry in respect of Agriculture, crop forms First generation bio-mass "Crop produce" Second generation Bio-mass and the Bio-mass REFUSE is the Third generation produce from bio-mass. Research and Development is needed to produce products of superior quality or comparable to their non-bio based products in terms of cost, performance, availability and environmental soundness. Focus is limited to materials that supply and use only renewable biological resource following the "value chain" approach from lignocelluloses materials to be based fuels chemicals, high value fibre and other industrial products.

Watershed programme need innovative approach. Watershed programme in the country was initiated as early as 1974 by the Ministry of Agriculture, Govt. of India by giving focus attention on the area covered by a drainage zone and water resources, integrated with soil, vegetation, animals including humans. The system aimed at development of Bio-economy by 2009 Prof. J.S. Bali and other crystallized the concept of Bio-industrial watershed. Parliamentary Standing Committee, Govt. of India who reviewed the watershed projects observed not only 10% of the projects sanctioned in 2009-2015 could be completed and the entire working process was "lethargic". Head of the centre for Agrarian studies at the National Institute for Rural Development and Panchayat Raj (NIRD & PR) who conducted evaluation of watershed programme observed idea of convergence of various departments is good but in practices each agency work in separate silos. Sustainability of watershed structures is also in the long run ignored for want of regular economic return besides ground water recharge from the project for the benefit of their living in the watershed.

"Innovative Bio-industrial watershed concept in agriculture based on food, fiber etc. needs to be highlighted". It also promotes conservation of basic natural resources soil, water, plants and animals including humans through micro – level watershed planning integrated community and gram panchayat participation. Agro-ecological sub regions of the state may be considered for climate smart agriculture (ICAR, NBSS & LUP, NARP and AESR information). Agriculture often remains unprofitable unless industry is integrated with it through processing of produce by value addition for diversified products. Bio-industrial watershed concept calls for agro-industries based on the crops grown within the watershed itself. For instance produce from coconut palm in the watersheds can easily be processed within the watershed itself for large number of food and fiber industries, animal husbandry etc. Prof. M.S. Swaminathan remarked while reviewing the Bio-industrial watershed Management concept and strategy (2005). "The most urgent task in our country is the diversification of income earning opportunities in rural areas where seventy percent of our population lives. In fact, wide-spread occurrence of under malnutrition is due to poverty and not due to food availability food in the market".

Key words: Bio-Industrial Watershed, Innovative Bio-Industrial Crop, Coconut Palm

Spatial Representativeness Analysis for Policy-making of the Gavkhouni Watershed, Central Iran

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The Gavkhooni Watershed with an area of 3365.22 km^2 in the Zayandeh Rood Basin and ending to the Gavkhooni Wetland faced many environmental problems such as drought, soil loss, and salinity. Spatial representativeness analyses would informpolicy-makers and land managers where to establish baseline study sites for the integrated watershed management in order to protect ecosystem functions and structures. Towards this, the present study introduced an innovative and quantitative-based index for improvising a sequence of representative sub-watersheds in the Gavkhooni Watershed. Accordingly, four GIS-based layers of elevation, slope, rainfall erosivity factor and land use were used as input layers to methodology programming using MATrix LABoratory (MATLAB) 2016 Environment. The representativeness index (RI) was then analyzed for 30 sub-watersheds of the Gavkhooni Watershed. The mean and standard deviation of elevation, slope and rainfall erosivity factor for study watershed were 1939.77±372.67 m, 4.51±6.70% and 22.36±5.66tm ha^{-1} cm h^{-1}. Additionally, different land uses of bare (39.38%), agriculture (32.53%), range (10.89%), forest (7.85%),water body (5.15%) and residential (4.21%) were found. The results of RI showed a range of 1.9 (Sub-watershed 9) to 74.1 (Sub-watershed 4) out of 100. The present research advised that according to hydrological independency, availability of hydrometric and meteorological stations and ultimately the general location of the candidate sub-watersheds, the sub-watershed 5 with RI of 56.20to be considered as a representative watershed and as a first priority for monitoring the effectiveness of any soil and water management and policy-making scenarios. Then, the sub-watersheds 4, 2 and 1 could also be selected as second priority respectively with RI of 74.10, 70.90 and 70.60. These findings draw a powerful roadmap for the National Mega Project on the Integrated Watershed Management in Iran.

Key words: Environmental Networks, Gavkhooni Swamp Reclamation, Indexed Watershed

Water-harvesting-based Integrated Farming to Boost Farmer's Income

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Water harvesting based integrated farming promises to double the income of small and marginal farmers within 3 years, besides recouping the initial investment incurred to install the system including water harvesting, drainage, animal shed, poultry shed and marketing network.

It reflects the traditional wisdom of rainwater harvesting viz. *Khet ka pani khet me, gaon ka pani gaon me*, mixed farming (horticulture, agro forestry, fish, rabbit and duck rearing, animal rearing) and organic farming (animal dung and urine, poultry excreta used in pond for fish and duck rearing besides enhancing the nutritive value of stored water in pond) leading to make an appropriate balance between the input-output for all the farm activities (output of one activity serves as input for the other to minimize the cost of production) with minimum use of insecticides/ pesticides/chemical fertilizers and practically no sign of degradation/ deterioration of natural resources. To increase per unit land productivity, vertical(multi-storied) farming, by making poultry/rabbit/duck shed above the pond bed was practiced in the farmer's participatory research conducted in 3 districts of Chhattisgarh state.

Two crops in a year was successfully taken by the farmers of this region using the in-situ and ex-situ rainwater harvesting and recycling in otherwise mono cropped rainfed area, where single crop in a year was not assured due to the twin threat of drought and submergence. To double the income in three years few interventions were required, for example, the local poultry breed *Kadaknath* fetched good market price (Rs. 600/ per kg due to low fat content, good for heart patient, eggs are sold Rs 15/- per piece). Similarly the indigenous cow breed (*Sahiwal, Gir, Red Sindhi*, *Tharparkar* and *Rathi*) provides A-2 milk that fetched almost double price in the city market. Fish duck, rabbit production contributes a lion share in the total profit of the farmers. This technique was found environment friendly (No exploitation but Recharging groundwater, mitigating drought and submergence), technically feasible (by use of JCB/dozers pond and shallow dug-well and drainage system can be constructed in short time) and economically viable. Government financial support in the form of Rs. one *lakh* cash in beneficiary account (small and marginal farmers) is required. Let the farmer be allowed to be the decision maker of his own farming not the government officials. This facility from the government will automatically become a people's movement, once the government recognizes the ingenuity of farmers.

Key words: Rainwater harvesting, rainfed, integrated farming, farmers income

Achieving Smarter Watershed Management with Ensured Presences of Environmental and Other Technological Constituents

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Ecological & climate change are projected to amend streamflow volumes and its inconsistency in majority of watersheds throughout the world, which will ultimately have adverse influences on agricultural, aquatic, and rural/urban environments. Human modifications such as the constructing bunds, dams, ponds, reservoirs and the extraction of water for agrarian and other uses, however, are thought to mask climate-induced changes in streamflow. Most of the researchers as well development agencies have reviewed the development and performance of watershed management approaches from the human and economic perspectives. This paper is aligned in a manner to be focused on inclusive role of environmental aspects to govern integrated development and management of natural watersheds. An effort is made to review, analysis, and churn out some food for thought to establish active linkages and importance of smart technological options (IT, ICT, IoT, AI, GIS & RS) and their functional utilities to facilitate smarter development and management of watersheds in an inclusive and integrated manner, taking care of prevailing ecological concerns inside watersheds. More emphasis is put towards hydrological and managerial slices of watershed management programs considering their protective as well as productive functions. Short term as well as long term influences of changes in hydrological entities (prevailing or projected) and their impact assessment on watershed functioning is reviewed and connected with water cycle elements at microscales. By now India has seen a long journey of watershed-based programs, schemes and strategic policy interventions. Author has shared his own 3 decades long real ground experience on dozens of natural watersheds across various states of India. The potential benefits and scope of watershed management stratagems, along with futuristic R&D issues on it are offered; which could be useful for researchers, watershed managers, field functionaries, and even the academicians and policy planners; to make them better equipped with acquaintances towards predominate issues of climate change, water productivities and environmental sustainability at catchment scales.

Key words: Watershed, Environment, Climate-change, Hydrologic Modeling, Soil Erosion

Evaluation of Water Harvesting Structures and Their Re-utilization Plan for Enhancing Productivity in Nuh Block, Haryana

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In "Jal Shakti Abhiyan" of Government programme, out of five objectives water conservation and harvesting, and revival of village ponds are two most important components which can combat groundwater depletion, water scarcity and enhancing productivity. Mewat district of Haryana, inhabited by mostly *Meo* community is largely rainfed and frequently encounters water stress. Traditional water bodies *Johad, pokhar, talab*, tank, etc. are the main water source for agricultural and other uses. These water harvesting structures (WHSs) hold the potential to meet the growing water demand. However, surface waters are vulnerable to pollution due to their easy accessibility for disposal of wastewaters. Before implementation there is the need for evaluation of existing WHSs w.r.t. their functionality, quantity and quality, therefore, spatio-temporal evaluation of storage capacity of WHSs and quality of stored water were studied in Nuh block using Remote sensing, ArcGIS and primary survey. It was found existence of 183 village ponds and 20 earthen dams, out of these 80 village ponds and all earthen dams were surveyed. Water quality analysis for pre-monsoon, monsoon and post-monsoon season of stored water fed by rainfall/runoff, canal and sewerage water showed that WHSs close to villages were used as disposal sites of toilet water creating nuiscence. WHSs fed with canal and sewerage showed substantially higher BOD. Irrigation Water Quality Index developed showed that out of the 80 WHSs, 75 WHSs fell under medium category of suitability during pre-monsoon and 78 WHSs each during monsoon and post-monsoon period. Overall, the majority of the WHSs in Nuh block are moderately suitable for irrigation. Crop water demand of major crops was estimated using the FAO_CROPWAT model. Participatory and scientific design was done for the pond selected in Unka village with deepening upto 1.5 to 2 m, two bath ghats, retaining walls, grass turfing/sodding, and stone pitching with proper shoulder bunds and berms. There is the possibility to increase the command area by 4 times with the existing cropping system and 2-3 times by cultivating remunerative crops through surface irrigation. Collaboration was made with Additional Deputy Commissioner (ADC) and the Block Development Officer (BDO) of the Nuh District, MNREGA personnel and Sehgal Foundation and interactive sessions with the farmers were held on the importance of the village ponds and their revival need. Due to revival of pond an additional storage volume of 22800 m^3 was created. To utilize this stored water optimization plan was being developed using LINGO software. Suitable management strategies for avoiding direct inflow of village sewerage and canal water to village ponds by installing suitable eco-friendly water treatment plant, desilting of ponds along with scientific design and integrated farming system can be adopted for improving water quality alongwith enhanced irrigation potential and income of stakeholders.

Key words: Village pond, Spatio-temporal evaluation, Water quality and quantity, Scientific design

The Yangtze River Basin Soil Erosion and Soil and Water Conservation Comprehensive Control Effect

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On the basis of analyzing soil and water loss actualities and basic characteristics of Yangtze River basin, the author first discusses the small watershed as a unit of mountain, water, land, forest, road of comprehensive control of soil and water conservation technique and method, and then analyzes the effects of the comprehensive control of soil and water conservation in Yangtze river basin. Accumulative total government of soil and water loss in Yangtze river basin area reach 390,000 square kilometers in nearly 30 years, soil erosion area embarked on a historic transformation by reversing the increase to decrease. the soil loss area was decreased from 622,200 square kilometers in the mid-term of 1980s to 530,700 square kilometers in 2013 by 38.18%, the vegetation covered rate up to 42.5%. In soil conservation regions, the intensity of soil loss was decreased 2-3 degrees, river basin ecological environment as into a virtuous cycle. The agriculture producing and living condition in these regions have been improved, which provide a population of over 20 million with adequate food and clothing. Economy in small watershed and counties are developing and these have promoted the new countryside construction.

Key words: The Yangtze river basin, Soil and water loss, Regulation, Effects

Factors Affecting Sustainability of Community-led Watershed Management Projects in Rainfed Agro-ecosystem of Northwest Himalayas

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Global agriculture will be under significant pressure to meet the demands of rising population using finite, often degraded, soil and water resources that are predicted to be further stressed by the impact of climate change. Indian agriculture, with an estimated 78 million hectare of rainfed area and about 65 million hectare classified as degraded land, the importance of watershed development for resource conservation and livelihood promotion cannot be underscored enough. In developing countries national and regional governments, local and international NGOs and other concerned organizations invest large sums every year for the implementation of resource conservation projects. A World Vision evaluation report analysis show that, most community development projects have failed to sustain themselves, become self-reliant and the communities have failed to continue running them after funding organizations withdraw their support. The presence of a well thought out strategy that not only looks at how a donor funded project is completed, but also the means to continue with the project after donor funds have been withdrawn is critical to the project's sustainability. The watershed development should be a programme for the people, by the people and of the people. The people should be involved in all the stages viz planning, designing, implementation and evaluation to ensure sustainable post-project management at their own without assistance from any external agency, at the same time, all the village groups within the watershed have to be involved to make it essentially a people's programme. For several decades, integrated and sustainable watershed management has been suggested and tried in several countries in the world, as an effective way to address complex water and land resource challenges. However its implementation has not been successful in most cases, due to various barriers. Although the primary objective of the watershed development programme is to conserve and develop water resources, it is necessary to address other related issues such as efficient use of water, optimum use of land based on the land capabilities such as livestock development, aquaculture, post-production processing, marketing of the produce and post project sustenance and maintenance. Such an integrated programme with all the components can enhance the benefits of the programme and sustain the interest of the community. So, it is necessary to study the factors responsible for the sustainable management of soil and water resources. Hence, it is important to understand how different factors respond to the soil and water conservation projects after the withdrawal from sponsoring agency. In this context, the present study was undertaken to assess the factors responsible for the sustainability of soil and water conservation projects in North –Western Himalayan region which is predominated by small and marginal farmer's population.

Key words: Sustainability, Rainfed, Watershed, Northwest Himalayas, People participation

Issues Pertaining to Horticultural Component in Watershed Management

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Watershed management is holistic approach for natural resources management for achieving sustainability, particularly in rainfed areas, which are considered most vulnerable to climate variability and droughts. Among the various components of integrated watershed management, horticulture is of prime importance for providing different forms of ecosystem services. The importance of horticulture can be realized from the multiple benefits of nutritional and food security, higher production potentian, utilization of marginal lands, employment generation, women empowerment and foreign exchange. Owing to their perennial nature, deep root system and canopy cover, fruit trees prevent soil erosion by rainfall interception,and improvesoil health by nutrient recycling. However, it has been observed that in many cases, realization of potential benefits (economicand ecological)are not up to the desired level. This can be attributed to an array of factors *viz.,* selection of inappropriate fruit crops/ varieties, neglecting marketing and value addition potential, supply of certified planting material, orchard establishment irrespective to land capability, assured irrigation facility, faulty planting and land configuration techniques, poor post-planting care and maintenance, lack of awareness to group/contract farming, and poor supply chain management system. In several watershed programs, fruit seedlings/grafts are usually distributed to the beneficiaries as freebies, which does not guarantee farmers' willingness to develop systematic orchard. Moreover, farmers generally are reluctant to allocate fertile land for block orchards as they prefer annual field crops for food and fodder. Therefore, fruit trees are planted at wider spacing on field bunds or backyard, which limitsthe implementation of improved horticultural practices to harness the production potential. Further it leads to, in many cases, farmers operate at subsistence level instead of managing commercial orchards. This, in turn, fails to create viable marketing and other processing related infrastructure, leading to low profitability. There is a skewed preference for some major fruit crops which limits the crop diversification. Further, in spite of numerous Central and State-sponsored schemes for horticulture development, lack of convergence and co-ordination with watershed development programs result in poor forward and backward linkages. At the field level soil water conservation structures are generally developed by project implementing agencies due to requirement of technical skill and high cost of construction. The sequence of watershed implementation phases governs the creation of water resources, concurrent to vegetation development. Lack of technical competency and subject expertise of field functionaries with respect to horticulture is also a constraint for intensive horticultural development in watersheds. Based on the aforesaid discussion, it can be suggested that there is need to make concerted efforts for site-specific horticultural planning with adequate market support for sustaining watersheds.

Key words: Watershed development, Horticultural components, Issues

Spring Flow Behavior in Lesser Himalayan Region of Uttarakhand (India)

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Springs of Lesser Western Himalayan (Uttarakhand) watersheds are rain-fed springs and the spring flow is rainfall dependent. Low and uneven distribution of rainfall in space and time restricts the availability of natural spring resources at hills to acute shortage. Their number, type and size of spring limits the population around them. A spring is a place where water issues from the ground and flows over the surface. Essential features in spring are the sources of water and the rock structure which brings water to the surface. Mountain springs emanating naturally from unconfined aquifers are the primary source of water for rural house hold in the Himalayan region. Climate change on precipitation pattern such as rise in rainfall intensity, reduction in temporal spread coupled with other anthropogenic causes, the problem of dying springs is being increasingly felt across this region. The key features of Uttarakhand springs which need attention are to classify the springs and to evaluate the relative performance of spring. Delineation of spring shed to implement rejuvenation activates.

From the average flow of long term, a total of thirty-three springs of Chandrabhaga and Danda were classified using the oldest classification given by Meinzer (1918). It is found that most of springs fall in sixth class with flow 6.5 to 65.5 m^3/day and in seventh class with flow 0.8 to 6.5 m^3/day. Further the relative performance of springs by four methods viz. (1) based on spring flow variability, (2) based on normalized spring flow (short and long duration), (3) based on rainfall spring flow lag and (4) based on spring flow gradient, is presented. A graphical presentation is reported on the scale of 0 to 5 for evaluating the relative performance of springs giving equal weight-age to all four methods. The climate change (including change in rainfall pattern) also impacts the spring flow pattern. The rainfall and spring flows have also been co-related to observe the impact of extreme rainfall events.

Key words: Himalayan springs, Spring flow classification, Rejuvenation of spring-sheds

Acceptance of Land Resource Inventory-based Planning in Watersheds of Karnataka

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During the last few decades, we have witnessed different approaches to watershed development programmes, each with their own advantages and constraints. Utilizing satellite imageries for generation of land resource inventories (LRI) and adopting scientific recommendations therefrom forplanning and developmentof watersheds on plot-level scale has been attempted for the first time in the state of Karnataka through Sujala-3 Project. The project partners carried out detailed survey of the watersheds on a 1:7920 scale for the ultimate goal of identifying land management units based on the potentials and constraints of each parcel of land. Recommendations on the optimal choice of field/horticultural crops and soil conservation measures were provided in the LRI atlas, the final produce of the survey. The LRI atlases were provided to the project implementing agencies (district agricultural departments) to enable them to prepare the detailed project reports/net plans and implement the plans based on the LRI-based recommendations. A survey covering 400 farmers at random in twelve micro-watersheds in four districts of Karnataka was carried out through a well-structured questionnaire to understand the response of the farmers to the LRI-based recommendations and the extent to which the science-based approach was accepted by them. The first round of interviews was conducted during June - November 2017, when plan execution was started/in progress in most of the watersheds. The second round was carried outduring October 2018 - June 2019, when the watershed activities neared completion.The farmers were asked whether they were aware of the approach of watershed management programme, whether they understood or were trained in the concept of LRI and its recommendations, whether the recommendations were acceptable to them, and whether they were willing to adopt the recommendations and spread the same to nearby villages/watersheds. During 2017, the percent respondents aware of the Sujala Project ranged from 81 to 86%, those aware of LRI-based approach ranged from 47 to 83%, and those willing to adopt the LRI recommendations ranged from 47 to 60%. However, intensive capacity building programmes if both field functionaries and farmers carried out by the State watershed/ agriculture departments along with KVKs located in the Project districtssince 2017 have significantly altered the response of the beneficiaries. During 2019 (present scenario) about 91% of the farmers across the four districts surveyed are aware of the project, 86% of them are aware of the benefits of LRI-based approach and more than 75% of the farmers are willing to adopt the recommendations in their own fields.Perusal of the two scenarios clearly depict an increase in acceptance levels of the science-based watershed approach adapted by the Project.

Key words: Land resource inventory, Sujala-3 project, Farmers' Acceptance, Capacity Building

Detection of Land Use and Land Cover Changes of a Watershed using Remote Sensing and GIS

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This study reveals to identify the changes of Land Use and Land Cover of the Munidevinipally watershed of Sangareddy district of Telangana state. The objectives of the study are to prepare temporal Land Use and Land Cover maps of the study area to analyze the nature and extent of Land Use and Land Cover changes and to identify the major components which promoted these trend changes. The detection of LULC change of the study area are analyzed and compared. The results are represented spatially as well as graphically by GIS maps. The study area has under gone a significant land cover change due to IWMP program. From this study it is inferred that there are significant changes in wasteland, forest and water bodies in the study area. It is necessary to conserve forest and water bodies of the study area for sustainable development. This study will be useful for efficient watershed management.

Key words: Land use and land cover, watershed and GIS

Land Resource Inventory (LRI) for Sustainable Watershed Development -A Case Study of Bisarahalli-1 Micro-watershed, Koppal district in Karanataka, India

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The land resource inventory (LRI) of Bisarahalli-1 micro-watershed which is located in the central part of northern Karnataka in Koppal Taluk and District, Karnataka State was taken up as a case study under Sujala III project for sustainable development. The total area of the micro-watershed is 571 ha. The climate is semiarid and categorized as drought-prone with average annual rainfall of 662 mm and length of growing period is less than 90 days. The LRI was conducted by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery at 1:7920 scale. The false colour composites of satellite imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The landscapes identified in the watershed area are Granite gneiss and Alluvium, based on geology. Fourteen soil series were identified and mapped as phases of soil series with 21 soil mapping units in the micro-watershed. Surface soil samples collected for fertility status (macro and micronutrients) at 320 m grid interval were analyzed in the laboratory. By linking the soil fertility data to the survey numbers through GIS, soil fertility maps (N, P, K, S B, Fe, Mn, Cu and Zn) were generated using Kriging method for the micro-watershed.

The master soil map was used to prepare several interpretative and thematic maps like land capability, soil depth, surface soil texture, gravelliness/ stoniness, AWC, slope and erosion were generated. Land suitability for major agricultural and horticultural crops grown in the area were assessed and crop suitability maps generated showing the degree of suitability along with the limitations associated with each management unit. Similarly, soil and water conservation treatments required were assessed and the treatment plans prepared for each micro-watershed covered under the LRI. By considering the highly and moderately suitable lands for each of the crop, a suggested land use plan has been prepared which helps in increasing the production on sustained basis. All the spatial and nonspatial data generated was converted into digital format and stored in the Digital Library and then made available to various line departments on a real time basis through an appropriate delivery mechanism like Land Resource Portal.

Key words: Land resource inventory, soil series, mapping units, thematic maps

Converging Agronomic Innovations for Sustainable Productivity of Watersheds: Experiences from Odisha

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Agricultural development in watershed can be viewed as an integrated social-technical system in which farmers and other stakeholders create solutions, opportunities for production and livelihood problems. A range of location specific technological options to general one are considered for varying farming scenarios. Agronomic interventions are of utmost importance in catchment after creating water harvesting facilities in order to increase the production, productivity and income of the inhabitants. A few worthy experiences of successful projects are mentioned herewith. The Kokriguda watershed located in Semiliguda Block of Koraput district, Odisha, was implemented under IWDP programme during 1998-2003. After implementation of the project, cropping intensity has increased from 100% to 117%. Twenty three hectare more area increased under cultivation in *rabi* season. Current fallows and cultivable wastelands reduced by half. Thirty seven hectare of unproductive hilly wastelands was developed under forestry production systems. More emphasis on vegetables was given due to ensured return by the near market and less duration crops. On similar lines in Malipungar micro-watershed in Semiliguda Block of Koraput covering an area of 275 ha area was implemented during 2001 to 2005. In the command area of watershed *Jhola kundi* intervention was done and farmers started tomato, maize, cabbage, cauliflower, capsicum, peas, coriander, cucumber cultivation. Twenty nos. of *Jhola kundi* irrigates 8 ha area benefiting 24 farmers in Malipungar watershed. Conservation and crop production technologies resulted in increase of organic carbon of about 1.3 times than farmer's field. One of the local agronomic intervention is farming system which takes a predominantly ecosystem approach and its scientific application for crop production and management. Increase of the number of small farming system is important indicators for watershed development. Similar kind of different innovative agronomical measures were taken and in consultation with the farmers' by using their traditional understanding of resource conservation were converged in execution and implantation of activities in different watersheds in tribal region of Odisha. Recently in Lachhaputtrgahti model watershed under NWDPRA post project analysis indicates that watershed productivity increased from 4962 kg ha^{-1} (pre-project) to 6126 kg ha^{-1} (19%) during period. This can be attributed to increased area under irrigation, increased productivity of crops, increased vegetable cultivation; which is highly remunerative than any grain crops raised in the watershed. Management of natural resources using convergence approach among different interventions at the catchment/watershed scale produce multiple benefits in terms of increasing food production, improving livelihoods, protecting environment, and equity issues along with biodiversity concerns.

Key words: Convergence, Innovations, Catchment

Development and Management of Integrated Water Resources under Integrated Farming System for Livelihood Security at North-Eastern Hilly Region

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Water availability is one of the key factors affecting the productivity of agricultural production systems in the world. Water resource development and its efficient management have to be undertaken with more space covering hill slopes under integrated farming system(IFS) approach. It is essential to increase the productivity per unit land with less water from rainfed hill ecosystems. There is an urgent need for adoption of advanced agricultural and water management practices to produce more crop, fish, meat products etc. per drop of water in IFS. An attempt has been made to harvest runoff water at foot hills (Valley) and lift through solar pump to store at hilltop in lined water harvesting structure for use in vegetable and spice cultivation along with fish and pig rearing. The study site is located at Umroi Madan Village, RiBhoi District. One pond was de-silted at valley and one number of ponds (plastic lined jalkund) was constructed. Runoff water from the upper area was collected in the pond located at the outlet (Valley) of the watershed. The collected water was pumped to the polyline ponds (jalkund) located at the higher elevation of the watershed by using solar power operated water pump. Mild slope terraces were constructed on the sloppy surfaces. For initial stabilization of the soils, vegetable crops like French beans, chilly and turmeric were planted on the prepared bed. Two piggery shed having dimension of 16 m × 20 m were constructed in the watershed. Six piglets were kept in each pig shed. Water from the *jalkund* was used for domestic purpose, irrigating vegetables, and for supply to the piggery units. Fish culture was undertaken with supply of fish feeds in both the upstream and downstream jalkunds. In order to have an efficient way of irrigating the raised bed from the jalkund, a solar power driven gravity fed drip irrigation system was developed. It was found that the pump needs to operate from as low as 2.3 hrs/day during December-January to as high as 4.8 hrs/day during April for supplying the required amount of water. This time requirement for the pump is within the capacity of the installed solar system which can support operation of the pump for six hours duration. French bean, Chilli and turmeric were grown on terraces having area of 647, 440 and 240 m^2 respectively under crop components of IFS. Productivity of French bean, chilli and turmeric were 94.56, 128 and 257.78 q/ha with water use efficiencies (WUE) of 15.76, 12.19 and 15.34 kg/ha-mm and economic WUE of Rs. 630.4,731.43 and 383.6 per ha-mm. Under live stock components of IFS, fish (IMC) and pig rearings were undertaken in 936m^2 pond and 320 m^2 pig shed. 376 kg of fishes were produced with WUE of 2.68 kg/ha-mm and 460 kg body weight of pigs and piglets with WUE of 299.01 kg/ha-cum. Economic WUE were Rs. 642.74/ha-mm and Rs.376.09/ha-cum for fish and pigs respectively. Farmers with 2583m^2 of land can earn Rs.3, 36,971/-per annum with IFS approach by using solar powered drip irrigation system.

Key words: Development, Integrated Farming system, Livelihood Security, Water Resources

Impact of Nutrient Movement in Agricultural Watersheds on Surface Water Resources of Nilgiris District, Tamil Nadu

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Water pollution is one of the main environmental issues that every living organisms are facing, as more than 70% of the Earth's surface is water-covered. One of the main causes of water pollution is nutrient enrichment due to indiscriminate use of agricultural inputs, disposal of untreated effluents from industries and urban waste in to water bodies. Agricultural watersheds which are located in hilly areas are considered to be more susceptible to Non Point Source (NPS) pollution of agricultural inputs. Nilgiri district being a high rainfall zone serves as an important water source for agriculture and domestic uses in Nilgiris, Coimbatore, Erode and Tirupur districts. Water bodies of Nilgiris are being polluted at an alarming rate due to population pressure and intensification of agriculture. Intensification of agricultural land has resulted in a significant increase in the application of both organic and inorganic fertilizers since the early 1960s which leads to enrichment of nutrients in surface water resources resulting in water quality degradation. Sillahalla is predominantly an agricultural watershed with main land uses of seasonal agricultural crops and tea plantation followed by forest and non agriculture with general slope of the watershed is from 2 to 16 per cent in the valleys and foot hills to about 50 per cent on the hill sides. The AGNPS (Agricultural Non Point Source Model) model was used to quantify the soil loss, runoff and nutrient loss from the watershed. The load of Nirtogen was estimated in runoff and sediment from the study area ranging from 2.1 (mg/l) to a maximum of 45.6 (mg/l). The phosphorus loading of the watershed ranges from 0.01 to 0.25 (mg/l). In this study efforts were taken to study the effectiveness of different nutrient management practices to reduce the nutrient enrichment of the surface water bodies. The nutrient load was simulated under two different nutrient management scenarios Viz., reducing 25% and 50% of the nutrient dose.The farmers in the study watershed are recommended to reduce the 50% applied Nitrogen and Phosphorus through chemical fertilisers for the major vegetable crops like potato and carrot with INM practices. The recommendation can be derived from STCR equations developed based on soil test values. Model also run with different scenarios by converting the agricultural land uses to other land uses and found that if 25% of agriculture land was converted to tea plantation the nutrient movement will further reduce due to low fertiliser application.

Key words: Agricultural watershed, foothills, nutrient management

Inter Watershed Water Transfer can Pave Way for Doubling Farmers' Income in NW Himalayas

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In India, most of the hilly regions present a paradoxical situation of scarcity amidst plenty on the water front. Though sufficient rainfall is received in most parts of different hilly regions during monsoon season, majority of it flows down the steep slopes as runoff and is not available for practical use. Water harvesting plays a key role in the hills. In some places of Himalayas, traditional water harvesting systems like *Naulas*, *Khals, Hauj, Guhls* etc. are still in place to meet domestic, livestock and irrigation needs. But there are inherent demerits and limitations. There are a few other sources of irrigation in the hills like lift irrigation through electric motor or hydraulic ram (commonly known as *hydrams*) but their wider applicability is limited due to high cost and other geographical constraints. Presently in Uttarakhand, only 10-12 per cent agricultural lands are irrigated in hill districts as the available surface and sub-surface (springs) water resources have not been tapped widely. Therefore, agriculture in this hilly region is largely rainfed, subsistence or there is not much surplus for the market. As a result most of the able-bodied men have migrated to other places in search of better livelihood options. In present climate and land use change scenario, water scarcity becomes the first most vital aspect in hill agriculture as climate change reduces the duration of water availability and land use change with intensive agriculture increases the water demand in agricultural watersheds. In many micro-watersheds of Himalayan ecosystem, surplus water exists due to low water demand and conservation of water naturally in their forested catchment. This effective natural water conservation is mostly because of the presence of thick vegetation and porous soil in upper reaches of catchment area which gives rise to perennial springs. Hence, increased water demand can be met to a greater extent by community based adoption of inter watershed water transfer through HDPE pipe line. This has been recently demonstrated in Hattal and Sainj villages of Dehradun district using participatory approach. These remote villages belong to *Jounsar* Tribal region of Uttarakhand state and situated in lesser Himalayas which is socio-economically backward and suffers from severe land degradation and water scarcity problems. About 270 families are inhabited in these villages and more than half of them are engaged in crop cultivation. Traditionally cereals, pulses, vegetables and fruits were cultivated in these villages under rainfed condition. After intervention of inter watershed water transfer, a total of 670 m^3 water is available to the farmers in 24 hours in these two villages which has led to 3.17 times increased in net irrigated area. Presently a total of 186 farm families are associated with participatory water resource management who had adopted the cultivation of off-season vegetables in about 35 ha area with assured irrigation facility developed in their villages. After four years of project period, during 2017, these farmers had produced tomato, cauliflowers and other vegetables worth of Rs 411.08 lakhs and average family income from agriculture has risen to 4.28 times. Reverse migration of 17 families has been observed in Sainj village where number of farmers had abandoned their fields due to scarcity of water.

Key words: Watershed, lesser Himalayas, rainfed, forested catchment

Energy Saving Solar Pump Combined with Micro-irrigation for Economic Use of Harvested Runoff in Semi-arid Region of Karnataka

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A field experiment-cum-demonstration was conducted in a farmer's field in Ballari district of Karnataka where an energy efficient DC Solar pump system was used in place of diesel run pump for water lifting from a farm pond. Drip irrigation was used in place of farmer's practice of surface irrigation for economic use of harvested runoff from the farm pond. The farm pond is having storage capacity 5407 m^3 with catchment of 24 ha area and during both *kharif* and *rabi* seasons, stream flow/runoff is harvested in the farm pond. The farm pond is filled during month of September and used for irrigation up to end of February. During *rabi 2017-18*, by utilizing harvested rainwater from the farm pond, the farmer had cultivated chilli and tomato in his 3 acres land using solar pump with drip system. It was observed that by using solar pump with drip irrigation method, 545 kWh of energy was saved, Rs. 7603/- is saved towards energy (fuel) cost, 357 Kg of CO_2 emission was avoided and net return increased by 55% over his earlier practice of surface irrigation. The B: C ratio wasalso found increased from earlier 3.3 to 5.2 in chilli, and1.4 to 2.0 in hybrid tomato. It infers that due to root zone application of water by drip system, it helped in increased frequency of life saving irrigations resulting in better crop growth and higher yield and simultaneously saving of energy by solar pump without any extra expenditure of fuel cost.

Key words: Energy efficient, Solar pump, Runoff, Drip system, B: C ratio

Multiple Use of Harvested Rainwater: An Economically Viable System for Small Farmers of Hilly Regions

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In order to meet the challenge of feeding ever-increasing population of our country, there is a dire need to produce more food and value from less water. What smallholder farmers need is a water supply system that provides water for both domestic needs and high-value agricultural production, including livestock. Such a system needs to be flexible so that householders can switch from domestic to productive use to match seasonal demands. About, 28.34% farmers lands are having operational area of one hectare or less in Nilgiris followed by 24.01% land holders are having 1-2 hectare and the yield of vegetable crops is adversely affected by water stress due to the frequent dry spells even during monsoon season. In addition, there is the scope to cultivate irrigated crop during summer (February to May) by using the harvested water which can give additional farm production. In order to mitigate the water stress during dry spells and summer and increasing farm production a model multiple water use system to enhance the land and water productivity and livelihood security of small farmers of Nilgiris has been developed and evaluated. A farm pond is excavated at the lower reach of the field to harvest the rain water. Model includes Tea cultivation in upper reaches, vegetables at middle reaches and live stock namely Geese and rabbits and farm pond with fish culture at lower reaches. Water availability at the farm pond for effective recycling was worked out to be 850 cu.m which is useful for minimizing the risk of dry spell induced crop failures. Out of the utilizable rain water, 750 cum water is enough to provide supplemental irrigation including maintenance of live stocks. Economic feasibility of the system was analyzed using the indicators *viz.*, Net Present Value (NPV), Benefit Cost ratio (BCR) and Internal Rate of Return (IRR). MUHW system was compared with the predominately prevailing rainfed cropping system i.e. carrot-potato + tea. Sustainable output of MUHW was computed by taking the average value for three years i.e. 2013-14 to 2015-16. Discount Cost and benefit flow charts were generated assuming the life of system as 10 and 15 years at different discounts rates (10, 12 and 15%) to factor-in the risk of rainfall variability in rainfed areas. At prevailing prices of crops estimated net benefits was to the tune of INR 256384, and it was assumed the same net benefits will be obtained from the system over its life. At the prevailing market prices, the values of NPV are INR 932215, 817405 and 671364 at 10, 12 and 15% of discount rate, respectively for 10 years whereas the same are INR 1283174, 1096114 and 870339 when life of the system is taken 15 years. The positive values of NPV indicate that system is economically viable generating more income than the amount of investment. In case of BC ratio, the thumb

rule says that it should be more than one for a system to be economically viable. In our case, BC ratios are more than one, at all the discount rates, and ranging from 3.96 to 2.71. Finally, in case of IRR, which shows the income generating ability of the system, the computed values should be should be higher than the discount rate (indicates the opportunity cost of the investment) to be a preferred choice of investment over the others. At all the discount rates, results indicate that the computed IRR (48.37 and 49.30 for 10 and 15 years of life, respectively) are higher than the discount rates suggesting that the system is worth investing. Interestingly, in all the cases of expected fall in prices, the values of indicators suggest that the system is still economically viable. More importantly, even if the prices drop by 50 per cent, the system is economically viable showing economical resilient under the prices fluctuations which is very common for these crops in the study area. The system proves that the micro scale water harvesting structure with multiple uses is the best offer to build climate resilience agriculture in small scale farming systems in mountains.

Key words: Micro scale water harvesting structure, climate resilience, small scale farming

Field Efficiency Assessment of Pressure-State-Response (PSR) Model for Watershed Health Characterization (Case Study: Shazand Watershed-Iran)

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The concept of pressure-state- response (PSR) indicate that the anthropogenic activities exert pressures on the watershed, changing the natural resources quality and quantity. Thence, these changes alter the watershed state ultimately result in watershed or human responses. However, the field assessment of the PSR performance has not been adequately taken into account yet. In the present research, the accuracy status of PSR was then estimated for health assessment of the Shazand Watershed, Markazi Province, Iran. To this end, PSR model was firstly developed for the Shazand Watershed according to 17 criteria for the year of 2014. For pressure indicator characterization, mean annual precipitation, mean annual evapotranspiration, population density, agricultural land area with slope above 25%, area under anthropogenic activity, environmental sensitive area index (ESAI) and slope of contribution area in runoff generation were used. Mean annual precipitation-evapotranspiration ratio, landscape diversity index, normalized difference vegetation index (NDVI), landscape dominance index and contribution area to runoff generation-total area ratio were characterized for estimating state indicator. Additionally, for response indicator, rangelands area ratio, landscape fragmentation index, soil degradation intensity, area generating the runoff coefficient, > high flow discharges,< low flow discharges ratios and drainage density criteria were used. To assess the performance of PSR results, a total of 110 points was taken as benchmark distributed over the entire study watershed and eventually were subjected to field surveying with help of two approaches of the Bureau of Land Management (BLM) and the Visual Soil Assessment (VSA). The Shazand Watershed health in 2014 were estimated 0.33±0.17 with respective pressure, state and response scores of 0.39±0.24, 0.37±0.14 and 0.36±0.23. The results of surveying verified that PSR model performed very well in mirroring watershed health, particularly for conservation objectives, in an effective and an acceptable level of accuracy of about 75%. The necessity of good management and monitoring activities was accordingly found crucial to minimize the destructive environmental impacts of the developmental activities in the Shazand Watershed.

Key words: Ecological indicators, Health monitoring, Planning tool, Watershed modelling

Rain Water Use Efficiency and Relationship between Rainfall, Runoff, Soil Loss and Productivity in Kandhamal District of Odisha

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A trial was conducted at All India Coordinated Research Project,OUAT, Phulbani during the year 2007-09 with the objectives to quantify the runoff and soil loss under different cropping systems, develop relationship among them and to obtain rainwater use efficiency. The treatments tried were T_1-Sole crop of rice, T_2- Sole crop of pigeon pea. T_3- Sole crop of groundnut,T_4-Pigeonpea and rice in alternate strips,T_5- Pigeon pea and groundnut in alternate strips, T_6-Intercrop of rice and pigeon pea (5:2),T_7- Intercrop of groundnut and pigeon pea (4:2),T_8-Uncultivated fallow,T_9-Cultivated fallow, All crops were planted across the contour. Intercrop of groundnut and pigeon pea (4:2) gave significantly higher rice equivalent yield compared to other sole crops. Mean rice equivalent yield was 38.62 q/ha. Groundnut + pigeon pea (4:2) introduction increased the yield by 158% as 97% and 21% when compared with sole crop of rice, pigeon pea and groundnut respectively. Groundnut + pigeon pea (4:2) gave the lowest runoff of 309mm which is 23% less than the cultivated fallow (401mm).Groundnut + pigeon pea (4:2) gave the lowest soil loss (8.03t/ha) which is 47% lower than the cultivated fallow (with highest soil loss 15.19 t/ha).The Groundnut + pigeon pea (4:2) gave the lowest (24.2%) mean runoff of the rainfall compared to other treatments. The relationship among rainfall, runoff and soil loss was found out which can be used to predict the runoff and soil loss from rainfall for same type of soil condition and slope. The rainwater use efficiency was highest 3.32 in Groundnut + pigeon pea (4:2) treatment. Thus it can be concluded that intercropping of groundnut with pigeon pea planted along contour may be practiced to increase crop yield and lowering the soil loss and runoff in the hilly tribal areas of Kandhamal district of Odisha.

Key words: Rainwater, Efficiency, Rainfall, Runoff, Soil loss, Kandhamal district, Odisha

Land and Water Resources Management in the High Cauca River Watersheds

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The high Cauca river watershed, drains more than fifty rivers which originate in the western and central Cordilleras of Colombia, forming a fertile valley in the southern zone with tropical climate, generous rainfall and inhabited by more than five million inhabitants. With the increase in population and activities to exploit the region's natural resources, there have been different negative impacts on land and water, including environmental pollution, water related use conflicts, soil erosion processes in sloping lands, salinization of soils, illegal activities, urban sprawl, logging, etc. In order to improve the use of lands and water, technical and legal measures have been implemented, such as the watershed management plans - POMCA, the water resources ordering plan –PORH and the Lands Ordering Plan – POT; which are the main planning tools for the Colombian territory. These POMCAS and PORH are mainly under the responsibility of the environmental authority of the state, those legal tools include the participation of the representatives of the communities and the stakeholders present in each watershed. Instead the POTs, are mostly related to the urban land development. The POMCAs and PORHs are complemented by including the risk analysis and the study of groundwater in each watershed. The different assessment plan evaluation, was carried out in different basins of Western Colombia. The main difficulties to develop those plans are related to the organizational deficiency of the watershed stakeholders, the difficult flow of information between government institutions and the private sector, insufficient financial resources for the development of extension programs and the reduction of government staff and resources for support and control. The lack of communication or the overlap of functions between some governmental institutions, can create difficulties in the land management plan development. The application of the POMCA, PORH and POT, policies, has allowed a better knowledge of the social and bio-physical aspects of the territory, improves management and standardization of information, cartography, consolidation of organization and communication processes with and between communities, governance, improvement of knowledge of water resources and monitoring system, a better water conflicts management, improvement in the use of water in agriculture, updated knowledge of the occupation of the territory and knowledge of the weaknesses of the Government with respect to the control and presence in the territory.

Key words: Tropical watersheds, Lands development, Water management

Preparation of Preserve from Different Varieties of *Aonla* (*Emblica Officinalis* Gaertn.) and their Physico-Nutritional Changes during Storage

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Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is one of the most important non-traditional fruits of Indian origin, having immense potentiality of cultivation on marginal wastelands. In Rajasthan, it occupied an area of 1730 hectare with the production of 13275 mt. The produce remains in market for a very short span. Since it is a perishable commodity it need quick disposal. Huge harvest of produce during peak harvesting season create glut and fruit can not consumed fresh or in raw state as it is highly acidic and astringent. It is therefore, not popular as table fruit. The excellent nutritive and therapeutic value as well as owing to restricted availability and high perishability of *aonla* fruit, value addition through processing would be the only effective tool for economic utilization of increased production of *aonla* in future. For this conducted an experiment on three different cultivars of *aonla i.e.* 'NA-7' (V_1), 'Anand-2' (v_2) and 'Banarsi' (V_3), their fruits were pricked by hand (P_1) and machine (P_2), the sugar treatment was done by concentration of sugar syrup by boiling (M_1) and solar heating (M_2) three different experiments. Thus, total 12 treatment combinations for preserve were laid out under factorial complete randomized design with three replications. The prepared preserve was stored in dried place at ambient temperature and observations on different physico-nutritional changes in *aonla* preserve was analysed prior to storage and during storage at monthly interval.

Results revealed that the best quality of *aonla* preserve prepared from 'NA-7' (V_1) with machine pricking (P_2) and concentration of sugar syrup by solar heating (M_2). The *aonla* preserve under above treatment was superior in respect to organoleptic rating as well as nutritional quality. As far as relative economics of the treatments is concerned the preserved prepared from $V_1P_2M_2$ resulted highest benefit cost ratio *i.e.* 2.24: 1.

Key words: Aonla, physico-nutritional changes, benefit cost ratio

Response of Organic Inputs on Nutrient Status of Soil in Potato and Turmeric Cropping Sequence

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Use of chemical fertilizers in imbalanced and indiscriminate manner has developed many problems like decline of soil organic matter, increase in salinity and sodicity, deterioration in the quality of crop produce, increase in hazardous pests, diseases and soil pollutant problems. Continuous use of inorganic fertilizers has not only brought loss of vital flora and fauna but also resulted in loss of secondary and micro-nutrients. In such a situation, a renewable and lasting alternative, that is organic farming, has to emerge for successful agricultural revolution and comprehensive management approach to improve soil nutrient status, soil health and ecosystem of an area. Organic farming has potential for reducing some of the negative impacts of conventional agriculture on the environment and is an option to restore the productivity of degraded soils. With this objective the present study was undertaken to study the response of organic inputs on nutrient status of soil in potato and turmeric cropping sequence. The present study comprised of different levels of organic inputs such as FYM, vermicompost and poultry manure. The study led to the conclusion that organic inputs were leads to improving organic matter content and nutrient status of soil. This overall alleviation in soil nutrient status through organic matter addition would lead to better soil health and productivity in long run, due to higher nutrient and water retention and also improved soil structure. Thus, it can be concluded that in the present scenario of deterioration organic matter content of soils and its ill effects on soil and crop health, the organic inputs i.e FYM, vermicompost and poultry manure enhanced fertility status of soil, which ultimately reflects a healthy soil and play a promising role in sustaining soil health for future generation.

Key words:Organic Matter, Nutrient status, FYM, Vermicompost, Poultry manure

Comparative Efficacy of FYM and Vermicompost on Soil Physico-chemical and Biological Properties under Cauliflower-tomato Production in Mid Hills of Northwestern Himalayas

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Cauliflower and tomato are the two commercially important vegetable crops of Northwestern Himalayas cultivated mainly Shiwalik region. Crops being heavy nutrient feeder can adversely affect soil health in long term cultivation. Sole application of chemical fertilizers provides only one or two nutrient elements to the crop and also deteriorates soil physical properties and cause imbalance to nutrient cycling supported by soil micro-organisms. Integrated nutrient management is an approach to soil fertility management that combines organic and inorganic methods of soil fertilization. The integrated use of chemical fertilizers and organics hold great promise in securing high level of crop productivity and also to protect soil health from deterioration and pollution hazards. With the objective of comparing the efficacy of FYM and Vermicompost on soil physico-chemical and biological properties under cauliflower-tomato production in mid hills of Northwestern Himalayas, the present investigation with different combinations of fertilizers, FYM and vermicompost was carried out under cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Pusa Snowball K-1 and tomato (*Solanum lycopersicum* L.) cv. Solan Lalima. The experiment was laid out in a randomized block design with three replications comprising eleven treatments *viz.* T1 (Absolute control), T2 (100% FYM), T3 (100% VC), T4 (100% N + 100% FYM), T5 (100% NP + 100% FYM), T6 (100% NPK + 100% FYM), T7 (100% NPK + 100% VC), T8 (100% NPK + 50% FYM + 50% VC), T9 (50% NPK + 100% FYM + 50% Rec. N through FYM & VC on 50:50 N-equivalence basis), T10 (75% NPK + 100% FYM + 25% Rec. N through FYM & VC on 50:50 N-equivalence basis), T11 (125% NPK + 100% FYM). The treatments consisting of FYM proved to be the better one than vermicompost in terms of significantly higher OC Values, soil microbial biomass and microbial activity. FYM treated plots in comparison to the VC treated plots improved soil bulk density and porosity to a greater extent, which in turn would lead to better soil structure as well as nutrient and water retention capacity, thereby, reducing their losses and improving the overall soil physical condition for higher crop growth and productivity. This study lead to the conclusion that organic amendments especially FYM can significantly affect the soil physico chemical and biological properties and at the same time integration of organics with chemical fertilizers would go a long way in sustaining soil health and productivity.

Key words: Soil physico-chemical properties, FYM, VC, Cauliflower, Tomato, Soil MBC

Design and Construction of Soil Conservation Structures using Wastage Materials

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The spread of gully is seen as cancer affecting many communal grazing spots, foot paths, cattle trafficking lines, roads, etc. It also obstructs field operations and movement. The subsoil and gravel mined by erosion is a major threat on lower lying fertile agricultural fields by burying them under. Keeping in view the above facts, a study on design and construction of gully plugging structures for soil and water conservation was carried at BRSM College of Agricultural Engineering and Technology & Research Station, Chhattisgarh in 2015-16. Soil and water conservation structures namely single row brush wood, double row brush wood, loose stone, gunny bag and gabion check dam, respectively were constructed and evaluated. For construction of structures, there was used wastage and broken fencing poles which were procured from college campus fenced in place of wooden poles. Wire mesh for gabion structures was procured as wastage wire mesh used for college fencing. Other materials such as boulders and Ipomea sticks were available near the field. Empty gunny was also collected from same buildings site. It was observed that importance of gully control structures by reducing the original gradient of the gully channel and the structures were diminished the velocity and the erosive power of runoff and recharged the ground water. Run-off during peak flow has been conveyed safely by check-dams. It was also observed that successful runoff reduction and sediment deposition in upstream side also. The performance of the structures was evaluated on the basis silt deposition and percentage depth of water ponding. The total silt deposition in upstream side of gully plugging structures was found to be 89.41 quintal which indicates the good features of soil conservations. The maximum 38.48 quintals sediment deposition was observed in upstream side of loose stone structures wile minimum of 7.75 quintals was recorded in double row brush wood structure. The maximum percentage depth of water ponding of 89% in gunny bag structure and minimum depth of water ponding 61% in single row brush wood structure.

Since constructed these gully control structures, we used wastage and broken fencing poles which were procured from fencing college campus in place of wooden poles. Wire mesh for gabion structures was procured wastage wire mesh used for college fencing. Other materials such as boulders and Ipomea sticks were available near the field. Empty gunny was also collected from same buildings site as wastage after grading for use. Hence it is very low cost structure.

Key words: Soil and water conservation, gabion check dam, runoff reduction

Watershed Development Planning through Socio-economic Survey of Ariyur Micro-watershed in Tumkur

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The survey was conducted in Ariyur micro-watershed of Tumkur District in Karnataka covering an area of about 597 ha. Forty two households including 3 landless were selected. Results indicated that, there were 23.64 percent of illiterates and 5.81 percent of functional literates in watershed. Hence, extension methodologies such as demonstration, street play, drama, video shows will be effective in dissemination of the technologies. Participation level of household members in the local institutions was found minimal hence, there is a need to support formation and membership in local groups such as SHGs, dairy cooperatives and other such institutions to enhance the participation of household members. The possession of livestock was found to be low hence, farmers may be trained on the role of subsidiary enterprises for higher income and availability of financial support for subsidiary activities. Further, government should encourage income generating activities such as areca plate making, growing of leafy vegetables and production of vermi composting by providing financial assistance along with the market linkages. During the agriculture season, farmers facing problem of non availability of machinery/ equipments. Hence, custom hiring centers has to be set up at hobli level which helps to carry out farming operation on time. Bore well was the major source of irrigation for 23.81 percent of the households and nine bore wells have dried up among the sampled households. Hence, farmers need to be educated on judicious use of water resource for higher crop productivity. In the micro watershed, 42.62 percent of the agriculture land is under dry condition, hence, Agriculture department has to be more active in popularizing and convince farming community to adopt the technologies like short duration crops, high yielding drought resistance crop varieties, drip irrigation technology and subsidy information to enhance the productivity of land as well as farmers income. Regarding the adequacy of fodder, 28.57 percent of the households have opined that dry fodder was adequate and only 16.67 percent opined that green fodder was adequate. Hence, fodder crops which are palatable to dairy animals need to be introduced at the farm level. Further, importance of leguminous fodder for higher milk yield has to be educated among dairy farmers. In the study area, 28.57 percent of the households have shown interest in cultivation of horticultural crops. Hence, department of forestry and horticulture has to supply saplings to interested households at nominal fee to encourage agri-horti-silviculture system of farming. In the micro watershed, 42.86 percent of the households have sold agriculture produce to the local/ village merchants. Hence, day to day prices for all agricultural produce along with market place which are nearer to famers need to disseminate for all farmers. Further, introduction of e-marketing facility for agriculture produce will help farmers to sell their produce at competitive price. Farmers in the study area (85.71%) have experienced soil and water erosion problem, hence households have shown interest towards soil testing. Hence, introduction and effective implementation of mobile soil testing vans is crucial for soil testing at the door step of farmers.

Key words: Socio-economic survey, Micro-watershed, Households, Income Generation Activity

Soil Moisture Balance based Crop Planning in Achathipura Sub Watersheds of Southern Karnataka

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A hydrological study was taken in Achatipura sub watershed in Chamarajnagar district under University of Agricultural Sciences (UAS), Bangalore. For judicious utilization and accurate estimation of water resources in time scale. The annual average rainfall was considered for water balance study through standard procedures, result indicates variation in available soil moisture during January (80 mm) to November (300 mm). More usage of ground water in the summer season for irrigation leads to fall in ground water level in the month of August 36.4 meters below ground level (mbgl), Later it rises to 22 m below ground level during (December) due to good rains in the previous months (August, September October). Similarly, water balance study indicates surplus minimum runoff water flow in April (19 mm) and Maximum runoff flow in November (83.3 mm). While the deficit in water balance was found during January, Febraury, March, July and December months, life saving irrigation is required to avoid crop stress (based on crop growing period) and to get a good crop yield. This soil moisture water balance study helps in choosing suitable crop in the watershed based on hydrological and land resource inventory study.

Key words: Soil moisture balance, Ground water fluctuation, Crop planning

Water Resources Scenario of India under Climate Change

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Fresh water is renewable natural resource, yet world's fresh water availability is decreasing steadily day by day. Water is the unique and essential source for sustainable crop production under climate change scenario. Its productivity is very low due to lack of proper technique and methods to fully utilize the resources which includes both ground and surface water resources. In India, all kind of weather is found within a year, and this demerit makes water resources more diverse, and because of diversity in weather and topographical factors, the single technique cannot be suitable for whole the country. Water not only affects crop production but also influence the other related sectors like domestic use, industrial sector and electricity and power generation sectors. Ground water based irrigation systems are equally important as surface, but irrigation based on ground water is more beneficial for small and marginal farmers' community. India is very rich in natural resources. According to UN estimates, total water availability on earth planet is about 1400 M km^3 which is enough to cover earth with a layer of 3000 meters. Out of that, 3 percent water comes under fresh water. Around 69% of the fresh water cannot be used due to permanently frozen in Polar Regions as locked up in glaciers and icecaps and remaining 31% is available as surface water. India supports 4 per cent of water resources in the world. Its annual water resource potential is around 4000 cubic kilometre.

Key words: Climate change, Crop production, Irrigation, Topography, Water resource

Assessment of Hypsometric Idiosyncrasy of Small Watersheds in the Upper Ramganga Catchment

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Hypsometric analysis describes the distribution of horizontal cross-sectional area of watershed morphology with respect to elevation. In geologic time scale youth, mature and old geologic stage represents peculiar hypsometric forms of watershed. The hypsometric analysis give picture about pertinent condition of transition from youth to old stage of watershed. Hypsometric characteristics of a watershed plays important role in the dynamics of surface and subsurface runoff generation and resulting soil erosion and denudation processes. Hypsometryis essential aid to measure and represent the form of a watershed and its evolution. The hypsometric integral was found a good indicator for comparison of watersheds based on their proneness to erosion and geologic evolution. This study focuses on hypsometric analysis of few Himalayan watersheds ofUpper Ramganga Catchment in Uttarakhand using remote sensing and GIS technologies.

Key words: Hypsometric analysis, Ramganga Catchment, Hypsometric integral, GIS

Land and Water Management plan in Dorika Watershed

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The present investigation was undertaken to study the alternative land management system by preparing land use plan for Dorika watershed of Sivasagar District in Assam based on soil site suitability evaluation of crops.The area coverage of this watershed comprises between 26°48′ to 27°03′ N latitude and 94°27′ to 94°52′ E longitude. The watershed boundaries were delineated based on Survey of India toposheet (1:50,000) no. 83J/13, 83J/9, 83I/12 and I/8 and. R2 L4 MX Remote sensing data. Generally, the soils under this watershed were found to be strongly acidic, high organic carbon content, low in CEC, medium to high base saturation and texture varies from coarse to fine texture. Soil pH, Drainage and nutrient constraints were the limiting factors for potential utilization of the land resources. Soil site suitability of crops was evaluated for crops such as rice, mustard, potato, tea etc. Several crops are recommended depending on their suitability for the post rainy season in the soils which are kept fallow in the present land use system. Rice is the main crop under this watershed and cultivated during the rainy season due to imperfect drainage though the soils are moderately and marginally suitable. In present study, it was observed that low precipitation in early crop growth stage or growing cycle during *rabi* crops is one of the major constraints. To deal with such situations or dry spells, for cultivation of *rabi* crops, it becomes necessary to harvest rainwater in water harvesting structures for life saving or supplementary irrigation. So, harvesting or storing of rainwater appears to be an alternative proposition. On the basis of remote sensing data and ground truth of river water courses, three nos. of water harvesting structures on Dorika river have been proposed. Considering suitability criteria, site specific cropping plan for different seasons were prepared. The study also covers identification of water harvesting structure at suitable sites; out of three feasible water harvesting structure identified, one water harvesting structure could store approximately 11.61 hectare meter of water which can provide life saving irrigation during *rabi* seasons for an area of 193 ha land for potato/ rapeseed. 232.2 ha for cabbage, 77.4 ha for tomato/ direct seeded ahu rice and 50.4 ha for transplanted ahu rice. Results of this study revealed that the study area under rice fallow cropping system could be modified into double cropping system with the use of proper fertility management and life saving irrigation.

Key words: Land use planning, soil site suitability, watershed, water harvesting structure

Hydrological Response to a Rainfed Agroforestry System with Different Water Conservation Practices

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Horti-Agri agro-forestry landuse systems hold the potential to enhance productivity, soil health, moisture regimes, and reduce land degradation, which can be further improved by the inclusion of *in-situ* water conservation practices (WCPs), legume intercrops and complete hydrological study. Therefore, an experiment was conducted at WTC, ICAR-IARI, New Delhi during *Kharif*, 2017 in a horti-agri system with split-plot designed, 3-legumes (soybean, cowpea, and mungbean), three WCPs (trench, micro-catchment (MC), ring basin (RB)) and no moisture condition (NMC) under *Bael* tree and no-tree. Throughfall and stemflow were measured by jerry cans, runoff and soil loss by Ramser sampler, soil moisture by TDR and then volume water balance approach was used for water budgeting. Total amount of throughfall, stemflow and interception loss were 339.3 mm (76.3%), 16.9 mm (3.8%) and 88.5 mm (19.9%), respectively, caused by 16 rainfall events. Throughfall and stemflow were in the order of trench>RB>MC>NMC, the reverse was true for interception loss. The order of soil moisture storage was trench>MC>RB>NMC and reverse trend was in runoff and soil loss with overall runoff and soil loss as 10.2% and 6.38 t/ha, respectively. *Bael*+cowpea+trench allowed the least soil loss (3.14 t/ha) followed by *bael*+trench+mungbean (3.44 t/ha). Nutrient concentration was found to be in order of stem flow>throughfall>rainfall. Throughfall is the major contributor to the inflow of water yield and consequent nutrient infux in an agroforestry system. Stemflow despites being richer in nutrient concentrations, did not contribute much too nutrient influx because of its very low volume. Overall, *Bael* tree intercropped with cowpea incorporating with trench was the best system to enhance farm productivity (53.5 /ha cowpea seed equivalent yield), income and soil fertility under rainfed conditions of arid and semi-arid climate.and resource use efficiency.

Key words: Agro-forestry, legume intercrops, water budgeting, runoff

Effect of Gravity Based Drip Fertigation on Growth, Yield and Quality of Okra

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A field study was conducted on sandy soil during kharif seasons of 2012 and 2013 to investigate the effect of gravity based drip fertigation on growth, yield and quality of okra. The experiment consisted of 11 treatments which comprised three levels of gravity based drip irrigation system (Flood Irrigation, Drip Irrigation and Drip Fertigation) with three fertigation levels (50%, 75% and 100%) at 3, 5 and 7 days intervals. The experiment was laid out in a randomized block design with three replications. The results of the study revealed that highest length, weight and yield of fruits were recorded through drip fertigation with 75% RDF at 5 days intervals and also the higher Field Water Use Efficiency in these treatments was due to optimum consumption of water throughout the season and higher Fertilizer Use Efficiency was recorded from the fertigation method due to high efficient use of fertilizers by the plant which resulted in higher fruit yield of okra and we also check the performance evaluation of gravity based drip irrigation system on the experimental field on the basis of data recorded were determination of uniformity coefficient, distribution uniformity, distribution characteristic, and emission uniformity. From economical point (B:C ratio) of view, the choice of the preference of different treatments was observed as flood, drip and drip fertigation. The maximum income from produce and net income were obtained in 75% RDF through fertigation in equal splits at 5 days interval and benefit cost ratio was obtained in 75% RDF through fertigation in equal splits at 7 days interval. Gravity based Flood and Drip irrigated average crop recorded 26.90 and 22.72 percent lower yield than drip fertigation through 75% RDF at 5 days intervals and the higher yield percentage in drip fertigation due to more favorable effect on vegetative growth of okra during 2012 and 2013 respectively.

Key words: Field Water Use Efficiency, Flood Irrigation, Drip Irrigation, Drip Fertigation

Lignocellulose Degradation and Production of Lignin Modifying Enzymes in Solid-state Fermentation by *Mucor circinelloides GL1*

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Lignin is a large recalcitrant substrate to degrade due to its aromatic nature and structural heterogeneity which leads to the accumulation of lignocellulosic materials in the forest soils. The degradation of lignin is recognized as an important aspect of the successful reûning of lignocellulosic biomass. In the present study conventional agricultural wastes namely areca husk was used for investigating the efficiency of the *Mucor circinelloides GL1* to degrade it by the production of lignolytic enzymes. After the solid-state fermentation process the lignocellulosic residues left over were evaluated for their physico-chemical studies and degradation pattern of cell wall constituents with activities of enzymes. During decomposition, *M. circinelloides* GL1 was found to produce all three enzymes (laccase, MnP and LiP), but their activities were remarkably different with respect to different fermentation time. It was observed that the specific activity of laccase increased from day 20–80, while the activity of both MnP and LiP enzymes increased from day 20–60 on each substrate and after that the activities gradually decreased. The CMCase activity on each substrate by the strains varied throughout the decomposition period and the maximum activity was observed on 20th day incubation. The activity gradually decreased after that time. The present study gives an insight into the dynamic fields of the production of extracellular lignolytic enzymes by the potential fungal strain *M. circinelloides* GL1 in solid media. The study has given an optimized growth conditions and a cheaper protocol for the maximum production of the lignolytic enzymes.

Key words: *Mucor Circinelloides*, Solid-state fermentation, Lignocellulose degradation, Laccase, MnP and LiP

Azadirachta indica (*Neem*) based Agroforestry System in Red and Laterite Zone of West Bengal

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On field experiment was conducted at Regional Research Station (Red & Laterite Zone), Bidhan Chandra Krishi Viswavidyalaya, Jhargram, Paschim Medinipur, West Bengal to evaluate the seasonal aerial growth and productivity of *Azadirachta indica* under alley cropping system with different intercrops (groundnut, rice, cowpea and blackgram) under rainfed condition. The farm where the experiments were conducted is situated at 22.5^0 N latitude and 87.0^0E longitude and at an elevation of 78.77 m above mean sea level under red & laterite zone of West Bengal. The experiment was carried out in upland situation where the soils are coarse textured and strongly acidic (pH 4.0-5.0) and poor in organic matter, available phosphorus, potassium and lime and highly susceptible to erosion hazards. Seedlings of the tree species were planted during August 2002 at a spacing of 5m X 5m. Four arable crops were grown successfully during *kharif* 2006 and 2007 after well establishment of the *Neem* plantation. The experiment was laid out in a randomized block design with 5 treatments (T_1 = Neem + groundnut + T_2 = Neem + rice, T_3 = Neem + cowpea, T_4=Neem + blackgram and T_5 = Neem or sole tree) and 4 replications. The grows plot size was 40m X 25m. All the intercrops were sown in the 2^{nd} week of July during *kharif* seasons of 2006 and 2007. The agronomic management practices of all the intercrops were given as per recommendation. Growth attributes of *Neem* viz. tree height and diameter at breast height (dbh) was recorded and volume yield was calculated measuring the area of the tree or log at the thin end, middle and thick end (in square units) by employing Newton's formula as described by Chaturvedi and Khanna (1982). Yield of different intercrops was calculated after harvesting of each crop. Soil moisture percentage and soil nutrient status were also studied. The data collected during both the years of experimentation were analyzed following the method of analysis as described by Gomez and Gomez (1984).

Key words: Neem, Agroforestry, Inter crop, Lateritic soil, West Bengal

Aonla-based Agroforestry System for Western Himalayan Sub Tropics

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Agroforestry involves the combination of agriculture, livestock production, forestry and other types of production systems on the same piece of land rotationally or simultaneously. Agroforestry systems result in a multitude of direct benefits like fuelwood, fodder, fruit, animal products and food grains. Additionally, agroforestry systems play an effective role in global carbon sequestration since it sequesters more atmospheric carbon in plants and soil than conventional farming. Agri-horticulture (agroforestry) system is a food-cum-fruit system where the tree component is a fruit tree, capable of providing cash benefits in addition to annual crops. A field experiment was conducted to determine the feasibility of intercropping *Andrographis paniculata* Nees. And *Emblica officinalis* Gaertin. At Dryland Regional Sub Station of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The objective was to study the effect of *Emblica officinalis* trees on the growth and yield of *Andrographis paniculata*as an intercrop. The treatments included *Andrographis paniculata* at three plant spacing (30 cm × 45 cm; 30 cm × 30 cm; 45 cm × 45 cm). Recommended spacing of 30 cm × 45 cm without trees served as control. The results show that due to competition among the components of the system all the intercropping treatments registered a decrease in growth and productivity parameters like fresh shoot weight, dry shoot weight, and fresh root weight, compared to control (no trees). However, on practical point of view, out of the three different spacing, plant spacing of 45 cm × 45 cm was found most suitable for successful cultivation of *Andrographis paniculata*as an intercrop under *Emblica officinalis*. It can be concluded that *Andrographis paniculata-Emblica officinalis* intercropping system can be practical and beneficial in the region. However, the distance between crops and tree rows should be adjusted to minimize interspecies competition.

Key words: Agroforestry; Carbon sequestration: *Emblica officinalis*; *Andrographis paniculata*

Livelihood Diversification through Fruit Based Agroforestry in Red and Laterite Zone of West Bengal

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Red and laterite soils in West Bengal are distributed in about 1.98 m ha under different districts are primarily characterized by shallow soils with low inherent fertility status, low and erratic rainfall with high variability, unabated land degradation and poor economic status of farmers. In view of the future prospects, it is now widely accepted that attention has to be paid on conservation, sustainable development and management of natural resources. Fruit-based agroforestry system is an alternative land use system that integrates the cultivation of arable crops, fruit trees and silvi tree components which provides higher economic return, improves the soil health and fills the gap of about 33% of land under forest cover. Fruit based agroforestry provide a range of productions such as crops, fruits, timber, fodder, fuel wood and environmental services such as conserving soil and water, carbon sequestration, etc. The present study was conducted to find out suitable components for a profitable agroforestry model under rainfed conditions on marginal and degraded lands of Red and Laterite Zone in West Bengal. Fruit crops *viz.*, Mango (*Mangifera indica)* were planted at a spacing of 10 × 10 m (100 plants ha^{-1}) and silviculture species *viz.,* Lambu (*Dysoxylum binectariferum)* was planted within the two fruit plants and at 5m spacing in between two fruit rows (300 trees ha^{-1}). To design strategies in the pursuit of promoting agroforestry its financial and economic benefits need to be evaluated systematically. Based on three criteria such as benefit–cost ratio, net present value, and return to labor, this paper evaluated the financial and economic benefits of agroforestry. Planting of trees were done in staggered contour trenches for water conservation. Five arable crops *viz.*, pigeon pea, black gram, maize and okra were grown during *kharif and* mustard in *rabi* season as intercrops during first and second year (2016-17 and 2017-18) of experiments. Compared to sole plantation, tree with intercrops resulted in higher fruit yield of mango (highest 5.34 t ha^{-1} under mango with Lambu along with pigeon pea as intercrops based agroforestry systems and better growth characteristics of Lambu trees. Okra (*kharif*) intercropped with mango and Lambu produced maximum gross income (INR.2,39,200), which was closely followed by maize (INR.2,28,050) grown as intercrop during *kharif*. Data on growth and yield parameters of the tree species were recorded. The soil pH, Organic carbon, available of Nitrogen (N), Phosphorous (P) and Potassium (K) were analyzed. The economic returns from each of the treatments were also determined. Fruit based agroforestry system improved soil health with higher return. Fruit-based agroforestry systems can profitably be grown in rainfed area which are supposed to improve and maintain good health of soil and people through filling up of the deficiency of nutrients by fruits and vegetables and, thereby, augmenting various employment opportunities and as a result the socioeconomic status of the local peoples could be improved favorably.

Key words: Fruit based agroforestry, Carbon sequestration, Sustainable, Intercrops

Quantification of Soil Biological Activities *vis-a-vis* Productivity in 206 Mango Orchards of Maal Region in Lucknow, Uttar Pradesh, India for Food and Livelihood Security

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Food availability and livelihood security of millions of fruit growers were dependent on conserving natural resource management. Simultaneously, importance of soil biological conditions can't be avoided for obtaining economic yield and quality fruits. Sustainability of mango growers in Mall block of Lucknow, Uttar Pradesh, India is fully depends on water conservation, nutrient cycling, soil biological properties, and canopy management under present day climate change. Two hundred six soil samples were collected from root zone depths, samples were air dried, processed and utilized for soil enzymatic analysis. It was found that majority of the orchards producing <10.0 t ha^{-1}. Soil enzymes *viz.*, dehydrogenase (DHA) had wider variations (24.08% coefficient of variations with mean value of 0.71 ± 0.0001μg TPF g^{-1} h^{-1}) while fluorescein diacetate activity (FDA) had (20.96% CV with mean value of 141.90 ± 4.30 μg fluorescin g^{-1} h^{-1}). Spatial distribution showed 83.5% belonged to the medium range of 0.51 to 1.0 μg TPF g^{-1} h^{-1} while only 4.9% had >1.0 μg TPF g^{-1} h^{-1} DHA activity. Interestingly, 61.7% of 206 mango orchards had low level d"150 μg fluorescin g^{-1} h^{-1} and 35% in the medium range of 151-200 μg fluorescin g^{-1} h^{-1} FDA activity. In both the cases higher soil biological activities were recorded in lower percentage which indicates immediate attention for improving resource management. Orchards might have undergone variable amount of moisture conservation practices, evapotranspiration and temperature fluctuations to influence on soil biological properties. Hence, in order to regain the optimum productivity level between 16 to 20 t ha^{-1}, adoption of advanced soil and water conservation measures along with nutrient and orchard management practices *i.e.* good management practices needs to be advocated in view of present day climatic changes to improve soil biological properties.

Key words: Soil biological indicators, Productivity, Mango orchards, Food security, Policy framework

Value Addition of Ash Gourd for Doubling the Farmers Income

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Krishi Vigyan Kendra(ICAR-IIVR), Kushinagar organised training programme to create awareness about processing and value addition of ash gourd(winter melon) as it has the great potential for value addition. Ash gourd has nutritional and therapeutic qualities, In the training programme pre and post knowledge of the respondents were evaluated and the value added product of ash gourd were prepared and organoleptic acceptability was assessed. The constraints in the adoption of techniques by the respondent were also assessed. The results showed that through training programme they gained the knowledge (70.35%) about value addition of ash gourd. Organoleptic acceptability of the value added product "Angoori Petha" was found highest on 9-point hedonic scale. The data depicted that Lack of awareness about proper marketing place was the main serious factor affecting the adoption of value addition practices and the respondents were least affected by the constraints Lack of proper knowledge of storage of ash gourd value added product. Therefore through value addition its consumption and utilization may be increased and it can be a better option for income generation and can double the farm women income.

Key words: Ash gourd, Value addition, Doubling the farm women income

Evaluation of Micro Watersheds of Coastal Navsari

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The study was taken up with the objectives of characterizing, identifying major problems, assessing land use changes and prioritizing the selected watersheds of coastal Navsari. The morphological characteristics of the micro watersheds under study were identified. Stream order was found to be 3 in all the micro watersheds whereas total stream length and relief ranged from 7 km to 16 km and 9 m to 15 m respectively. Micro watershed 1C2 with ruggedness number 24.58 was found to be most prone to erosion compared to other micro watersheds. Drainage density varied from 0.84 in 1C1 to 1.62 in 1C2. The highest values of form factor, circulatory ratio and elongation ratio were 0.57, 0.85 and 0.86 in 1C1, 1C2 and 1C1 respectively. According to hydrological characterization, micro watershed 1C8 should get top priority followed by 1C4 and least priority should be given to 1C1. With respect to availability of water in form of water bodies and canal water supply, 1C3 required top priority whereas on the basis of soil and water parameters, 1C7 required top priority. 1C8 and 1C9 required top priorities based on their socio-economic condition. The overall priority showed that micro watershed 1C2 needed top priority followed by 1C3, 1C9, 1C8, 1C4, 1C1, 1C7, 1C5 and 1C6. This prioritization could be used by government departments, NGO's and funding agencies while planning and executing projects to fulfil specific mandates. It was concluded that all the micro watersheds needed groundwater recharging to combat sea water intrusion and brackish water aquaculture should be avoided where it is possible to harvest rain water and cultivate sweet water fish. Evaluation and assessment of changes in watersheds over a period of time could help in rectifying the follies committed in the past and necessary steps could be taken in prioritized micro watersheds.

Key words: Geographic Information System, Morphological characteristics, Prioritization, Remote sensing, Watershed

Bio-Resource Recycling through Integrated Farming Systems in North Eastern Region of India

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Over the ages, tribal farmers developed some potential indigenous farming systems in the region using their ingenuity and skill. In North-East India, the concept of Integrated Farming System (IFS) helps to safeguard the agricultural systems with biodiversity value since, majority of the population in the region depends on agriculture for their livelihood but there is a very poor complimentary interaction between the various farming components which results in under/over utilisation of natural resources with poor land and crop productivity. Farmers manage several organic and mineral resources in order to attain their production goals. However, the net flow of resources is not equal for the various fields belonging to a single farm household but varies substantially, creating areas with carbon and nutrient accumulation and depletion. Economic and ecological access to food could only be ensured by adopting farming system approach consisting of change from commodity- based to resource-based planning and integrated use and management of land, water and human resources. Sustainable development in agriculture must include efficient soil, water crop and pest management practices, which are environmentally friendly and cost-effective. According to this concept, integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs by another within the context of the farming system. Recycling of biological resources, wastes and by-products improves natural resources and income. Farmers of North Eastern Region generally do not apply any external input for crop production, hence, recycling of in-situ/ex-situ of biomass are crucial for sustaining soil health and farm productivity in Hill ecosystem.

Key words: Bio-resource flow, sustainable income, economic efficiency, nutrients, integrated farming system

Biomass of Different Jerusalem Artichoke Clones Dedicating to Green Protein Production Purposes

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In the past 100 years, the assessment of the Jerusalem artichoke (*Helianthus tuberosus* L.) has been very controversial.Phenotypic plasticitymakes it suitable for adapting to harsh environmental conditions such as drought or durable high temperature, poor quality of soil. Along with it the phenotypic plasticity also has advantages and disadvantages: On the one hand Jerusalem artichoke isknownas a dangerous, invasive and almost ineradicable weed in Central-Eastern Europe nowadays. Otherwise, due to the valuable biomolecules/phytochemicals, as multipurpose industrial crop and vegetable specialty can cultivate. It can produce high value with low energy investment (e.g. minimal nutrient supply, no need pesticide). The whole plant is valuable: according to the literature the underground potato-like tubers contain high amount of polysaccharides (mainly inulin) and some protein. The dry aboveground biomass can utilize because oflignocellulose material.

However, utilization of green biomass is less known. It can be limited fed with animals, especially goats and lambs because of trichomes. Considering the protein content and other phytochemicals however, it can be incorporate into the green biorefinery concept. For this purpose the harvested green biomass can be separated by different pressing. The resulting fractions (fiber and green juice) after further processing yield leaf protein concentrate (LPC) and brown juice as by-products. The fiber and brown juice fractions can also be used as materials for further industrial usage. Together with the above, our aim was in this work to compare 7 Jerusalem artichoke varieties /ecotypes (representing different climate zones)primarily for green protein production purposes. The small plot experiment were repeated in 2 years (2016 - 2017) in Central European climateunder low in-put condition (no added fertilizer; rain-fed condition). Two-timesharvest of the green biomass could be accomplished in a vegetation season, due to re-growing ability of plants.

The harvested fresh biomass was processedby pressing and after using thermal coagulation. Various physical and chemical analyzes were performed. Generally total crude protein content changed between 30 – 35 m/m% in LPC, 10 – 14 m/m% in fiber fraction and 0,5 –1 m/m% in the brown juice depending on the varieties and the harvesting time. The amino acid composition was favorable. The concentration of lysine as limiting amino acid reached 2,5 g/100g in LPC fractions and the methinonine1,1 g/100 g.

Key words: Jerusalem artichoke, green biorefinery, low in-put condition, protein

SESSION-IX

Geospatial Techniques and Simulation Modeling for Soil and Water Management

Applicability of Erosion 3D Model to Simulate Runoff and Soil Loss in Lower Shivaliks of Punjab, India

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Hydrological models are being used all over the world to estimate the soil erosion hazard in different watersheds and to simulate the best management practices to mitigate the hazardous effects of soil erosion. The hydrological models are usually site specific and hence their applicability in a particular region needs to be verified before using it as a tool for management of soil erosion in a particular region. In the present study a physically based model namely EROSION-3D for assessing runoff and deposition yield was used. Erosion-3D needs only a few input soil parameters as compared with other hydrological models like WEPP, EUROSEM etc. The model has been used at many locations all over the world but has not been tested in the conditions prevailing in the Shivalik foothills. The study was carried out to test the applicability of EROSION-3D to simulate runoff and soil loss from two micro-watersheds situated in lower Shivaliks of Punjab. The model requires four main input files, viz. Climate, soil, slope and land use file. Some of the parameters (skin factor, surface roughness and resistance) required to prepare the soil file were determined using the rainfall simulation tests. The model was calibrated by using data from seven rainstorms from first micro-watershed and was validated using 11 rainstorms from another micro-watershed. The calibration was done by adjusting the input parameters like skin factor, soil erodibility and initial soil moisture content. The model simulated the runoff quite accurately as is evident by low values of RMSE (1.72 mm) and percent error (19.19) and high values of correlation coefficient (0.94) and model efficiency (81.25%). Similarly, the model simulated the sediment yield with reasonable accuracy as corroborated by low values of RMSE (0.19 Mg/ha) and percent error (17.16) and correlation coefficient (0.97) and model efficiency (74.48%). From the present study, it can be concluded that EROSION-3D model can be used as decision support system for management of soil erosion in lower *Shivaliks* of Punjab.

Key words: Soil erosion, runoff, hydrological models, EROSION-3D, *Shivaliks*

Soil Quality Assessment in Mountainous Agro-Ecosystem using Geospatial Approach

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A decline in the soil and land quality due to land degradation by soil erosion has become the major issue in the mountainous ecosystem of the Himalayan region. Information on soil quality of fragile land resources of Himalayan mountainous ecosystem is vital for sustainable use and management land resources. Availability of high resolution remote sensing satellite data and digital elevation model (DEM) emerged as powerful tools in characterizing soil types and terrain of hilly and mountainous landscape for spatial assessment of soil and land quality in the watershed using GIS.

The present study was aimed to assess soil quality in Maniyar river watershed of mountainous ecosystem in mid Himalaya located in Tehri Garhwal district of Uttarakhand, India. The study involved characterization of soil and terrain parameters and estimation of Soil Quality Index (SQI) by selecting minimum soil dataset. Soil Quality Index is a function of summation of weight multiplied by score for soil quality indicators. Digital elevation model – CartoDEM was used in automated delineation of landforms (hillslopes) based on Topographic Position Index (TPI) algorithm using Arc-GIS. Total 103 soil samples (0-20 cm and 20-50 cm) from 45 sites were collected from various landforms and analyzed for physico-chemical properties of the soil. After analyzing soil samples, Principal Component Analysis (PCA was used for minimum data set selection or identifying suitable indicators.The landform analysis delineated upper slope (9.7%), mid slope (44.8%), lower slope (34.5%), and toe slope (valley) (11%) in the watershed. Soils in the watershed were characterized as moderately deep to deep with higher amount of coarse fragments. Soils on mid and lower hillslopes had higher coarse fragments and lesser in valley (toe slope). Soil depth was characterized lowest in upper slope and highest in toe slope (valley). Organic carbon content varies from 1.35 to 1.52 per cent. Soils of valley (toe slope) were found highest in cation exchange capacity (CEC) followed by mid hillslope, lower hillslope and upper hillslope. Total N contents in the soils ranges from 0.14 to 0.20 per cent. Highest TN was estimated in soils of valley followed by lower, mid and upper slope. Bulk density of the soils ranged from 1.25 to 1.37.

Principal Component Analysis (PCA) was used to identify suitable soil quality indicators. These indicators were assigned with weight and score to compute Soil Quality Index (SQI). Weight assignment was done following Analytical Hierarchy Process (AHP) and scoring was done by scaling method. SQI of each landform types in the watershed were estimated. SQI in the valley area was estimated highest (0.72) followed by lower hillslope (0.68), mid hillslope (0.67) and upper hillslope (0.65). Soil quality evaluation at hillslope scale will serve as an important mean to prepare effective land use and management plan in the watershed. It will provide information toward understanding the long-term effects of soil and water conservation practices and sustainability of agriculture in the watershed.

Key words: Soil quality, hillslope, Geospatial, Himalayan region

Estimation of Suspended Sediment Concentrations in the Yellow River using Landsat ETM+: Application of a Spectral Mixing Algorithm

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The remote sensing of inland water has been far less successful than that of ocean, coast, and lake water, due to the high sediment load and the complex interactions among optically active substances [e.g., phytoplankton, suspended sediments, colored dissolved organic matter (CDOM), and water]. To address this problem, we developed a spectral mixing algorithm (SMA), based on a spectral linear mixture modeling approach. Through a tank experiment, we found that the SMA-based models were capable to estimate sediment concentration high up to 12 g/L in the Yellow River, China,the largest river in the world in terms of sediment transportation. In this paper, we take advantages of the daily SSC measurements from the Yellow River hydrological monitoring system for developing of the SMAapproach to remote sense the SSC in the Yellow River by using the Landsat-7ETM+ data.The results show that the SMA-based approach can obtain a more promising relationship (R=0.71) between SSC and reflectance than the conventional regression of single band (Max. R=0.62). The key point for successfully applying the SMA-based estimation model to satellite data is the selection of end-members and it's standard reflectance spectra (SRS). Our study proves that the consideration of two basic components of water and sediment in the SMA is reasonable for estimating SSC in the Yellow River. Among the four general optical active constituents in water, we believe COD are ignorable without remarkable impact to the estimation, but the omit of Phytoplankton could reduce the accuracy of the method. Our study also shows that the satellite images derived SRSs of reference clean water in nature could compromise the effect from lack of information on phytoplankton. We also test the potential use of SMA based remote sensing approach to map out the SSC along the river and over the season. These results further confirmed that the SMA could effectively separate information on the concentration of each end-member from that of the others, by using the spectral linear mixture modeling approach.

Key words: Inland water, suspended sediment, phytoplankton

A Method of Assessing the Regional Potential Soil Erosion Change based on Remote Sensing and GIS

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Soil erosion is a major global environmental problem. It is well known that calculation or prediction of the absolute amount in soil erosion is relatively difficult and its accuracy is relatively low, especially for small areas. Therefore, a method of assessment of potential changes in soil erosion is necessary for assessing the risk of soil erosion, as well as soil and water resource management. This paper aimed to develop a comparatively simple method for calculating potential soil erosion change (*PSEC*) by combining the Universal Soil Loss Equation (USLE) and a Geographic Information System(GIS). The *PSEC* is equal to 1-A_a/A_b, A_a and A_b were the potential soil erosion in a given area after and before implementation, respectively. A_a and A_b can be calculated by USLE and GIS based on the basic materials, including the remote sensing images, topographic data, soil and meteorological data, etc. This method did not use remote sensing image pixels as the calculation unit, relying instead on land use classification as the calculation unit. Firstly, the PSEC for each computing unit was calculated. Then, the PSEC of the entire study region was computed on the basis of a patch area weighting method. This method ensured that the land use type and the measured type is the same in one computing unit, and the results could be closer to the actual physical situation.

Key words: Geographic Information System, Universal Soil Loss Equation, Remote sensing, Soil and water conservation, potential soil erosion

Orthogonal Numerical Simulation of Influencing Factors on Soil Erosion Induced by Underground Mining

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The Loess Plateau is one of the most serious areas of soil erosion in China, most of the coal mines in Shanxi, Shaanxi and Gansu are located in this area. Soil and water loss, as a major environmental geological problem in the coal mining area, seriously restricts the sustainable development of the mining area. This paper takes Wangjialing Coal Mine, Hedong Coalfield, Shanxi Province, which is located in the gully area of the Loess Plateau as the research object. Based on the analysis of the influence of geological conditions and mining technology conditions on soil erosion in mining area, the mining thickness, mining depth and natural slope of surface are determined as the key factors affecting soil erosion in mining area. The orthogonal numerical simulation experiment method is used to study the influence of different parameters on the change of surface slope and slope length. Three factors (mining thickness, mining depth, surface slope) and three levels of orthogonal experiment scheme are selected to carry out FLAC3D numerical simulation experiment. The simulation results are analyzed by variance analysis method. The results show that under the influence of mining, the surface slope increases with the increase of mining thickness and mining depth; coal mining makes the length of surface slope decrease, but the extent of reduction increases with the increase of coal thickness and decreases with the increase of mining depth; increase of mining thickness leads to increase of surface slope, decrease of slope length, increase of erosion modulus and increase of soil erosion. Different factors have different effects on surface slope and slope length after coal seam mining, the order of affecting surface slope is mining thickness, natural slope and mining depth; and the order of affecting slope length is mining depth, natural slope and mining thickness. Based on the research results, the mining method considering soil and water conservation in mining area is given, which can provide references for the control of soil erosion in mining area.

Key words: Loess Plateau, Soil erosion, Underground mining, Orthogonal numerical experiment, Mining subsidence

Micro-Watersheds Prioritization Using of ArcGIS Interface for Effective Soil Conservation Planning of Sub-Watershed

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Among the major causes of soil degradation in India, water erosion is considered to be the most severe one which covers almost 68.39% of the affected area resulting into the annual soil loss of about 5.3 billion tons through erosion. In the present study an attempt has been made to measure and model the water erosion to identify priority of micro-watersheds for watershed management planning of study area using the ArcGIS interface. Sub-watershed (5D1A5c) that catches water from main stream of Dediapada region (Dist.-Narmada, Gujarat) was selected for the study purpose. The sub-watershed covers 7 micro-watersheds i. e. d, e, f, g, h, j and k. Revised Universal Soil Loss Equation (RUSLE) was used to estimate cell wise gross soil erosion of study area. The parameters of RUSLE were estimated separately by adopting standard procedure. The erosion susceptibility map was derived using gross erosion rate and soil loss tolerance limit of the study area using standard formula. Two different approaches were adopted for prioritization of micro-watersheds. In the first approach, gross erosion values of each micro-watershed were arranged in descending order to decide the priority of micro-watersheds while in second approach, the priority of micro-watersheds was decided based on the highest area under very high priority (> 35 ton/ha/yr) with lowest area under safe zone (< 0 ton/ha/yr) for each micro-watershed. The prioritization of micro-watersheds from both the approaches gives same priority. The priorities of micro-watersheds were decided as d, g, j k, e, f and h for micro-watershed planning, execution and management program.

Key words: Erosion Susceptibility Map, Micro-watershed Prioritization, RUSLE

Geo Spatial Interpolation for Mapping the Qualitative Soil Properties using GIS

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High population prevalence and increased demand for food based on the environment and natural resources have resulted in the assessment and recognition of further inputs, particularly soil and water resources. In this regard, soil characterization is a well-documented approach to providing basic information on land resources. As a branch of the applied statistics, the Geographical Statistics Branch uses the site where samples were collected to provide a wide range of estimates of land characteristics in locations where samples were not taken. A number of 200 soil profiles data were evaluated for the performance of estimates inverse distance weighting, kriging, and Cokriging to map some of the soil quality properties in a pare soil of west desert in Egypt. The percentage of clay, silt, sand, calcium carbonate, organic carbon, and concentrations of micronutrients such as iron, copper, zinc, manganese, and concentrations of macronutrients including nitrogen, potassium, and phosphorus as main parameters affecting the soil quality were assessed. Sampling was performed on grids 250 × 250 meters for 500 soil profiles and 200 soil profiles were used for the application of geostatistics. Experimental semivariograms were drawn After normalization of the data. spherical, exponential, circular, and Gaussian models were utilized for the estimation by Kriging and Cokriging while the parameters of 1-5 power were used for the estimation of variables using Inverse Distance Weighting. Kriging and Cokriging showed the best estimation of results for the estimation of electrical conductivity and soil' iron content. However inverse distance weighting method with power one was found to have the least error leading to the best interpolation to estimate the other parameters of soil (sand, organic carbon, pH and lime).

Key words: Geostatistics, Geographic Information System, Soil Quality

Prioritization of Mago Basin based on Erodibility through Morphometric Analysis using GIS Technique: A PCA-based Approach

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A morphometric analysis of Magobasin of Arunachal Pradesh was carried out using RS and GIS techniques. The Watershed was delineated using ArcGIS10 software and divided into 15 sub-watersheds and prioritized based on principal component analysis (PCA) approach using SPSS 14.0 software. The study area, Mago watershed, is situated at the eastern part of the Arunachal Pradesh, India. It is characterized by narrow undulating features extending from 92^o 0′ 28.5" E to 92^o 28′ 3.5" E longitude and 27^o 53′ 17.5" N to 27^{o}31′ 16.5" N latitude with an elevation range of 2355 to 6436 m above mean sea level. The total area of the watershed is 841 sq. km.

The basic parameters (i.e., area, perimeter, stream order, stream length and stream number) of each sub-watersheds were carried out separately using the ArcMap10. Sub-watershed 4 was found to have the highest basin area of 138.67 km^2 and sub-watershed 7 with the lowest basin area of 4.62. The sub-watershed 4 was found to have the highest basin length of 21.61 km and sub-watershed 7 with the lowest basin length of 3.13 km. The linear morphometric parameters (stream order, total stream length and bifurcation ratio); aerial morphometric parameters (drainage density, stream frequency, form factor, circulatory ratio, elongation ratio, texture ratios, compactness constant and Ruggedness number); and relief morphometric parameters (relief ratio, relative relief, average slope and hypsometric integral)were computed with the help of standard formulae. PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables. These uncorrelated variables are termed as principal components and are further used for computing prioritization of the watershed. The principal components were selected and then ranked based on their relationship with erodibility. The sub-watershed having the least compound parameter was assigned the highest priority and so on. The linear, aerial and relief aspects of the watershed determined in the study were found to have immense utility in river basin evaluation, basin prioritization for soil and water conservation and natural resource management.The RS data (SRTM-DEM data of 30m resolution) coupled with GIS technique and PCA-based approach are an important tools in the morphometric analysis and prioritization of watershed. The study area was found to have streams of highest order of 3, with order 1, having highest frequency. The obtained low drainage density of the basin indicates that the region is highly permeable. From the prioritization analysis, it was found that sub-watershed 2, 4, and 14 were the most erosion prone areas with rank 1. Therefore, these sub-watersheds need to be considered first and given prior importance for the implementation of any soil and water conservation measures for watershed management.

Key words: Erodibility, Mago Basin, Prioritization, Morphometric Analysis, PCA

Spatial Variability Assessment of Soil Fertility in Black Soils of Central India Using Geostatistical Modelling

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Capturing the location specific variability in soil attributes is a crucial requirement for precision agriculture that involves site specific fertility management. A study was conducted in Kelapur block of Yavatmal district, Maharashtra covering 83000 ha area in basaltic region of central India for addressing the spatial distribution of soil fertility parameters *viz.*soil reaction (pH), electrical conductivity (EC), organic matter (OM), available nitrogen (AvN), phosphorus (AvP), potassium (AvK), sulphur (AvS)as well as cationic micronutrients (Fe, Mn, Zn &Cu) in its available form. A total of 4627surface samples (0-15 cm depth) were collected in grid pattern locating through differential global positioning system (DGPS). Each grid was positioned at325m distance interval considering agricultural land use only. The results showed that all the soil parameters *viz.* OM, pH, AvN, AvP, AvK, AvS and available micronutrients (Fe, Mn, Zn & Cu) were distributed normally except EC (log normal distribution). Majority areas were very low (<140 kg ha^{-1}) inAvN. More than 90% area was found very low (<15kg ha^{-1}) to low (15-30 kg ha^{-1}) in available phosphorous. Availability of potassium was very low (<120 kg ha^{-1}) to low (121-180 kg ha^{-1}) in 16.6% area, medium (181-240kg ha^{-1}) to slightly high (241-300 kg ha^{-1}) in 10.4% area and high (300-360 kg ha^{-1}) to very high (>360 kg ha^{-1}) in majority (73%) of the area. AvS was low (<6.0 mg kg^{-1}) in 12.6% area, medium (6-12mg kg^{-1}) in 47.4% area and high (>12mg kg^{-1}) in 39.9% area. Spatial distribution of cationic micronutrients was also delineated in terms of their deficiency and sufficiency level. The geo-database was subjected to kriging based geostatistical analysis through experimental semivariogram building. The best fit model for each soil parameter was evaluated based on lowest RMSE (root mean squared error). Spherical model was found to be the best fit for experimental semivariogram of soil AvP, AvK and AvS; whereas, exponential model was the best fit for remaining soil parameters. Variability in terms of coefficient of variation was high (CV=>35%) for all the soil parameters except pH and AvN. Results indicated a moderate degree of spatial dependence for all soil fertility parameters except phosphorus where strong spatial dependence was noted. Strong spatial dependence of available P in black soil region is mainly regulated by pH and higher content of smectitic clay minerals. This kind of spatial variability assessment of soil fertility parameters through geostatistical modelling can support precision agriculture through site specific plant nutrient management, boosting of agricultural production and environmental protection. This indeed is a time and cost effective technology for developing soil health card under national mission with minimum compromise in precision and accuracy.

Key words: Geostatistics, Kriging, Geospatial Variability, Soil Fertility

The Role of Elevation's Data Accuracy in Erosion-Accumulation Modelling Particularly in Relation to Crop Yields

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Accelerated erosion is currently the most serious factor contributing to the degradation of agricultural land. In places where erosion manifests, soil mass is removed, the soil profile is reduced and organic matter and mineral nutrients are lost. Production potential and yield potential are decreasing, but there is also a significant influence on edaphone. Negative effects are also related to the water environment in the landscape. For the evaluation of erosion threats, modelling techniques are used. In the Czech Republic,it is mainly the USLE model which captures the average long-term loss of soil. However, for erosion to potential crop yields, it is preferable to use erosion-accumulation models assuming lower yields on erosion slopes and higher in deposit places. However, the model results are always highly dependent on the quality of the input data, respectively accuracy of input parameters. The erosion and erosion-accumulation models also depend on the selected method of calculating the flow accumulation, which significantly contributes to the modeling result. On the examples of two soil blocks in South Moravia in the Bošovice cadastral area we describe the influence of the choice of the input relief elevation model on the results of the erosion accumulation modeling, respectively on real yield data. We consider variations of altitude data in the form of generalized LIDAR models with a cell resolution of 5x5 m (DMR4G) and 2x2 m (DMR5G) and two elevation models based on contour lines (Create TIN and TopoToRaster methods). The aim of the paper is to outline the recommendations for the choice of input altitude data, based on which the resulting Erosion-accumulation model would be streflect the real crop yield data. This research was carried out with the help of grants from the National Agency for Agriculture Research of the Czech Republic no. QK1720303 and QK1810233.

Key words: Erosion, USLE, crop yield, elevation model

Rainfall Runoff Simulation Modeling using Remote Sensing, GIS and HEC-HMS Model

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Estimation of rainfall-runoff and flood is a difficult task due to influence of different factors. So estimation of surface runoff in a watershed based on the rate of received precipitation and quantifying discharge at outlet is important in hydrologic studies. Improper estimation of runoff in basins causes problems in optimum management of water resources and reservoir dams. Therefore, simulation of rainfall runoff is a proper solution for runoff estimation. The use of remote sensing and GIS, in combination with semi distributed hydrological model provides new possibilities for deriving spatially distributed time series of input variables, as well as new means for calibration and validation of the hydrological model. The purpose of the present study is to recognize the best infiltration model among the infiltration methods available HEC-HMS model for an agricultural dominated Pathardih Catchment of Seonath Sub-basin. It is found that the Clark method produces better results than SCS-UH transformation method in rainfall-runoff simulation in terms of both the runoff peak and runoff volume. Better performance of all these models for the new event of rainfall-runoff transformation approves the applicability of HEC-HMS model in the study area. The findings in the present study are very useful for water resources engineers, researchers and will play an important role in water resources planning and management.

Key words: Rainfall-runoff simulation, HEC-HMS, model, remote sensing, hydrlogic modelling

Soil Fertility Evaluation of Kotihalli Micro-Watershed, Tumkur District, Karnataka using Geospatial Technique

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Land resource inventory of Kotihalli micro-watershed, Tumkur District of Karnataka which is located at North latitude 13°17’40.424" & 13°19’10.407" & East longitude 77°1’51.914" and 77° 2’57.618" covering an area of about 405 ha was done using geospatial techniques. Cadastral map at 1:7,920 scale was used as base map for the study. The satellite image (Quickbird 0.60 m) along with Survey of India toposheet was used for delineation of land forms and physiographic units. Transects were identified in different landforms in which soil profiles were studied. Grid soil samples collected at 320 m^2 interval were analyzed for various physical and chemical properties. Studying and understanding the soil physical and chemical properties and their distribution over an area has proved useful for the development of soil and crop management plan for efficient utilization of limited soil resources. Soil map indicating twelve soil phases was prepared. Soils varied from sandy clay loam to sandy clay texture. Soil depth varied from deep soil (100-150 cm) to very deep soil (>150 cm). The micro-watershed area has non gravelly (0-15%) soils with slight erosion and very gently sloping. The pH of the soils varied from very strongly acidic to neutral (4.59 to 7.21), electrical conductivity was normal (0.05 to 0.51 dS m^{-1}), organic carbon was low to medium (0.18 to 0.75%). Among the macro nutrients, available nitrogen content was found to be low (<250 kg ha^{-1}), available phosphorous content was medium (23-56 kg ha^{-1}) and available potassium content was medium (140-330 kg ha^{-1}). Among secondary nutrients exchangeable Ca was sufficient [>1.5 c mol (p^+) kg^{-1}], exchangeable Mg was sufficient [>1.0 c mol (p^+) kg^{-1}] and sulphur was high (>20 ppm). The micro nutrients such as copper (>0.20 ppm), manganese (>1.0 ppm), iron (>4.50 ppm) and zinc (>0.6 ppm) were sufficient in 86.0% of area (348.5 ha). Available boron was found to be low (<0.5 ppm) in 86.0% of area (348.5 ha). The database on soils and soil fertility of Kotihalli micro-watershed can serve as an important advisory for soil fertility management and suggesting appropriate crops and suitable intervention in order to increase production.

Key words: Soil fertility, Geospatial techniques, LRI and Micro-watershed

Mapping of Soil Organic Carbon Status and its Spatial Distribution Pattern in Achattipura Sub-watershed, Chamarajanagar District, Karnataka using Geospatial Techniques

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The present study was carried out to know the soil organic carbon distribution in Achattipura sub-watershed. This sub-watershed comprises of six micro-watershed *viz.*, Achattipura, Kilgere 1, Kilgere 2, Madalavadi, Uttur and Yeraganahalli. Totally 315 grid samples were analysed from these six micro-watersheds. Out of 315 samples, 54.28% (171) of the total grid samples were low in organic carbon status where as 31.75% (100) and 13.97% (44) samples were medium and high in organic carbon status, respectively, with a mean value of 0.50%. On area wise, out of 3,458 ha of Achattipura sub-watershed, 1,464.9 ha (42.36% of total area of the sub watershed) was low in organic carbon status, among six micro-watersheds, the highest area of 409.1 ha was in Madalavadi micro-watershed followed by Yeraganahalli (292.3 ha) and lowest area was in Achattipura micro-watershed (25.3 ha). Medium organic carbon status was observed in an area of 1499.8 ha (43.37% of total area of the sub watershed). The organic carbon status was medium in Achattipura micro-watershed (495.6 ha). Only 2.89% (100 ha) of the total area of Achattipura sub-watershed has high organic carbon status. Using GIS thematic maps showing the organic C status of all the micro watersheds were prepared. The maps clearly indicate the spatial pattern of carbon status in the micro watersheds of Achattipura sub-watershed. The statistical analysis revealed that the frequency distribution curve of organic carbon status in Achattipura is right skewed and platy kurtic with values of skewness and kurtosis, 0.51 and -0.17, respectively. Furthermore, potassium, calcium, magnesium, copper and zinc content in soils of Achattipura sub watershed have positive correlation with organic carbon status whereas iron and manganese have negative correlation. Nitrogen, phosphorous, sulphur, boron and sodium have no correlation with organic carbon. The soil organic carbon content in pedons indicated that in upland pedons the organic carbon content was higher in subsurface layer (2^{nd} depth) than the surface layer and decreased thereafter with depth. The higher organic carbon in the subsurface might be due to pedogenic movement of organic carbon from the surface layer. The regular organic manure addition has to be taken in all the micro-watershed as the organic carbon content in major area falls under low organic carbon status category. Maintaining and improving the level of soil organic matter is fundamental to ensure soil quality, productivity and sustainability and it is also important to maintain overall carbon stock.

Key words: Organic carbon, Spatial pattern, GIS, Nutrient holding capacity

Estimation of Leaf Chlorophyll Content in Wheat using Hyper-Spectral Vegetation Indices under Irrigation, Residue Mulch and Nitrogen Management Practices

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Chlorophyll converts light energy into chemical energy, so crop growth and yield are directly affected by the leaf total chlorophyll content. Many studies have shown significant and positive correlation between leaf nitrogen content and chlorophyll content. To avoid laborious and time consuming destructive sampling and laboratory wet chemistry sampling methods, field measurements of leaf chlorophyll content by handheld devices (SPAD-502) based on optical techniques has been developed. Though SPAD readings are nondestructive and fairly reliable, they are still time consuming and expensive, particularly when they are used for monitoring chlorophyll content over large heterogeneous areas. In contrast, remote sensing techniques, particularly the use of satellite imagery, has a great potential for frequent chlorophyll estimation at spatial scale. Keeping these in view the present experiment was undertaken to estimate leaf chlorophyll content in wheat under crop residue mulch, irrigation and nitrogen treatments. The experiment was undertaken during *rabi* season of 2012-13 and 2013-14 at the research farm of ICAR-IARI, New Delhi. The experimental soil was high in available N, medium in organic carbon and low in available P and K. The experiment was laid out in a split-split plot design with irrigation levels as the main plot, mulch as the sub-plot and nitrogen as the sub-sub-plot factors, replicated three times. The irrigation levels were I_2 (irrigation at CRI and flowering stage) and I_4 (irrigation at CRI, tillering, flowering and grain filling stage) of 60 mm each. The mulching treatments were M_0 (without mulch) and M_1 (with maize straw mulch @ 5t/ha). The nitrogen treatments were N_0: No nitrogen, N_{60}: 60 kg N ha^{-1} and N_{120}: 120 kg N ha^{-1}. The canopy reflectance was measured with the help of hand held ASD FieldSpec spectroradiometer at flowering stage. The leaf chlorophyll content was also measured at this stage with the help of spectrophotometer after extraction from fresh leaves by Dimethyl sulphoxide (DMSO). Nineteen spectral indices (SIPI, Ratcart, PRI, PSRI, MCARI, TCARI, SR705, ND705, mND705, mSR705, Readone, RGRcan, NDVIcanste, MTCI, DD, Red edge model, Green model, GI and TCI) related to chlorophyll content estimation were computed using these spectral reflectance data. The leaf chlorophyll content varied between 0.830 (I4N0M0) to 1.615 (I4N120M1) mg/g of fresh leaves during the study period. Out of the 19 spectral reflectance indices, 13 were significantly positively correlated, 3 were significantly negatively correlated and the remaining 3 were not at all correlated with the leaf chlorophyll content. Among these 13 spectral indices, the spectral reflectance index RGRcan showed highest R^2 of 0.865 and lowest RMSE of 0.12 mg/g of fresh leaves with nRMSE of 9%. Hence the spectral reflectance index RGRcan can be satisfactorily used for leaf chlorophyll estimation in wheat under various agronomic management practices.

Key words: Wheat, Chlorophyll, Spectral reflectance index, Residue mulch, Nitrogen

Modelling of Snowmelt Runoff in Lidder River Catchment of Himalayan Region

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The present study was conducted to evaluate the implications of climate change and modelling of snowmelt runoff using Snowmelt-Runoff Model (SRM) in Lidder River Catchment of Himalayan region. Moderate resolution imaging satellite (MODIS) daily snow product MOD10A2 was used to map snow cover for the hydrological years (October-September)2009-2014. The different model input parameters were modified to run the SRM model. The model accuracy was evaluated by coefficient of determination (R^2) and volume difference (D_v) from the measured river discharge data and simulated discharge. The model was calibrated for 2009–10 and validated for 2010–14.The coefficient of determination (R^2) was determined 2009-10 to 2013-14 which was found to be 0.96, 0.92, 0.95, 0.90 and 0.94, respectively, while the volume difference (D_v) was equal to 11.7,-10.1, -11.8, 1.96 and 8.6, respectively with an average coefficient of determination 0.93 and average seasonal volume difference (D_v) was 0.07%. The simulated results were determined for climate change scenario of a) increases in +20% in precipitation b) +2°C rise in temperature and c) an increase in +2°C temperature along with 20% increase in precipitation. It was found that a 20% increase in precipitation can result increase runoff by 37%, an increase of 2°C in temperature can increase the discharge by 53% and a 20% increase in snow cover and 2 °C rise in temperature can increase the summer discharge by 67%.The SRM model can be used for simulation, flood forecasts and water resource management in the Himalayan region.

Key words: Lidder catchment, Snowmelt Runoff, Discharge, SRM model, GIS, Remote Sensing

Investigation on Soil Fertility Constraints for Site Specific Recommendations in Hanumali Sub-Watershed, Davangere District, Karnataka by Using Geo-Spatial Techniques

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An investigation was carried out at UAHS, Shivamogga to study the soil fertility constraints for site specific recommendations in Hanumali sub watershed in Channagiri taluk, Davangere district of Karnataka, India. Grid wise three hundred surface soil samples (0-15 cm) of Hanumali sub watershed comprising five micro watersheds viz., Kanchiganahalli-1, Kanchiganahalli-2, Kanchiganahalli-3, Korasagu-3 and Korasagu-4 were collected by using cadastral map and the collected soil samples were analysed for their fertility status and mapped by using GIS techniques. Nutrient status maps developed revealed that the Hanumali sub watershed soil texture was clay to sandy clay loam. pH and electrical conductivity were ranged from 4.49 to 8.95 and 0.04 to 0.86 dS m^{-1} respectively. Soil organic carbon status of the sub watershed was low to medium. The highest mean value of soil organic carbon content was observed in Kanchiganahalli-1 (6.85 g kg^{-1}) and lowest in Korasagu-3 (5.06 g kg^{-1}) micro-watershed. The available nitrogen status of Hanumali sub-watershed was ranged from 87.12 to 425.74 kg ha^{-1}, however among the micro-watersheds highest mean value of available N was noticed in Kanchiganahalli-1 (250.10 kg ha^{-1}) and lowest in Korasagu-3 micro-watershed (195.28 kg ha^{-1}). The soil available phosphorus status of Hanumali sub-watershed was medium in status, the highest (47.39 kg ha^{-1}) and lowest (29.77 kg ha^{-1}) mean value of available phosphorous content was observed in Kanchiganahalli-3 and Korasagu-3 micro watersheds respectively. In general the available potassium status of the sub-watershed was low to high, among the micro watersheds area of the Hanumali sub-watershed lowest available potassium was observed (210.24 kg ha^{-1}) in Korasagu-3 and highest (377.36 kg ha^{-1}) in Korasagu-4 micro-watershed. The exchangeable Ca and Mg were sufficient in the entire sub watershed study area (2896 ha). Available sulphur content was found to be medium to high in Hanumali sub watershed. When compare within the micro-watersheds, the highest mean value of sulphur was observed in Kanchiganahalli-3 (28.02 mg kg^{-1}) and lowest in Korasagu-3 (13.84 mg kg^{-1}) micro-watershed. In entire sub watershed area (2896 ha) DTPA extractable micronutrients like Cu and Mn were sufficient, while the available iron sufficient in 2732 ha (74.48%) and deficient in 164 ha (4.47%) area, available zinc was sufficient in 1003 ha (27.34%) and deficient in 1893 ha (51.62%) and available boron was low in 943 ha (25.7%) and medium in 1953 ha (53.25%). The mapping of nutrients by GIS technique in the sub-watershed revealed that OC, available N, Zn and Fe are important soil fertility constraints indicating their immediate attention for sustainable crop production.

Key words: Soil fertility, Soil available nutrients, Micro-watershed, Sub-watershed, GIS

Remote Sensing and GIS based Approach for Assessment of Groundwater Vulnerability Zone to Pollution in Kharun Watershed

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Groundwater is the most vital water resource on this planet.In India groundwater isone of the major source of water supply for drinking andagriculturalactivities. Assessment of groundwater vulnerability zone is a useful tool for prevention and controlling of groundwater pollution. Groundwater pollution control and prevention should be a priority to avoid remediation of groundwater after it has been polluted. The main objective of groundwater vulnerability assessment is to identify the areas that are more likely to be polluted than others as a result of human activities. Remote sensing and GIS has been proven as effective tool for groundwater resources management. The different thematic layers of soil, land use/cover, geology, slope etc. was prepared in a GIS environment for the analysis. ERDAS IMAGINE 2016 image processing software were used for the pixel based supervised classification of Landsat satellite data. The groundwater vulnerability zone map was constructed by means of the DRASTIC method. The hydrogeological factors viz depth to water, net recharge, aquifer media, soil media, topography, impact of vadose zone, and hydraulic conductivity of aquifer were used in DRASTIC model to produce DRASTIC Index map which represent intrinsic groundwater vulnerability to pollution of the study area.The final DRASTIC Index map wasclassified in four classes Low, Moderate, High and Very High depending on the DRASTIC Index values. The DRASTIC vulnerability index values vary from 56 (minimum) to 168 (maximum). It was observed that high and very high vulnerable zone of DRASTIC index was shown in North, some portion of Tilda block in south east and in central area of the Kharun watershed.

Key words: GIS, Remote sensing, Groundwater, DRASTIC

Estimating Roof Rainwater Harvesting Potential using Remote Sensing and GIS in Onjal, Macchad and Dandi Village of Navsari District

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The supply of water has been diminishing at a rapid rate and it has become a critical issue both in rural areas. The gap between demand and supply of water is widening even in the villages of south Gujarat where sufficient rainfall occurs due to increasing population. In future, the demand of drinking water will be escalating even more; therefore, it has become imperative to adopt cost effective technologies that could conserve rainwater to satisfy drinking water demand. People in certain villages of south Gujarat experience dearth of drinking water availability during summer. In this study, three villages namely Onjal, Macchad and Dandi where the scarcity drinking water exists were selected to estimate their roof rainwater harvesting potential. The suitability of roof structure and provision for storing the roof water had been analysed using ground truth data. The demand of drinking water was determined from the population data and the data of current supply of water was assessed for its sufficiency. Remap software was used for land use classification and identification of roof top areas capable of collecting rainwater. The potential sites where visited to obtain actual ground truth data and assessing the suitability of sites for harvesting rainwater. It was inferred from the study that the villages had tremendous potential for rain roof water harvesting and it could solve the drinking water demand of the population economically. The rain water harnessed from the rooftop could augment the current water supply and immensely help in fulfilling the drinking water demand of the population residing in the selected villages.

Key words: GIS, RS, Rainwater harvesting, Roof water harvesting structure

Constitutive Model of Single Root System's Resistance to Tensile Stress

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Forest root reinforcement mechanism has received widespread attention and led to many interdisciplinary studies, a series of indoor root tensile tests and in situ root-soil composite pullout tests were carried out to determine the root system's resistance to tensile stress. However, these functional constitutive models were empirical in nature, since mathematical functions are selected based on the best curve fitting to experimental data, and the experiment data determining the model parameters did not have clear physical meaning, so the accuracy and applicability of these models were greatly limited. In this study, based on large number of root tensile tests, a new constitutive model of single root system's resistance to tensile stress was developed in order to provide theoretical foundations for forest root reinforcement mechanisms and offer a reliable basis for root tensile strength analysis. In this model, the critical point of root deformation was introduced, before the critical point, the linear deformation was dominated and after the critical point, the non-linear deformation became significant. The boundary conditions of root deformation were determined with typical tensile tests of single roots. The model parameters, such as linear elastic modulus (*E0*) and peak secant modulus (*Ep*), were determined by laboratory tensile tests. The model was verified by a large amount of experiment data, which showed that the calculated values were in good agreement with the experimental results of single root tensile tests. The proposed constitutive model of single root resistance to tensile stress provided a theoretical basis for the study of the slope stabilization by vegetation.

Key words: Constitutive model; soil-reinforcement; forest; root system; stress-strain relationship

Analysis of Historical Droughts for Tarikere Taluk, Chikkamagaluru District of Karnataka using Standard Precipitation Index

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Drought is the world's most expensive natural disaster. In simple terms, it is the absence of water for relatively long period of time, at a place where it is considered 'not normal' compared to its usual conditions to support human, animal and plant life. Droughts can occur when there is the lack of 'expected' precipitation. Drought frequently covers large areas extending across several catchments or river basins and manifests itself as a regional rather than a local event. There are several methods that have been used in the past as the drought assessment tools such as measurement of lack of rainfall, shortage of streamflow, reduced levels of water storage and drought indices. Drought indices are widely used for drought assessment. In this study meteorological drought was analyzed in the Tarikere Taluk, Chikkamagaluru district of Karanataka using multi-temporal Standard Precipitation Index (SPI). Tarikere Taluk is located between 76^0 2′32.43′′ E to 75^0 47′ 54.27′′ E longitude to 13^0 53′ 36.61′′ N to 13^0 30′ 46.04′′ N latitude covering an area of 1222.15 square kilometers. The historical rainfall data (1960-2018) of gauging stations which falls in Tarikere Taluk was collected from KSNDMC, Bengaluru. Average annual rainfall was found 859 mm. Using monthly rainfall SPI was developed for various time scales (Ex., 1, 3-, 6-, 9-, 12-, 24- months etc.,). 1 and 3 month SPI time scales are useful in monitoring short term droughts having greater impact on agriculture, 6 and 9 month time scales are used to assess the medium term droughts which affects the streamflow and reservoir level, 12 and 24 month time scales are used to study long term droughts which are useful for monitoring hydrologic and socioeconomic condition of the region. Program SPI_SL_6, developed by the National Drought Mitigation Centre (NDMC), Nebrasca was used to compute time series of Standard Precipitation Index. Using SPI series drought properties like most intense droughts, number of drought months, drought incidences, average and longest duration of drought, drought severity and drought frequency was analyzed. Analysis indicated that most intense droughts were occurred in 2003 in SPI_1 and SPI_3 time scales and 2004 in SPI_6, SPI_9, SPI_12 and SPI_24 time scales. Most intense short term droughts had return period of 17-18 years. Most intense medium term and long term droughts had return period greater than 100 years. Drought probability was also analysed using Markov chain analysis. This study will be helpful for water management authority and drought planning committees to start planning much earlier for the future droughts events.

Key words: Natural Disaster, Drought, Drought Indices, Standard Precipitation Index and Rainfall Data

Geospatial Approach for Nutrient Management and enhanced crop production Using Remote Sensing and GIS in Chikka Begur Micro-watershed, Chamarajanagar District

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Soil test based fertility management for suitable crops can be used as an effective tool for enhanced productivity and crop production. Soil nutrients play a vital role in crop production, its availability and spatial distribution need to be studied before planning for nutrient recommendation. The present study focused on mapping spatial variability of soil nutrients in Chikka begur micro-watershed, which is spread over 629 ha located between North latitude 12°5′10.84′′ and 12° 7′14.82′′ and East longitude 77°21′24.20′′ and 77°23′56.4′′ of Chamarajanagar taluk, Chamarajanagar district, Karnataka. Cadastral map at 1:7920 scale was used as the base for the study. Cartosat-1 PAN 2.5 meters and Resourcesat-2 LISS-IV MX merged Image and SOI Toposheet were used to delineate the landforms. A total of Sixty two soil samples were collected at 320 m grid spacing, analyzed for soil reaction, salinity, organic carbon, major, secondary and micro nutrients at laboratory using standard methods. The data generated was processed in Arc-GIS platform to develop a database. Geostatistical analyst tool was used and Krigging interpolation technique was adopted which gave the best linear unbiased prediction of the intermediate values. The analyzed data was interpolated to obtain a raster surface from points (grid points) in GIS environment to generate fertility maps. The current land use map was generated in Arc-GIS platform and crops like cotton and coconut were identified as the major grown crops in Chikka begur micro-watershed. Criteria were developed to generate suitability maps for the identified crops using land capability classes and management units. Fertility status maps were generated and majority of the area was found low in Nitrogen (<280 kg/ha) and Phosphorus (<23 kg/ha) where as medium in Organic carbon (<0.50-0.75%), Potassium (140-330 kg/ha) and Boron (0.5-1.0 ppm). It was observed that the areas had Sufficient quantities of Calcium, Magnesium and micro nutrients but Iron is found to be deficient. Wherever the available NPK was low in soils, additional 12.5 Kg NPK per ha is to be provided to supply balanced nutrients along with recommended dose of fertilizer for finger millet. Likewise, fertilizer recommendations can be made for other crops to enhance their productivity. Soil test based application of balanced fertilizers would go a long way in enhancing soil fertility and productivity.

Key words: Spatial distribution, land capability classes, management units, suitability, GIS, interpolation

Mapping of Major and Micro Nutrients of Haradanahalli Micro Watershed, Chamarajanagar District using GIS and GPS

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Soil nutrients are the major source of soil fertility that helps for the plant growth. Soil resource is now facing threats due to various soil nutrients deficiency. A study was conducted in Haradanahalli micro-watershed of Chamarajanagar district with the objective of assessing soil nutrient status *viz* major, secondary and micro nutrients through Geographic Information System (GIS) techniques. Haradanahalli micro-watershed (Haradanahalli sub-watershed, Chamarajanagar taluk and district, Karnataka) is located in North latitude 11^0 52′3.091″ and 11^0 53′54.775″ and East longitude 76^0 55′53.545″ and 76^0 58′7.336″ covering an area of 680 ha bounded by 3 villages (Haradanahalli, Bandigere and Kotaganahalli villages). Soils of Haradanahalli micro-watershed were studied for available nutrient status and mapped using GIS platform in ArcGIS 10.4. Fifty two surface soil samples at $320m^2$ grid were collected in Haradanahalli micro-watershed and assessed for the available major and micro nutrient status. Results revealed that, soil pH varied from slight to strongly alkaline. Slightly alkaline pH noticed in 24 ha, moderately alkaline and strongly alkaline soils observed in 401 and 136 ha respectively. Organic carbon was found to be medium in 558 ha of the watershed. The majority of the area in the watershed was low in available nitrogen (558 ha), where as available phosphorus, potassium, exchangeable calcium and magnesium was sufficient in 560 ha respectively. However available sulphur content in study area was found to be low in 150 ha and high in 410 ha respectively. Among micronutrients zinc, manganese, iron and copper was found to be sufficient in major part of watershed whereas and boron was found to be low in 160 ha and medium in 400 ha of the study area.

Key words: Available nutrient status, GIS, soil fertility, watershed

Application of RS & GIS in Identification of Soil Fertility Constraints of Ballapura Micro-watershed, Tumkur District, Karnataka

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Soil and water are the two precious natural resources which are essential for crop production and other activities. Rainfed agriculture is under severe stress due to erratic distribution of rainfall, indiscriminate use of fertilizers, adoption of improper land management practices, soil erosion and decline in soil fertility and ground water resources leading to low crop productivity. Land resource inventory of Ballapura micro watershed situated between North latitude $13^0 24'12''$ and $13^0 24'17''$ and East longitude $77^0 3'2.09''$ and $77^0 3'49''$, Tumkur district of Karnataka was carried out by using geospatial techniques. Cadastral map at 1:7,920 scale was used as base map for the study. The soil texture, slope, erosion and gravel classes were studied parcel wise. A grid of 320 m^2 spacing was overlaid on the cadastral map. There were 73 grids in the micro watershed covering an area of 694 ha. Surface soil samples were collected in the respective grids by following standard procedure and were geo tagged. Soil fertility maps were prepared using GIS tools. Sandy clay texture was observed in 573.7 ha (82.70%). Major portion of micro-watershed is non Gravelly i.e., 616.6 ha (88.9%). Very gently sloping lands covered an area of 578.3 ha (83.40%) and slight erosion was observed in 616.60 ha (88.90%), which requires soil and water conservation measures to impound rain water. The results of soil analysis revealed that the pH of soils vary from strongly acidic (pH 5.0-5.5) to slightly alkaline (pH 7.3-7.8) with normal electrical conductivity (<0.8 dS m^{-1}) and organic carbon was low to medium ($0.52 \pm 0.20\%$). The available nitrogen content was low (187.81 kg/ha), phosphorus and potassium content were medium (51.50 and 252.21 kg ha^{-1}, respectively) and the available sulphur was medium (11.33 ppm). The exchangeable Ca and Mg were 4.58 and 2.28 c mol (p^+) kg^{-1}, respectively. The contents of DTPA extractable micro nutrients Fe, Cu, Mn and Zn were sufficient (7.47, 1.02, 7.79 and 1.31 ppm, respectively). The hot water extractable boron content was 0.50 ppm. The study revealed that, soil organic carbon, available nitrogen, phosphorus, potassium, sulphur and boron were important soil fertility constraints and in addition soil conservation needs to be taken up in order to enhance soil productivity.

Key words: Soil fertility, RS, GIS and Micro watershed

Analysis of Land Cover Changes and Assessment of Drought by using Remote Sensing and GIS - A Case Study from Anantapur District of Andhra Pradesh

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Analyzing the land cover changes and understanding the trends subsequent to changes contribute to the present complex dynamics of land cover and is important for policy making, planning and implementing of natural resource management. In this study, the land cover changes in an area of 19,130 km^2 in Anantapur district, Andhra Pradesh state has been investigated. Anantapur district is one of the worst drought hit districts in Andhra Pradesh, where aridity aggravates drought conditions causing severe stress to the local economy and agriculture. District lies in the subtropics, experiencing extreme climatic conditions, with maximum temperature ranging between 38°C and 45°C during summer and minimum temperature between 14°C and 30°C during winter. Anantapur faces recurrent droughts as the district is deprived of both south west and north east monsoons. The annual rainfall of the area is 666 mm with 40 rainy days in a year. The rainfall is erratic with uneven distribution which could be a cause of excess water erosion in the region. Landsat satellite imageries from 2009 and 2018 used to appraise the land cover changes and Geographic Information System (GIS) were employed to interpret maps and ground truth checking. Changes have also been detected using digital imagery analysis and ground truth checking. The aggregate of change through time tested using the combined techniques revealed that, the rates of conversion of land cover were observed between 2009 and 2018 and observations were recorded from forest cover, water bodies, rock land, agricultural crop, mining, habitation and fallow land. The size of forest cover decreased from 13.89% to 12.99% and water bodies (0.51% to 0.48%), agricultural land (32.09% to 26.37%), mining (0.05 to 0.06%) respectively. Whereas, fallow land (47.26 to 53.83%) and habitation (0.38% to 0.47%) increased. Results showed that, increase in the population and poor rainfall distribution would result in different forms of land degradation *viz.* soil erosion, runoff, excessive sedimentation, reduced infiltration rates, soil moisture and crop failure and ultimately resulting in drought. The outcome could be utilized to pave the way to mitigate drought and climate change towards natural resource management.

Key words: Anantapur, GIS and Remote Sensing, drought, land use and conservation

Application of Remote Sensing and GIS Tools in Land Resource Inventory for Watershed Planning in Lateritic Soils of North Karnataka

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Land resource inventorization for site specific planning and development of watersheds on scientific basis is essential for successful planning and implementation of watershed programmes. An investigation on application of remote sensing and GIS tools for land resource inventorization (LRI) in lateritic soils of north Karnataka was undertaken. The study area comprised of Raipalli sub-watersheds covering an area of 6377.47 ha having lateritic red soils in Humnabad taluk of Bidar district in Karnataka state. The remote sensing tools like digitised cadastral map and satellite imagery (Cartosat-I and LISS-IV merged data) of 1:7920 meter resolution were used to carry out survey work for LRI in the sub-watershed. The delineated physiographic boundaries were transferred on a cadastral map overlaid on satellite imagery and used as base map for mapping soils. Surface characterization and soil sample collection for chemical analysis was done at 250 meter grid interval. Deep profile up to hard substratum transacting ridge to valley in sub-watershed were opened and studied. Based on similarity of characters soil mapping unit and land management units were developed. The data sets obtained from LRI were developed into thematic maps by using Arc GIS tool which was used to formulate soil and water conservation measures for different physiographic units in upland, midland and valley regions in the sub-watershed. Land management units were used to formulate site specific crop recommendations. The horticultural crops like cashew, custard apple and tamarind were found to be most suitable for highly degraded lands. The agricultural crops like Redgram, soybean, Greengram were found suitable for moderate soils in mid lands whereas, the valley areas with deep and good soils in the watershed were found to be more suitable for commercial crops like vegetables, sugarcane and Ginger. The results of chemical analysis of soils in different mapping units in sub-watershed pointed out low levels of nitrogen, moderate to high levels of potassium and deficiency of zinc.

Key words: Remote sensing, GIS, land resource inventorization, soil and water conservation

GIS and Remote Sensing Approach in Identifying Ground Water Recharge Zones of Cherial Watershed

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India has been bestowed with substantial water resources. Ground water, which is the source for more than 85 percent of rural domestic water requirements of the country, is depleting fast in many areas due to its large-scale withdrawal. A study was conducted in a watershed to identify the ground water recharge zones and suitable structures using Remote Sensing coupled with GIS and AHP. The parameters such as Geology, Geomorphology, Soil type, Land use, Lineament, Elevation, Slope and Ground water table depth were selected that are closely linked to surface and ground water availability. A base map of watershed was prepared by digitizing the boundary in bhuvan. The satellite images DEM 30 m, LISSIII 25 m and field inputs were used to derive different thematic maps. Multi criteria decision making was applied to all the parameters in thematic maps by assigning ranks from 1 to 5 scale andreclassified depending on its influence on the storage and movement of groundwater. The pair wise comparison for the 6 layers were given based on the comparison between the layers and their relative importance towards groundwater prospects and a 6×6 matrix was formed. Based on the comparison matrix the reclassified maps were multiplied with normalized weights and added up in raster calculator to get the final suitability map. From the analysis it is found that 5.70% of area is suitable forrecharge and 60.58% of area is moderately suitable and 33.71% is less suitable for recharge.

Key words: Water resources, groundwater, base map, suitability map

Soil Erosion Mapping Alandur Block, Perambalur District, Tamil Nadu using Landsat-8 Satellite Data

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In our study was based on soil degradation / erosion estimation with the application of Landsat-8 Optical data, from which the land cover and crop cover were derived after the data processing. The contour, slope and topography of Alathur block were derived from the DEM elevation data with the 1:25000 scales, which is used for the prediction of USLEK and C factor. From which the volume of soil loss is transferred to equivalent of 0.1 to 1cm of the top soil. Remote Sensor High-resolution Landscape-8 Optical and USLE are estimated at the time of the integration of information on the loss of soil loss in the specific area.

Key words: DEM, Erosion, Landsat-8, Slope, Soil

Comparison of Evapotranspiration Estimates from Satellite Remote Sensing and FAO-56 Approach

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Water is the most valuable and renewable resource of nature. The growing world human and livestock population puts a direct demand on agriculture to supply food, fibre and fodder, implying consumption of huge volume of water to meet this demand. Increasing demand of water has led to effective water management, the irrigation scheduling need up-to-date real time information on the irrigated area and the crops being grown, also data on the amount of water being used by each crop. Remote sensing provides a powerful tool for the identification of crops, estimation of crop coefficients, evapotranspiration and crop water requirement when used in conjunction with Geographical Information Systems (GIS) in the catchment area.The remote sensing based vegetation indices were used to estimate the crop coefficient and evapotranspiration in the Ozat catchment situated in Junagadhdistrict, Gujarat state, India.Multi date satellite images of Landsat-7 and Landsat-8 for year 2013-14 and 2014-15 were used in the ArcGIS 10.3software to derive vegetation indices to estimate crop coefficient and crop evapotranspiration. The FAO-56 based average crop coefficients of wheat crop for local condition were calculated as 0.79, 1.19 and 0.83 for different growth stages. The crop coefficient was estimated as 0.86, 1.22 and 0.75 using NDVI and as 0.76, 1.21 and 0.70 using SAVI for different growth stages of Wheat crop. The crop evapotranspiration was estimated using FAO-56 and remote sensing based vegetation indices. The daily reference evapotranspiration for different day of year as per the satellite image available were estimated as 3.240, 3.040, 2.810, 3.110, 3.040 and 5.040 mm/day using Kc-FAO. The maximum daily crop evapotranspiration was estimated as 6.704, 5.325, 5.998 and 3.464 mm using NDVI, SAVI, LAI and FAO-56 respectively. The estimated daily crop evapotranspiration using NDVI, SAVI and LAI were compared with that of FAO-56 method. The correlation coefficientsof ETc-NDVI,ETc-SAVIandETc-LAI with ETc-FAOwere 0.566, 0.826 and 0.407 for year 2013-14 and 0.683, 0.712 and 0.489 for year 2014-15 respectively. The maximum correlation coefficient was obtained between ETc-SAVIand ETc-FAO 0.826 and 0.712 for year 2013-14 and 2014-15 respectively. The seasonal crop water requirement was estimated as 404.37mm (ETc-FAO) using Kc-FAO, 428.03 mm (ETcNDVI) using Kc-NDVI, 412.06 mm (ETc-SAVI) using Kc-SAVIand 385.36 mm (ETc-LAI) using LAI.

Key words: GIS,ArcGIS 10.3software, NDVI, SAVI, LAI,ET, Kc

Mapping Flood Affected Area of Budhi Gandak River in Bihar with Optical and SAR Data of Sentinel Satellites

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Monitoring and mapping flood affected areas accurately is an important and basic application of remotesensing. Various water body mapping approaches and algorithms have been developed to extract water bodies from remote sensing data, including single band density slicing, unsupervised and supervised classification, and spectral water indices. Among these methods, the spectral water index-based method is considered the most reliable, user-friendly, efficient and low in computational cost. Specifically, Normalized Difference Water Index (NDWI), using the green and Near Infrared (NIR) bands is of vital use. NDWI is based on the phenomenon that the water body has strong absorbability and low radiation in the range from visible to infrared wavelengths. NDWI can enhance the water information effectively in mostcases, but it is sensitive to built-up land and often results in over-estimated water bodies. To overcome the shortcomings of NDWI, Modified Normalized Difference Water Index (MNDWI) that uses the Shortwave Infrared (SWIR) band is one of the most popular and accurate methods.Newly launched Sentinel-2 satellite can provide fine spatial resolution multispectral images. This new dataset is potentially of important significance for regional water bodies' mapping, due to its free access and frequent revisit capabilities. The Sentinel-2 images would surely be of great significance for regional water bodies' mapping, due to its appealing properties (i.e., the 10-m spatial resolution for four bands and the 10-day revisit frequency) and the free access. It is noted that the green and SWIR bands of Sentinel-2 have different spatial resolutions of 10 m and 20 m, respectively. To take full advantage of the 10-m information provided by Sentinel-2 images, a novel 10-m spatial resolution MNDWI is produced from Sentinel-2 images by downscaling the 20-m resolution SWIR band to 10 m.

However, optically sensed satellite data will be of little use in this case because visible and near-infrared sensor collected images over the study area of BudhiGandak during monsoon (flood period) season have been concealed due to the persistent cloud cover, so for this purpose, cloud-penetrating, active radar sensors operating in the microwave region are used regardless of cloud coverage. ASentinel-1A radar dataset was also used in this research to map the flood affected area in nearby BudhiGandak river. Level 1 product of Sentinel-1A, 20m by 22m spatial resolution, C-band, Synthetic Aperture Radar (SAR) data was used for flood monitoring purposes.Data processing was completed with the ESA SNAP 6.0 software program and QGIS 3.6 open source software. In a nutshell, it was observed that remotely sensed data are very useful in flood extent mapping and estimation of affected areas with damage assessment. Optical sensor data are readily available free of charge and can be used with available well-defined, robust data processing techniques. Since, optical sensors cannot penetrate clouds so, effective and timely flood mapping can be done with frequent radar observations of flood-proneareas through cloud cover. However, radar data can be more difficult to interpret and analyze.

Key words: Satellite data, active radar sensors, flood mapping

Model for Spatial Soil Quality Assessment and its Application Using RS and GIS Technique

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Spatial assessment of soil quality within different land use boundaries are valuable for sustainable agricultural production. In this model profile of functions on morphological, physical and chemical properties of nine soil series on their relative physical capacity to provide support for plant and physical stability of soils were considered. The soil series database developed under soil resource mapping project 2009-10 were evaluated for assessing the soil quality of area under Barwani Tehsil in Madhya Pradesh. The assessment for soil physical, chemical properties and soil erosional susceptibility parameters under two land use types namely agriculture and open scrub studied for making comparison. Whereas, steep slope (>15%), shallow depth (10-25 cm), past severe soil erosion and high coarse fragments (>40%) accounted for the assessment of soil quality hazard indicators in Barwani Tehsil of Madhya Pradesh. In agriculture land use soil quality is significantly higher than open scrub. Soil quality index confirms the area covered by Chandsera, Dhabla soil series are under good soil quality and the area of Dharad and Sendhwa soil series are categorised under moderate soil quality which covers an area of 12012 ha and 8778 ha respectively. Whereas area under Borali soil series classified under poor soil quality occur in 23523 ha under agricultural land of Barwani tehsil. This is mainly ascribed to presence of steep slope (15-25%), high coarse fragments (40-60%) and shallow depth (10-25cm). In open scrub land use system, the area under soil series namely Larni, sahapura and Khadaka were classified under good, moderate and poor soil quality respectively which covers an area of 33629 ha. About 83138 ha of land use form part of non-study area comprised namely forest, habitation and waterbodies.

Key words: Erosion susceptibility parameter, Hazard indicator, Physical properties, Soil Quality

Development of Automated Drip Fertigation System using GSM based Controller

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Lack of sufficient water to grow enough crops for meeting the food demand of the ever increasing population is the major threat to Indian agriculture. The surface irrigation techniques cause seepage losses, erosion and water logging problems, deep percolation, salinization and runoff. To get satisfactory growth, application of right quantity of water and nutrients at right time and at right place is very important. This can be accomplished only through micro irrigation techniques. Through automated drip fertigation, we can easily attain the agriculture intensification. The present study was focused on the development of GSM based automated drip fertigation system. In this study, calibration of capacitance type soil moisture sensors were carried out in laboratory for different soil types viz. laterite soil, black soil and costal alluvium soil. Field study was carried out with an Ujwala (KAU) variety of chilli crop under three treatments such as 100 percent irrigation and 100 percent fertigation with automation (T1), 100 percent irrigation and 100 percent fertigation without automation (T2) and 100 percent irrigation and 70 percent fertigation with automation (T3). The automated drip fertigation system consists of four capacitor type sensors, electronic fertilizer injection pump and fertilizer mixing device. Total yield and crop growth parameters showed better performance under 100 percent irrigation and 100 percent fertigation with automation (T1). Combination of 100 percent irrigation and 70 percent fertigation with automation (T3) also gave the good result which was on par with T1. Therefore, it could be concluded that with 30 percent less fertilizer, better performance of crop was obtained with automated drip fertigation system. It could also be shown that the right quantity of water at right time at right place is giving better performance of crop. The developed automated drip fertigation system is cost effective, portable, can perform better in field.

Key words: Capacitance sensor, Microcontroller, Fertigation scheduling, GSM modem

Empirical Algorithm for Estimating and Monitoring of Water Quality Parameter using Sentinel 2 Images: An application to Brackish Aquaculture

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Availability of good quality of brackish water is paramount for aquaculture operation which could be judged from the primary productivity status through chlorophyll-a, turbidity and salinity of the water body. Chlorophyll-a acts as phytoplankton biomass indicator, turbidity is directly related to underwater light penetration which affects the primary productivity and salinity plays an important role in the growth and survival of farmed species. The present study, empirical model were generated to estimate the water quality parameter, therefore was undertaken with the main objective to investigate the seasonal temporal variation of chlorophyll-a, turbidity and salinity using remote sensing data of muttukadu creek of Tamil Nadu. In this context of research effort, using remote sensing techniques to estimate and map chlorophyll-a concentration is a significant undertaking for improving the monitoring and assessment of water quality in estuaries. Various algorithm have been developed to retrieve the chlorophyll-a, turbidity and salinity. The best applicable algorithm, using both the sampling points and remote sensed data under different regression model Models for Chl-a, turbidity and salinity has been derived from relationship between wavelength of the bands reflectance and field data. The well suited model for Chl-a, turbidity and salinity has high regression value and well correlated, it has been derived successfully for the study region and it is more helpful to identify the condition of the creek. Field data of relevant dates have been used for development and validation process. The results indicates a relativity high coefficient of determination (R^2), fact that characterized the satellite development algorithm reliable and efficient to monitor the water quality parameters.

Key words: Chlorophyll-a, Salinity, Turbidity, Sentinel-2, Empirical model

Modelling of Runoff and Soil Erosion Using SWAT Model in Salebhata Catchment of Mahanadi Basin

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Several empirical methods and model are available to simulate the hydrological behavior of a watershed are the more assumptive manner than the actual field value. Generally,the Geographical Information System (ArcGIS)isemployed to investigate the most reliable field data along with topographic future for watershed management and planning. In the present study physical based, semi-distributed river basin Soil and Water Assessment Tool (SWAT) model interface with Geographical Information System (ArcGIS) tool was used to simulatethe runoff, sediment yield and to understand the sensitivity of model input parameters in Salebhata catchment area Mahanadi river basin (4,605 km^2), Odisha, India.The present study was conducted to calibrate and,runoff and sediment yield parameter sensitivity analysis was performed using the semi-automated algorithm (SUFI-2) in SWAT-CUP package. The model was calibrated for 10 years of time period starting from 1997 to 2006 which include 3 years of the warm-up period from 1997 to 1999, where the validation was done for 4 year period starting from 2007 to 20010 using field measured flow and sediment yield data.Performance of the SUFI-2 in SWAT-CUP was evaluated using various statistical indices such as Nash–Sutcliffe coefficient (NSE), coefficient of determination (R^2) and Percentage Bias (PBIAS) showed a good correlation between the measured and model-simulated data. Model sensitivity analysis was carried out by recognizing 11 stream flow and 18 sediment yield parameters. Out of which Base flow alpha factor (ALPHA_BF) and Sediment concentration in runoff (SED_CON)was found to be most influencing parameters for runoff and sediment yield, respectively. The observed and model simulated monthly stream flow with $R^2$of 0.74 and 0.77, NSE of 0.69 and 0.62 with varying PBIAS of 4.4 to 20.3 respectively, during calibration and validation period. While sediment yield computed with R^2 of 0.65 and 0.72, NSE of 0.65 and 0.69 with varying PBIAS of (-)23.0 to(-) 24.50 respectively,during calibration and validation period.Also, an attempt has been made to identify the critical sub-basin based on both runoff and sediment yield rank combination and performed the best management practices priority in order to reduce the runoff and sediment yield. From the performance efficiency of the model to simulate runoff and sediment yield, it can be concluded that the SWAT model really a good tool for simulation of runoff and sediment yield and could be used for the implementation of best management practices on critical sub-basin sale level.

Key words: modelling, runoff and soil erosion, swat, catchment, Mahanadi

Simulation Model for Assessment of Hydrologic Response in a Developing Urban Catchment

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The growth of impervious surface increases due to urbanization, which significantly affects the hydrologic response related to storm water runoff, rainfall pattern and magnitude in a developing catchment. In this study, the attempt is made to investigate the impact of three covariates namely impervious surface, urbanization and storm water runoff on hydrological processes for three future time periods 2016–2020 (Phase-*I*), 2021-2025 (Phase-*II*) and 2026-2030 (Phase-*III*) in a typical mega industrial catchment (MIC) in Bidkin, Aurangabad (MS) India, under various storm conditions, in which 42 subareas are marked inside the study area as the basic drainage system. Using SCS-CN method for the estimation of runoff, SWMM model considering different urbanized scenario a model-based analysis is conducted. The storm water management model is specified, optimized and validated in three development phases with catchment area (3179.1ha) but different land use intensities. Three hydrologic parameters inside marked subareas which is overall runoff depth (Q_t), maximum runoff depth (Q_p), and time of concentration (T_{lag}) are simulated by using the storm water management model (SWMM) to express the precise rainfall-runoff attribution. Three impervious mechanisms, total subarea imperviousness (TSIA), Effective subarea imperviousness (ESIA) and directly connected subarea imperviousness (DCSIA), are employed to quantify the spatial characteristics of imperviousness of the subareas. Regression analyses are used to analyze the augmentation and contingent understanding of impervious mechanisms in forecast runoff variables under various storm conditions. The study results imply that for various runoff responses in the selected subareas showed that higher TSIA tended to generate more Q_t and Q_p, whereas subareas with greater ESIA had shorter time of concentration also with increasing rainfall peak ratio or duration. The performance of imperviousness also showed a slight decreasing trend whereas runoff maximum discharge and time of concentration of the entire catchment were found to increase. The system has been designed considering in total of 31.65%, 40.78% and 25.57% for phase-*I*, Phase-*II* and Phase-*III* of the impervious area. These results can provide understanding of the hydrologic role of imperviousness, which is essential for storm water management (SWM) design and runoff regulation in developing urban catchments.

Key words: Developing catchment, Effective subarea imperviousness, Mega industrial catchment, Total subarea imperviousness, SWMM

Geospatial Modelling of Hydrological Processes Governing Soil Erosion and Soil Quality in a Watershed of Mid Himalaya

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The soil erosion impact on the soil quality is more concerned due to steep slopes, fragile geology, immature soil and intense rainfall in the Himalayan landscape. Spatial distribution of soil hydrological parameters is critical for understanding soil erosion processes and its impact on soil quality parameters. High resolution satellite data and digital elevation models (DEMs) are providing precise and spatial hydrophysical data inputs for modeling soil erosion processes and its impact on spatial distribution of soil parameters.The present study aims to estimate the surface runoff and soil erosion and their impact on the soil quality parameters employing modified MMF model in a Mid Himalayan watershed.The CartoDEM and Indian Remote Sensing data – IRS LISS IV satellite data with 5.8 m resolution were used for terrain characterization and generation of terrain, soil and land use input parameters of the model.

The surface runoff and soil erosion have a direct impact on soil hydrological and chemical parameters. The lowest aggregate stability of 0.75, the infiltration rate of 0.36 cm/hr, unsaturated hydraulic conductivity of 0.22 cm hr^{-1}, and highest bulk density of 1.59 g cm^{-3} was estimated in the high surface runoff area of the watershed. It shows that hydrological parameters are adversely influenced by surface runoff. The chemical parameters such as soil pH, total carbon (TC), nitrogen (N), available soil phosphorus (P), and available soil potassium (K) were estimated for surface and sub-surface soil samples in the watershed. The lowest amount of total carbon of 1.73%, total nitrogen of 0.19%, available phosphorous of 21.85 kg ha^{-1}, and potassium of 115.40 kg ha^{-1} were estimated from the high surface runoff. It indicated that surface runoff has a direct influence on soil chemical properties. The area with low surface runoff was estimated with a high percentage of total carbon, N, P and K. The same trend of declining soil physico-chemical parameters was observed in the area of high soil erosion in the watershed. The influence of surface runoff on the hydrological parameters especially in the hilly terrain defines its soil quality. The study demonstrates methodology of spatial distribution of soil quality parameters influenced by soil erosion processes.

Key words: Soil quality, Soil erosion process, Surface runoff, GIS, Himalayan region

TOPMODEL: Rainfall-Runoff Modeling of a Watershed Area using Different Time Scale and Different Topographical Index

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TOPMODEL is a topographically based semi distributed hydrological model which provides the compromise between the complexity of fully distributed process models and the relative simplicity of lumped models. In short, TOPMODEL represents a set of modeling tools that combines the computational and parametric efficiency of a lumped modeling approach with the link to physical theory. In TOPMODEL, rainfall-runoff modeling at the catchment outlet is made based on the theory of hydrological similarity of points in a catchment, with the topographic index used as an index of hydrological similarity. Topographic index can quantify the control of topography on rainfall-runoff process and indicates the spatial distribution of soil moisture and surface saturation. Because of the structural simplicity, explicit interpretation of the assumed physical concepts, incorporation of geomorphological effects, a few number of model parameters, and its role of bridging the gap between the conceptual and the physically-based distributed rainfall runoff models, TOPMODEL has become a widely used hydrologic model in different regions of the world among the hydrologists. The present study was carried out to determine the effect of time scale on rainfall-runoff modeling using two types of time series with different time scales: storm events, daily and monthly and annually data sets. Also, three different flow direction calculation algorithms, were employed to calculate topographic index as a key component in TOPMODEL. For the evaluation of the TOPMODEL performance, the Nash Sutcliffe index (E) and correlation coefficient between observed data and calculated data (R) was used. Estimation of peak points by TOPMODEL indicates more capability of TOPMODEL to simulate stream peak flows for the basin. Modeling results of annual events and especially of daily data sets are satisfactory. The results of storm rainfall-runoff modeling are not satisfactory.

Key words: Nash Sutcliffe index, Correlation Coefficient, TOPMODEL, Topographical Index, Time Scale

Satellite Data Inputs for Baseline Studies on Water Use Efficiency (WUE) of Vengalarayasagaram Medium Irrigation Project - A Case Study

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Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. It is also a limited resource. India has more than 18 per cent of the world's population, but has only 4% of world's renewable water resources with 2.4% of world's land area. Water is one of the most important inputs for sustaining agriculture. In view of increasing demand of water for agriculture and other purposes, there is urgent need for efficient use of water. India is amongst the largest irrigator countries in the world today. There is, however, increasing concern about some of the Irrigation Potential Created (IPC) not brought into the functional system, low operating efficiency, less crop productivity etc. System performance monitoring, evaluation and diagnostic analysis are keys to appreciate the improvement or inefficiency in our irrigation projects. Irrigated lands baseline inventory in spatial and time domains using spatial information technologies (satellite remote sensing, digital image processing, GIS and GPS) provides an array of performance evaluation matrices to address this issue. Irrigation system often have a number of competing objectives and are assessed by interest groups with differing values and perspectives, a wide range of performance indicators is thus required. The importance of particular indicators depends on the relative scarcity of land and water, and the cropping patterns and sequences – mono-crop or mixed cropping. Cropping pattern, cropped area, Crop condition, Irrigation Intensity, Water Utilization Index (WUI), Depth of water applied and Adequacy form an some of important set of satellite remote sensing derived spatial performance indicators. The present study is aimed at evaluating the performance of Vengalarayasagaram Command area located in Vizianagaram District, Andhra Pradesh, India for the year 2016-17 using the above said indicators. The results are cropped area 7982.09 ha against the 9996 ha of IPC, Cropping pattern of the command using remote sensing data is Paddy and Sugarcane against the 100% of Paddy crop. The irrigated crop inventory data together with the basic field data on localization particular (CCA information) and water releases into canals facilitate estimation of irrigation system performance indicators such as Irrigation Intensity is 147 per cent against target of 100 per cent, 117.32 ha/ M cum for WUI against the target of 143.05 ha/ M cum of wet crop, 852.34 mm for depth of supply and another parameter Adequacy which is the ratio of Water supplied to the Water estimated is 0. 77. Thus, Irrigation systems can be managed to improve the overall performance and also to increase the water productivity in a sustainable manner.

Key words: Irrigation potential created, Utilized, Crop classification, Cropping pattern

Simulation of Water Resources in Gundlakamma Sub Basin using Soil and Water Assessment Tool

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The main objective of this study was simulation of water resources in the Gundlakamma subbasin. A study has been conducted on the Gundlakamma subbasin to simulate the water availability in the subbasin. The Soil and Water Assessment Tool (SWAT) can be effectively applied to simulate the flow into a reservoir very accurately in the Gundlakamma subbasin. The data base has been developed using the secondary data and field survey. SWAT model was applied to simulate the available water resource and reservoir volume in subbasin. The water yield was simulated during 2010 to 2016 from Gundlakamma subbasin. The most sensitive input parameters in SWAT was delay time for aquifer recharge (days), saturated hydraulic conductivity (mm/hr) for the Gundlakamma subbasin. The was obtained in calibration and validation NSE and R^2 of 0.79, 0.87 and 0.65, 0.72. The reservoir outflow maximum and minimum flow in 2010 as 828.94 and 171.03 m^3/s.

Key words: SWAT Model, Gundlakamma sub basin, hydraluic conductivity, aquifer recharge

Integrated Modelling Approach for Achieving Ground Water Sustainability in the Critically Depleted Regions of Central Punjab, India

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Punjab State of India utilizes a major portion of ground water for crop production. Due to overdraft of groundwater, there is a rapid decline of groundwater table in the State. Ground water depletion in four districts of Central Punjab *viz*. Barnala, Moga, Sangrur and Patiala is very critical at present. The average groundwater table depth varied from 16.8-20.7 m and 16.2-20.8 m during the pre monsoon and post monsoon (*rabi* season) seasons, respectively for these four districts of central Punjab during the last two decades. Barnala district was observed to be the most critically depleted groundwater region in central Punjab where the average pre monsoon and post monsoon groundwater table depth during 1999 to 2018 was 20.7 m and 20.8 m, respectively, followed by the Sangrur, Moga and Patiala districts. Rice-Wheat cropping system is dominant where a major portion of groundwater is being utilized for irrigating the crops in the region. Availability of groundwater may further become a limiting factor due to the changing climatic scenarios in near future. For sustainable ground water use and crop production, the impact of climate change on future ground water availability under the existing and alternative cropping systems will play a vital role. The present study is aimed at investigating the ground water recharge under different cropping systems for devising an alternative cropping plan under the changing climatic scenarios to achieve the sustainability in ground water uses in the region. Remote Sensing (RS) and GIS techniques along with integrated crop-groundwater-climate modelling approach will be used to devise suitable cropping plans in order to achieve sustainability in the ground water utilisation and crop production in the study regions.

Key words: Ground water depletion, Cropping system, Climate change, Crop-groundwater-climate modelling approach

Root Growth Simulation Models for Cotton Crop Grown under Specified Environment in Saurashtra Region of Gujarat

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The cotton root growth was observed through vertical soil column studies. The maximum root depth of 175cm was attained at 180 DAS. However, rooting depth of 148 cm could be obtained at 120 DAS only. It was observed that major part of total root length was concentrated within 30cm up to 80 DAS and within 60cm up to maturity. The root depth data were fitted to models such as Rasmussen & Hanks (1978), Hanks & Hill (1980), Reuss (1980) Fereres et al. (1981), Borg & Grimes (1986) Schouwenaars (1988), and Subbaiah & Rao (1994), by regression analysis. Among these, the model of Rasmussen & Hanks was found the best fitted, followed by Hanks and Hill, Subbaiah and Rao, Borg & Grimes, Fereres et al., Reuss and Schouwenaars.

Key words: Root model, Cotton, Simulation models, Validation of model

Mathematical Modeling for Summer Sesame Grown under Varying Thermal Regimes

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A field experiment was conducted at instructional farm of soil and water engineering, CAET, JAU, Junagadh during summer season(Feb-May) The crop was exposed to different moisture regimes by varying the irrigation interval (3, 4 and 5 days irrigation interval) and mulch level (wheat straw mulch @ 5 t/ha and no mulch). It was observed that, sesame yield is significantly influenced by the thermal regimes and moisture regimes by varying water application under drip irrigation. The sesame yield response to seasonal thermal heat units as well as to stage wise thermal heat unit's availabilities could be described well by the quadratic model. The linear form of the model for the yield response to irrigation interval shows that the yield decreases with increase in irrigation interval. The developed model showed that for the 3 days and 4 days irrigation interval, the sesame grain yield increased more rapidly under mulch as compared to no mulch for the lower values of thermal heat units but for the higher values of thermal heat units, the yield decreased more rapidly under mulch as compared to no mulch. The sesame yield response to seasonal irrigation depth could be found linear indicating that the applied water was less than the crop evapotranspirations(ET_c) or the optimal water requirements and yet there is a scope for increasing the yield by increased water application.

Key words: Modeling, Summer Sesame, Thermal regime

Geospatial Technology and its Applications in Sustainable Agricultural Development

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Sustainable agriculture has become a matter of global need. It is a mechanism of development in which the goals are fixed in such a fashion that the progress is made without constraining natural resources. It is the method of utilization and management of natural resources without environmental degradation. It requires information accuracy with regard to time, space and spread. Hence, geospatial technology for sustainable development needs to be precise and reliable. It enables to capture, storage, retrieval, analysis and display of spatial data from the real world. Traditional information sources of geography have failed to raise the occasions. The new information system of technology has come up as a powerful tool for maximize the efficiency of planning and decision making, capacity to integrate information from many sources and provide complex analysis/query involving geographical referenced data to generate new information. The present study intends to focus on the applications of geospatial technology(viz, soil management, crop disease management, crop acreage and productivity estimation, land use planning, plant growth pattern etc.) in combining varied information with special reference to agriculture and functional ability in the contest of sustainable development.

Key words: Geospatial, Remote Sensing, GIS

Modelling Microclimate of a Protected Structure for Precision Climate Monitoring, Management and Development

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The microclimate of a protected structure varies three dimensionally within the plant community due to a frequent variation in climatic parameters with respect to outside conditions. Thus, precise monitoring and management of protected environment becomes imperative for optimal plant growth and development. In the present study, theoretical models (in the form of partial differential equations) were developed using sensible and latent balances to predict temperature and humidity in the vertical plane of the protected structure. The statistical comparison between predicted and observed data indicated a good agreement between them with a model efficiency (η_{eff}) of >90%. The developed models would be helpful in monitoring and managing optimal plant growth conditions through different climate control strategies including irrigation and fertigation management of the crops grown. The developed models can also be used in further development, such as a design tool to optimize the characteristics of ventilation system and control settings with a significant saving in energy and time.

Key words: Microclimate, modelling, monitoring, protected structure

Application of Remote Sensing and GIS Technique for Land and Water Resources Management of Farm Level

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Water resources are increasingly in demand in order to help agricultural and industrial development, to create incomes and wealth in rural areas, to reduce poverty among rural people, andto contribute to the sustainability of natural resources and the environment. Reliable and timely information on the available natural resources is very much essential to formulate a comprehensive land use plan for sustainable development. The land, water, minerals and biomass resources are currently under tremendous pressure in the context of highly competing and often conflicting demands of an ever-expanding population. Consequently, over exploitation and mismanagement of resources are exerting detrimental impact on environment. In India more than 75% of population depends on agriculture for their livelihood. Agriculture plays a vital role in our country. Satellite remote sensing data have the advantage of providing up-to-date and comprehensive information needed for systematic and scientific planning of watershed development activities. It provides spatial information on drainage, stream, tank, land-use/land cover, geology, soils and many other natural entites etc. Soil and land resource inventory using the False Color Composite (FCC) of IRS-R2 LISS IV geocoded data and Geographical Information System at farm level on 1:4000 scale has been generated for Maniari watershed in Lormi block of Mungeli district. Information in the textual or attribute files of the cadastral, such as land value, ownership, or use, can be accessed by these unique parcel codes (*Kasra* numbers) shown on the cadastral map. Four farming situation were identified, characterized and mapped as per the local names of *viz. Bhata, Matasi, Dorsa, Kanhar.* based on the soil sampling analysis and peoples participating research interaction in the villages. The geodatabase in digital format was created by preparing all the spatial information of the sub watershed no. 4G3F4n comprising of 40 villages and 25535 farm fields.Total 1217.77 ha, 129.76 ha and 23.37 ha of current fallow under *Matasi, Dorsa and Kanhar*farming situation respectively during *Kharif* and 2870 ha under *Kanher* farming situation during *Rabi* can be brought under cultivation utilizing the additional developed water resource of 12.43 Mm^3

Key words: Cadastral mapping, Farming situations, Geospatial, GIS, Remote sensing

Application of Geochemistry and the Fingerprinting Technique to Trace the Sources of Fine Sediment in a Mountainous Catchment Located on the Lower Jinsha River, China

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Identification of the relative contribution of sediments from different sediment sources is needed to target sediment control strategies to mitigate excess sediment delivery to near dam reservoirs on the lower Jinsha River. We combined the source fingerprinting approach with geochemistry (i.e., comparison of potential sources, and distribution pattern of major and tracer elements) to use element tracers to estimate the relative contribution of different land-use areas to streambed sediment in the Luowugou catchment located on the Heishui River, which is the first branch of the Jinsha River. A total of 57 samples (i.e., stream bank, cropland, grassland, forest land, and sediments) were collected, and then, 15 elements were analyzed for each sample. The fingerprinting results demonstrate that a total of four individual properties (Cd, Cu, P, and Mg) could serve as optimal composite fingerprint tracers. These tracers were used to correctly identify the sources of 85.1% of the samples. The stream bank (62.42%) had the greatest relative contribution to the sediment yield, while cropland, grassland, and forest land contributed 18.59%, 14.85%, and 4.14% of the sediment, respectively. In comparison to the fingerprinting method, even though the results based on geochemistry only provide a qualitative assessment, the ranking of sediment contributions based on geochemistry was consistent with the sediment fingerprinting results, that is, stream bank>cropland>grassland>forest land. Our results show that the focal point for sediment control practices should be the stream bank rather than cropland in this catchment, and geochemistry can satisfactorily discriminate between a wide range and different types of sediment sources (stream bank, cropland, grassland and forest land) to compensate and validate the fingerprinting results.

Key words: Sediment sources, Fingerprints, Geochemical properties, Land use, Soil erosion

Application of ArcSWAT Model for Estimation of Sediment Delivery Ratio at Sub-Watershed Level

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Indiscriminate use and mismanagement led to soil degradation which is an important global issue causing adverse impact on agricultural productivity and environmental quality and ultimately quality of human life. The success of planning for watershed developmental activities depends on the quality and quantity of information available of natural resources. The process of assessing soil erosion using conventional methods is cumbersome, time-consuming and costly therefore, in the present study, an attempt has been made to estimate sediment delivery ratio at sub-watershed level using RUSLE and SWAT Model. The raster layers of K, L, S, C, P factors and computed R factor value was used to derive gross soil erosion map of study area using raster calculator of spatial analyst tools in ArcGIS interface. The MUSLE was used to route and estimate the sediment yield at watershed outlet using SWAT model. Highest area covered by agricultural land (i. e. 41.54) of study area having 33.28 tons/ha/yr gross soil erosion needs immediate treatment of soil conservation in order to reduce water erosion. The average gross soil erosion rate for study area was estimated as 39.25 tons/ha/yr whereas; the sediment yield by SWAT was estimated to be 22.78 tons/ha./year. The estimated sediment delivery ratio indicates that 58 per cent of eroded soils go out of the watershed which reduces the soil depth and fertility of land on site and reaches Karjan reservoir thus reducing the water storage capacity of reservoir each year.

Key words: ArcSWAT, MUSLE, RUSLE, Sediment Delivery Ratio

SESSION-X

New Paradigms in Soil Health and Nutrient Management

Integrated Soil Management Strategies for Enhancing Soil Quality in Resilient Agriculture for Southern Guam

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One of the most threatening factors to soil quality especially in the tropical islands of Micronesia is the low organic matter content. Soil organic matter (SOM) is among the most degradation factor and the cause of poor soil quality in Guam and the other islands of Micronesia. Soil organic matter content are enhanced by effective management activities such as; manipulation of soil environment via conservation tillage and crop rotation practices, and more effectively by land application of composted organic wastes. In our case studies, preliminary results have shown that the application of composted organic wastes increased crop yield and significantly improved the quality of the soils in plots under study. The yield increase was 45%, 38%, and 33% for 30, 60, and 90 tons/ac of application rate as compared to the control (0 tons/ac). Also, the organic matter content of the soils under study increased from 3.4% to 6.3%. In our study, composted organic waste was applied on soils of agricultural fields as an alternative to commercial fertilizers to provide nutrients and also to enhance the organic carbon content and improve the overall quality of these poor soils of northern Guam. In our pilot project compost is produced from wood chips mixed with animal manure, chicken litter, and other organic wastes available at the local farms and turned mechanically until reached maturity. Mature compost is then applied on the study plots at the rates of; 0, 30, 60 and 90 tons per acre as soil amendment on the poorly behaved 'Guam soils series' of northern Guam. Corn is planted and monitored for growth performance and yield evaluation. In this presentation, the methodology as well as up-to-date data will be presented to illustrate the effect of land application of composted organic wastes on organic matter content and other soil quality indices.

Key words: Soil organic matter, Soil quality, Resilient agriculture, Compost and composting, Guam

The Impacts of Agricultural Practices on Land Cover and Soil Quality in the Middle River Njoro Sub Watershed in Kenya

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The Middle River Njoro watershed inhabitants are involved in a number of land use activities that are being driven by the need to provide food, fiber, water, and shelter to the growing population. Such land use activities have enabled humans in the watershed to appropriate an increasing share of the watersheds resources, but they have also potentially undermined the capacity of the ecosystem to sustain food production and forest resources. The objective of the study was to assess the impacts of agricultural practices on land cover and Soil quality from 1987 to 2014 in the Middle River Njoro sub Watershed. The Land sat ETM+ image (June 1987, May, 2000 and July, 2014) was downloaded from USGS Earth Resources Observation Systems data website. Remote sensing image processing was performed by using ERDAS Imagine 9.1. Three land use/land cover (LULC) classes were established as agriculture, forest and shrub land. Land cover changes occurred from 1987-2000, where subsistence agriculture increased by 968 ha (+70%), and forestry reduced by 1056 ha (-72%) and shrub land by 161 ha (19%). Between the year 2000 and 2014, commercial agriculture increased by 538 ha (+65%), and subsistence agriculture by 500 ha (+21%), shrub land reduced by 315 ha (45%), and the forest by 259 ha (-64%).Forestry and shrub land consistently reduced and agricultural activities increased accompanied with soil quality degradation quantified through a questionnaire It will be necessary to initiate activities that restore the environment to its original status.

Key words: Watershed, Land use\land cover change, Landsat imagery, Geographic Information System

Microbial Interventions for Paddy Residue Degradation for Enhancing Crop Productivity and Improving Health of Salt-affected Soils

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In India, over 500 million tons (Mt) of agricultural residues are produced every year and of this 34 per cent is by rice and 22 per cent by wheat crops. Continuous removal and burning of residues can lead to net losses of nutrients under standard fertilization practices, which ultimately will lead to higher nutrient cost input in the short term and reduction in soil quality and productivity in the long term. Rice-wheat is dominant cropping system of North India and even on salt affected lands, this system dominates. The most common practice adopted by farmers is burning, especially in areas where the succeeding crop is grown in a short time thus allowing less time for its incorporation into soil for decomposition. Alternative to burning, rice straw management options remain costlier for its incorporation into the soil. On the other hand, burning is implicated for causing pollution and affecting soil fertility adversely. An attempt was therefore made to identify the efficient microbes for faster decomposition of crop residues. Bio-augmentation of crop residues with efficient cellulose degrading microbes were aimed that can help in degrading residues and recycling of soil nutrients. These efficient degrading microbes can degrade crop residues, helps in build-up of soil C that can facilitate reclamation of sodic and saline-sodic soils and overall soil health.

Salt tolerant cellulose and lignin degrading bacteria were isolated from different sources including sodic soils and were purified and screened. The three efficient strains were tested on left over stubbles of paddy on sodic soil at research farm through spray of culture broth of the efficient strains individually and in combination with whey to compare their performance on degradation of the stubbles and straw with respect to time. The microbial strains reduced the stubble weight by 31.9 to 40.1% after 35 days. Inoculums of consortia of degrading microbes along with whey resulted in decrease in stubble weight by 46.7% compared to the initial weight of stubble. The C:N ratio of the residue material (stubbles and straw) decreased to maximum of 24:1 from 66.5:1 in 35 days after inoculation of consortia with whey. It was observed that there was maximum reduction of 59.8% with inoculation of decomposer microbial consortia. The in-situ degradation of paddy residue also significantly enhanced the succeeding wheat yield. The consortia of two efficient and compatible halophilic bacterial lingo-cellulolytic strains having plant growth promotion traits were prepared in suitable standardized media as bio-formulation 'Halo-CRD' as decomposer for crop residues.

The outcome of the study will facilitate to utilize the residues for recycling nutrients, enhance soil microbial activity and C enrichment to promote bio-remediation apart from saving energy that helps in achieving desired level of production and health management of salt affected soils.

Key words: decomposition, stubbles, salt tolerant, cellulose degrading, Halo-CRD

Soil Phosphorus Status and Management in Agriculture: Prospects and Retrospect

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Phosphorus (P) is essential nutrient for plant growth and often a major limiting nutrient in agriculture. The P deficiency is a common phenomenon in agricultural soils worldwide. Phosphate rock (PR) deposits are the non-renewable natural resources for manufactured water soluble P fertilizers which are being depleted rapidly. Many studies have suggested that almost half of the currently available PR resources will be depleted by 2100. On the other side, it is frequently evidenced that P is being used inefficiently in agriculture and about 10 to 20% of applied P fertilizer was recovered in crop production. This may lead to its accumulation in the soils as and the possible loss from the soil system might be due to eutrophication of soluble P in water bodies only which is also an alarming situation for aquatic ecosystems. It has been suggested that this accumulated P also termed as residual P or legacy P or native soil P in agricultural soils is sufficient to sustain crop yields worldwide for 100 years.

The soil P is the difference between P inputs including fertilizers, manures etc. and the P outputs including P losses from the soil which may exists in adsorbed P, mineral P and organic P forms. This has to be desorbed, solubilized or mineralized to provide the phosphate anions for plant uptake. The critical concentration of readily available P must be maintained to obtain good crop yields depending upon various soil and plant factors like pH, mineralogy, temperature, moisture, organic matter, nutrient interactions, microbial activities, enzymes etc. in the soil and root architecture, mycorrhizal infection, morphological, physiological and biochemical properties etc. in plants. Various characterization studies suggested that sufficient amount (>50%) of the residual soil P may be utilized for plant nutrition using suitable interventions including phosphate solubilizing microorganisms, phosphatase enzymes and enzyme activators, low molecular weight organic acids, humic acids, lignin, crop residues, biochar and zeolites etc. There are growing evidences that soil P activators can promote the release of phosphate from soil and, hence, have potential for mitigating the impending global P crisis. Numerous microbial species including bacteria fungi, mycorrhiza, actinomycetes etc. has been reported as potential soil P solubilizers in different soils. Soil enzymes and organic acids appreciably increased the solubilization and mobilization of soil P for plant nutrition. Legume plant species exhibited highest solubilization efficiency for soil P.

Therefore, prospects endowed to assess the distribution and composition of soil P, characterize accessibility and recycle the accumulated soil P for plant nutrition in different agricultural production systems. The P fertilizers are expected to get more expensive as demand overtakes the supply, therefore P inputs can be managed by balancing fertiliser inputs with removals in plant or animal materials. The approaches for P use efficiency, soil P accessibility and recycling potential needs to be refined for real time assessment in modern agricultural production systems.

Key words: Phosphate rock, Soil P fixation, Soil P solubilization, P use efficiency

Crop Residue and Potassium Management Practices to Improve Soil Quality and Water Use Efficiency under Zero Tillage Maize-Wheat Cropping System at Indo-Gangetic Plains of India

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Crop residue is an asset if we use wisely as a soil amendment in different agroecosystem to improve soil health status and productivity of intensive cereal-cereal cropping system at Indo-Gangetic Plains (IGP) of India where residue burning after paddy harvest is widespread and poses many soil and environmental problems. Imbalanced and excess application of nitrogen (N), phosphorus (P) fertilizer by skipping potassium (K) illusions the farmers that only NP fertilizer will give higher productivity. This has resulted considerable yield reduction in maize and wheat due to need of K nutrition by the crops. Therefore, identification of suitable crop residue (CR) and K management practices can be a feasible option. With this background an experiment was laid out in split plot design with four residue levels (0, 2, 4 and 6 t ha^{-1}) and five potassium (K) levels (0, 50%, 100%, 150% RDK [recommended dose of K] and 50% RDK + Potassium solubilizing bacteria, KSB). The results revealed that crop residue retention @ 4.0-6.0 t ha^{-1} significantly (p=0.05) improved maize equivalent yield (MEY), water use efficiency (WUE), soil organic carbon, exchangeable K, soil biological activities (alkaline phosphatase, cellulase, dehydrogenase, fluorescein diacetate, microbial biomass carbon and K solubilising bacteria) compared to non residue and 2.0 t ha^{-1} CR applied plots. The bulk density, pH, EC and available micronutrients did not vary significantly with CR and K management. Among K management practices, 50% RDK+KSB, showed significantly higher values of MEY, WUE of maize and wheat with concurrent enhancement in soil physico-chemical and biological health indicators over No K and 50% RDK, but it was statistically identical with 100% RDK and 150% RDK. Thus, a combination of 4-6.0 t ha^{-1} CR retention and 50% RDK along with seed inoculation of KSB microbial strain could be pre-eminent options to improve MEY, water use efficiency and soil health indicators in zero tillage maize-wheat cropping system.

Key words: Conservation agriculture, KSB, Maize-wheat system, Soil health indicators, Water use efficiency

Effect of Forest Degradation on Hydrodynamic Soil Quality and Carbon Storage in Semi-arid Mediterranean Climate

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Soil is a major component in food security. When we conserve the soil, we protect the water quality, which impacts crop productivity. In Morocco, especially in our study area, there is pressure on the soil resource that becomes more important with climate change. In recent years, there has been a regression of the forest area in favor of the agricultural land. The study area is located in the Bouregreg catchment area, which is part of the Moroccan central plateau. The average annual rainfall is 588 mm. Soils formed on shale are the most widespread. These soils always look brown with increasing stoniness depending on the soil depth and variable depending on the exposure or slope. In this study, we investigated the effect of conversion of green oak forests into cereals on hydrodynamic behavior, soil surface state and carbon storage potential in the various reservoirs (Aboveground, belowground biomass and soil). The hydrodynamic characteristics (imbibition rainfall and infiltration capacity) for these different land uses were estimated using a rainfall simulator. The soils surface state was evaluated by measurements of the opened and covered surfaces percentage. Three circular parcels of 12 m radius were installed within each land use. Aboveground (live trees, dead wood, Undergrowth and litter) and belowground biomass (the roots on 30 cm deep) were evaluated by the destructive method. Live trees within the parcel with a diameter greater than 5 cm are measured at 1.30 m height above the ground using a measuring tape. For dead wood, all dead and standing tree trunks and stumps with a diameter of 5 cm and a length of 0.5 m were sampled for the determination of wood density. The results revealed that imbibition rainfall and infiltration capacity, as indicators of runoff and soil susceptibility to erosion, significantly decreased after deforestation. Agricultural soils are more compacted with an increase in penetration resistance of 39% compared to forest soils. After deforestation, a decreased by 47% and 37% in the covered and opened area was showed. Carbon stocks are 13.35 Mg ha^{-1} and 0.5 Mg ha^{-1} in aboveground biomass, 9.42 Mg ha^{-1} and 0.6 Mg ha^{-1} in the roots and 42.63 Mg ha^{-1} and 10.7 Mg ha^{-1} in forest and cereals respectively. Total carbon stocks in the various reservoirs decreased by 82% after conversion of green oak lands to agricultural areas.

Key words: Land use; deforestation; carbon sinks; infiltration; oak

Impact of Conservation Agriculture on Soil Physical Condition, Organic Carbon Content and Plant Root Response – A Global Meta-analysis

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Food security involves sustainable utilization of soil and land resources. Conservation agriculture (CA) practice is a proponent of better resource utilization, and is believed to improve soil physical condition, and a potential migrating option for climate change. However, the impact varies widely across agro-climates, cropping system over the CA history and soil depths. A meta-analysis was performed, based on 4131 pairs of data from 522 studies spread globally, to evaluate the effect of NT in comparison to conventional tillage (CT), on soil physical condition (bulk density, BD; mean weight diameter of aggregates, MWD; field capacity water content, FC; and steady-state infiltration rate, IR), soil organic carbon (SOC) content, and the root response (RLD). Care was taken to extract data from each study so that these are consistent to one another.Means of parameters for NT and CT were extracted from each study at each depth interval. Data that were available in figures were extracted by using WebPlotDigitizer version 3.12. Paired data were categorized into four groups,viz. climate, study duration, soil texture and cropping system (CS). Climatic classification was made as tropical, subtropical and temperate corresponding to 0 to 20, 20 to 30, and 30 to 66 degrees latitudes, respectively. The duration under NT was classified into <6, 6-10, 11-15, 16-20 and >20 years. Cropping systems were many, and for convenience in analyzing and interpreting results, five categories were made: (i) cereal only (C-C), (ii) cereal with legume (C-L), (iii) cereal with non-cereal and/or non-legume in rotation (C-O), (iv) legume only (L) and (v) other i.e. non-cereal and/or non-legume only in rotation (O).Soils were classified into 3 major textural groups: clayey (sandy clay, silty clay and clay), loamy (sandy clay loam, silty clay loam, clay loam, silt, silty loam, loam and sandy loam) and sandy (loamy sand and sand). Result revealed was no change in BD across depth with the adoption of NT practice. However, a direction of increase in BD is apparent under NT up to 20 cm depth, wherein marginal increases of 1.3% (0-5 cm), 4.7% (5-10 cm) and 1.7% (10-20 cm) were recorded, compared to CT. The meta-analysis indicated that the CA significantly improved MWD and FC in both surface and sub-surface layers by 19-58% and 6-16% respectively, and IR also increased by 66% under CA. The 0-5 and 5-10 cm layers had significantly higher SOC content under CA, while in other layers, it either reduced or not changed, resulting in a small and insignificant change in SOC stock (~1.1%) in favour of CA. The RLD improved by ~35% in CA only at 0- to 5-cm soil depth. Impact of climate, soil type and cropping system could not be broadly recognized, but the benefit of CA certainly increased over time. Improvements in soil aggregation and hydraulic properties are highly convincing with the adoption of CA, and therefore this practice leads to a better and sustainable use of soil resources.Meta-analysis substantiated the fact that adoption to CA practice was fundamentally important for improving soil quality and less important for soil C sequestration.

Key words: Meta-analysis, No-tillage, Soil physical parameter, Organic carbon, Plant root

Importance of Potash for Sugarcane Cultivation in Punjab, India

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Among the various depleted nutrients, Potassium is of prime concern as its exhausted @ 300 kg ha^{-1} yr^{-1} in the Punjab state, which traditionally not returned back into the soils by Punjab farmers. Punjab soils are generally assumed to have abundance of K-containing minerals viz. illite, smectite while these were the facts 55 years ago. Field crops deplete 581,560,000 kg K $year^{-1}$ from Punjab soils while 9,929,000 kg K $year^{-1}$ is the additions, which is equivalent to only1.7% of loss. Alone rice-wheat sequence removes 300 kg ha^{-1} yr^{-1} of potash from 0-15 cm soil and it is reported that rate of potash removal from Punjab soils has increased from 136 kg ha^{-1} (1970-84) to 149 kg ha^{-1} (1984-2004). Thus, the Punjab soils will get completely exhausted of potash in 125 years if no K applied (total K reserves 40,000 kg ha^{-1} and K-loss 300 kg ha^{-1} yr^{-1}). However, upon each harvest, depletion of K from the soils lead to rapid opening of cleavage points of minerals, loss of active cation holding sites, leaching of silicic acid and narrowing down of Si:O ratio. Excessive K loss may result in acidic conditions, which further alter all the soil water nutrient interphase. Fields with low sugarcane land productivity normally receive high N and critically low K levels. Low K levels result in lower N-use efficiency which further result in high reducing sugars and low sucrose content in sugarcane juice. Further, illite altered to vermiculite, if excessive withdrawal of potassium is not checked or potash is not applied through fertilizers, then many features of a natural soil viz. good tillage, non-tearing of roots under water stress, Mg+2 retention may be lost for forever. Therefore, strategy must be planned in sugarcane to add need based potassium at least what is removed from soil, to maintain the potash reserves, otherwise it might be too late, if potassium deficiency symptoms waited for potash application in sugarcane. Sugarcane- a heavy feeder of nutrients as only aerial parts of sugarcane in one hectare generally has more than 200 kg of K, which if is in short supply then adversely affects quality parameters and land productivity. Potassium is a must for the synthesis and movement of sucrose from leaves to other parts, therefore decreases the attack of insect-pests. K also controls the opening of stomata, therefore plant supplied with required K, withstands better under water stressed conditions than the K-deficient plant. Finally, as potassium improves both yield and quality of the produce and also nitrogen use efficiency and therefore, it is now imperative to go for balanced fertilization to improve the farm economics as well.

Key words: Potash, Punjab, K in soil, Sugarcane, Yield and Quality

Deficit Saline Irrigation and Mulching Improve Biological Health of Soil Cultivated with Fodder Sorghum-Wheat Sequence in Salt-affected Soils of Northwest India

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Scanty and erratic rainfall as well as soil salinity adversely impede agricultural productivity in arid and semi-arid region. Irrigation with underground saline water is the only option to solve the recurring problem of salt build up, drought and crop water requirement in these areas. In this dilemma, a proper soil-water-crop husbandry is not only essential to check the deleterious impact of soil salinity, but also enhances root zone water and restoring soil biological properties. Keeping these in view this experiment was set up in a saline area (electrical conductivity of saturation extract, EC_e 4.0-36.0 dS m^{-1}) accompanied with shallow saline groundwater (1.2-3.0 dS m^{-1}) with *Kharif* fodder sorghum (*cv*. HSSG-5000)-*rabi* wheat (cv. KRL-210) cropping system irrigated with saline water (8 dS m^{-1}) as per the treatment requirement since 2014 at Nain Experimental Farm, ICAR-CSSRI, Panipat, Haryana. Soil of surface layer (0-15 cm depth) with three replication of fallow (F); 100% water requirement through best available water (100BAW); 100% water requirement through saline water + rice straw mulching, 5 t ha^{-1} (100SWM); 100% water requirement through saline water without mulching (100SW); 60% water requirement through saline water + rice straw mulching, 5 t ha^{-1} (60SWM) and 60% water requirement through saline water without mulching (60SW) were collected after harvest of sorghum (Oct, 2015 and 2016) and wheat (April, 2016 and 2017) and processed; and refrigerated for analysis of microbial biomass C and N (C_{mic} and N_{mic}) and soil enzymes *viz*., dehydrogenase (DHA), *a* and *b*-glucosidase (*a* and *b*-glu) urease (URE) and alkaline phosphatase (AlP) activity within one month from sampling. Both $pH_{(1:2)}$ were unaffected in treatments, whereas $EC_{(1:2)}$ declined in *Kharif* after harvest of sorghum than the ending of *rabi* season wheat. Soil salinity declined the activity of soil biological properties at *rabi* than *kharif*. Deficit irrigation and mulch are effective in reducing the $EC_{(1:2)}$ in root zone 60SWM (2.14 and 2.56 dS m^{-1}) compared to 100WR (2.42 and 3.33 dS m^{-1}). Mulch with 60WR had significantly higher values of *a*-glu in soil after the harvest of sorghum, but the activity of AlP was higher in 60WR with no mulch in the soil after the harvest of sorghum and wheat. Application of 100BAW increased the activity of DHA compared to saline irrigation, but the activities of AlP declined with 100BAW. Mulching with deficit irrigation showed significant effect on wheat and dry fodder sorghum yield (6.5and 10.7 Mg ha^{-1}) compared to 60% water application without mulching (5.7and 10.4 Mg ha^{-1}).

Key words: Soil salinity, Soil microbial biomass C, Dehydrogenase activity, Glucosidase activity

Reducing Nitrogen Losses Accountable for Environmental Pollution by Altering its Mode of Application in Saffron Growing Soils

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In order to identify and suggest the best nitrogen (N) input method that can optimize its recovery or uptake with minimum N losses accountable for environmental degradation, while still assuring high yields, an investigation was carried out in saffron growing cold humid region of north-west Himalayas. Different N-input/application methods were explored during the investigation. It was observed that N application through mid-rib placement upper to corms in two splits (MRPU-2S) resulted in significant reduction in N losses due to nitrate leaching, surface runoff and nitrous oxide N emissions. An increase in saffron yield over conventional methods was also observed in MRPU-2S. Besides empirical models were also developed that can predict and quantify saffron yield, nitrate leaching and nitrous oxide N emission well in advance. The nitrogen input method suggested during the investigation, i.e. MRPU-2S will minimize N losses due to leaching, surface runoff and nitrous oxide emission without affecting the saffron yield negatively.

Key words: Nitrous oxide emission; Nitrate leaching, Saffron

Marine Gypsum: An Effective Alternative Ameliorant to Mineral Gypsum for the Management of Degraded Sodic Soils

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The total salt affected soils in India are 6.73 Mha, out of which 3.77 Mha is sodic in nature. Gypsum ($CaSO_4.2H_2O$) had been widely used as an ameliorant for the reclamation of sodic soils so far but being a natural resource, its availability is becoming scarce due to extensive use in cement industries, making plaster of paris and gypsum boards. The increasing input costs and its poor purity poses problems in the reclamation process. Thus, it was imperative to find either a suitable alternative to gypsum or some compound that works efficiently in the process of reclamation. To tackle this issue, phosphogypsum, fly ash and various organic amendments had been tried earlier as an alternative amendment but due to one or the other reasons, it could not be applied widely in the reclamation process. Therefore, it was hypothesised that marine gypsum (MG) which is a by-product of salt industry and contains $CaSO_4.2H_2O$: 89.72-92.62%; NaCl: 0.48 to 2.08%; $MgCl_2$: 0.57%; $MgSO_4$: 3.42%; Insolubles: 3.48 to 7.65%, may become an important candidate in the reclamation of sodic soil. The presence of NaCl, $MgCl_2$, $MgSO_4$ as impurities in MG may increase its solubility by increasing ionic strength of solution and providing more Ca^{2+} ions for the replacement of Na^+ ions from soil exchange site.

Looking into the above, a field experiments with 6 treatments were laid out in the plots of 40 m^2 using a randomized block design having 3 replications during kharif season taking rice as a first crop. The required doses of (MG) and mineral gypsum (GYP) were mixed in soil as per the treatments based on the gypsum requirement. This was followed by ponding of 10 cm water and allowing for vertical leaching for 15 days as per the treatment design. The treatments were: T_1– Control; T_2 – 50 GR gypsum; T_3 – 50 GR (Eq.) Marine gypsum; T_4 – 25 GR Gypsum; T_5 - 25 GR (Eq.) Marine Gypsum; T_6 – 25 GR gypsum+25 GR (Eq.) Marine Gypsum. The rice (CSR-36) was transplanted. The analysis of soil samples after rice harvest revealed maximum reduction of pH in 25GR GYP+25GR MG with respect to control. No significant difference in electrical conductivity (EC_e) was noticed among the treatments except control. The maximum reduction in exchangeable sodium percentage (ESP) of soil was observed in 50 GR MG (39.7 cmole kg^{-1}), statistically on par to 50 GR GYP and 25GR GYP+25GR MG. A very good correlation was found between ESP–pH_2 (r^2= 9) and ESP-pHp (r^2=77). The net dispersive charge was significantly lowest in 50 GR MG (4946 mmol kg^{-1}) compared to control (8276 mmol kg^{-1}) and rice yield was found to be numerically higher (4.11 tons ha^{-1}) in 25 GR GYP+25 GR MG but statistically on par with 50 GR GYP and 50 GR MG. Thus, it could be inferred from the results that MG may act as a better substitute of GYP in the sodic soil management, in view of scarce availability of GYP.

Key words: Gypsum, Marine gypsum, Sodic soil, Reclamation, Dispersive charge

Decentralised Approach of Wastewater Treatment and its Impact on Soil and Potato Crop Quality

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In peri-urban area, due to easy availability and high nutrientscontent, farmers are using wastewater for the irrigation. This wastewater is contaminated with excessive quantities of nutrients, pathogens and toxic chemical substances. Continuous irrigation of agricultural land with such wastewater may cause heavy metal accumulation in the soil and vegetables, and then introduced into the food chain.

A field experiment was conducted for three years to investigate the effects of drip irrigation with wastewater, and treated water on Potato at the Research farm of ICAR-Indian Agriculture Research Institute, New Delhi. A bioreactor was installed at field for the purpose of treatment of wastewater for the irrigation. Bioreactor is comprises of a tank, a settler and a compressor with spargers. In this research study, the level of heavy metals was found more in wastewater irrigated potato than the treated water. There was a 26% less accumulation of metals in treated wastewater compared to untreated drip irrigated potato.

Key words: Bioreactor, Drip irrigation, Treated wastewater, Wastewater

Estimation of Critical Dry Spell in Shipra Basin for Enhancing Crop Productivity

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Rainfall has a major role in rainfed agriculture. So, estimation of critical dry spells along with actual evapotranspiration assist in the design of irrigation systems under irrigated and rainfed agriculture. In this context, a study was undertaken to estimate the critical dry spell (CDS) in Shipra Basin, MP, India using the rainfall data of 51 years. ETo plays a key role. Simulation of ETo was performed using the Penman-Monteith method in CROPWAT 8.0 software. The important characters of rainfall influencing production from rainfed farming are the date of onset monsoon, the duration of rainy spells, the dates of occurrences and duration of intervening dry spell and distribution of weekly/minimum rainfall and number of rainy days. The daily rainfall and evaporation data of the Shipra basin was obtained from the National Institute of Hydrology (NIH), Regional Centre, Bhopal. This data was analyzed to find the minimum, maximum, normal monthly rainfall, average annual rainfall and number of rainy days.The dates of onset and end of effective monsoon were determined for individual years by applying the criteria stated by Ashok Raj (1979). Also mean dates of OEM and end monsoon were determined. Dry spells were found during every year. Mean dates of critical dry spells along with their mean duration were also determined. The average dates of start and end of wet spells is determined. The present study revealed that, the average annual rainfall at Shipra basin was recorded as 931 mm and the average monthly rainfall of the basin was found to vary from 870 mm to 994 mm. The mean dates of OEM were found to be from 15 June to 20 June. The mean date of end of monsoon was found to be 17 to 21 September. The mean dates of critical dry spells were 24 June to 1 July with mean duration of 13 to 32 days for the first CDS, 30 July to 16 September with mean duration of 11 to 37 days for the second CDS, 16 August to 5 September with mean duration of 10 to 40 days for the third CDS and 17 august to 20 September with mean duration of 11 to 32 days for the fourth CDS.

Key words: CROPWAT, Reference evapotranspiration, Critical dry spell

Short-term Impacts of Conservation and Traditional Agriculture on Natural Resources and Corn Yield

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Practices of traditional agriculture (TA) in the Peru's highlands are expensive, tedious and deleterious for natural resources. Contrarily, conservation agriculture (CA) is a suitable technique for increasing the crops economics profits, conserve natural resources and soil biodiversity. Two experiments were set up on the field with corn crop, the aim was to compare the two agriculture systems and encourage the principles of CA in the zone. Bulk density (D_b), volumetric moisture ($è_v$), erosion, corn production cost, corn yield and earthworm population were evaluated. In the first experiment, $LSD_{0.05}$ test with 10 replications of corn grain yield and 20 replications of D_b and $è_v$at two soil depths (0 – 10 y 10 – 20 cm) and a completely randomized design with 3 replications of 50 erosion pins were designed ($p < 0.05$). In the second experiment, dried cover of wild radish was burned and cut on TA and CA plots, respectively, leaving on the last one 1.714 t ha^{-1} of straw biomass, where $LSD_{0.05}$ test with 5 replications of corn ears yield's samples and 10 replications of earthworm population at two soil depths were designed. The land preparation cost of TA was far higher than CA when the labors were done through animal traction. Earthworm population in CA soil was significantly higher at both depths, 6.2 and 3.2-foldgreater than TA soil, respectively. CA soil Db was constant in the first 10 cm of soil and TA soil Db was significantly lesser, at both depths, than CA. CA soil $è_v$ was significantly higher than TA in the first 10 cm of depth, 36 m^3 ha^{-1}, in average, more than in TA soil. Soil wild weed cover significantly reduced almost the half of TA soil erosion. Corn grain and ear yield were significantly higher in CA soil than TA soil, 87 and 139.23% more, respectively ($p < 0.05$). Results showed that practices of CA are more economically profit, friendly with natural resources and soil biodiversity and the crop could adapt better to eventual droughts, than TA. However, the adoption of CA techniques in the zona is slow due to colonial agricultural parameters established and the peasants like all paternalistic help.

Key words: Bulk density, Volumetric moisture, Erosion, Earthworm population, Corn yield

The Residual Effect of the Modified White CKD on Peas Plants Grown in Sandy Soil

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The reuse of cement kiln dust (one of the by-products of cement industry) prevents or at least reduces the environmental pollution. The CKD is beneficial as a raw material, construction material, absorbent, and improving the sandy soil properties. Pot experiment was carried out in Soil Sci. Dept., Faculty of Agric., Minia Univ., El-Minia, Egypt to study the residual effect of fine CKD on the second crop (peas) grown in the same pots, that were previously treated with CKD at rates 0, 2, 4, 6, 8, and 10 g kg^{-1} and used for the first crop (corn). In this experiment, peas seeds were planted in each pot. In general, treating the sandy soil with the different application rates of fine CKD increased the vegetative growth parameters (plant height, fresh and dry weights), water use efficiency and uptake of N, P, and K by peas plants grown in the treated sandy soil, compared with the untreated control. The increase in almost the studied parameters, was proportional to the increase in the application rate of CKD up to 8 g kg^{-1}. It could be concluded that it is possible using the white CKD at application rate of 8 g kg^{-1} as a soil amendment for sandy soils in Egypt. Also, it is possible to use CKD only once for its initial and residual effects on the successive crops grown in the newly reclaimed sandy soils in El-Minia Governorate, Egypt.

Key words: Sandy soil, CKD and peas

Study of No-tillage and Straw Turnover of Sweet Corn in Guangdong Province of South China

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Sweet corn is one of the most important economic grain crops in south China. Under conventional tillage, the soil should be rotary tillage 2 to 3 times before sowing seeds, and fertilizing on the soil surface 3 times throughout the growing season, and the straw burned or removed after harvest of sweet corn ears, and the total cost was up to $ 2489.13/ha in one season with plant sweet corn. The No tillage and straw turnover was implemented in Huizhou and Guangzhou farms, Guangdong province in two years from 2015 to 2016. The management was included the straw turnover mechanically, seedling and transplanting manually with no-tillage, ditching fertilization with machinery. The results were showed that No tillage with straw turnover could increase the production by 3.19%, reduce the cost by $ 2489.13/ha, and increase incomes of farmers by $469.57/ha. At the same time, The soil bulk density of 0-20 cm layers of soil decreased from 1.62 g/cm^3 to 1.48 g/cm^3, with the total porosity increased from 0.32 ml/cm^3 to 0.34 ml/cm^3, and the solid content decreased from 126.89 N/cm^3 to 116.97 N/cm^3, The qualities of soil were improved obviously compared to conventional tillage.

Key words: Sweet corn, No-tillage, Straw turnover

Soil Quality Assessment of River Flood-Plain in Savannah Agro-Ecological Zone of Nigeria, West Africa

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Floodplain is land area adjacent to rivers, it is predominantly used for cultivation of rice and other crops in many parts of the world. Sixty composite soil samples were taken from 30 hectares of land in 2018 to assess fertility status of floodplain in Nigeria. Physical and chemical properties of the soils were analyzed in the laboratory using standard procedures. The results of the soil analysis indicates that sand particles ranged from 43.52 to 80.80%, silt ranged from 10.14-37.57%, clay content ranged from 3.60 to 24.98%)and the soil texture ranged from sandy loam to loam. Bulk density ranging from low to medium (1.36 to 1.65g/cm^3). Percentage porosity ranged from 38 to 47%. Water-holding capacity ranged from 20.66 to 60.88%. Particle density ranged from 1.54 to 2.87%. Moisture content ranged from 0.40 to 21.34%. Soil reaction (pH) ranged from acidic to neutral(4.90 to 6.8). Electrical conductivity ranged from 0.05 to 0.17dS/m. Organic matter ranged from 22.4 to 44.8 g/kg, available nitrogen ranged from 11.2 to 96.5g/kg. Available phosphorous ranged from medium to moderately high (11.7to 35.3mg/kg). Exchangeable calcium ranged from 1.0 to 4.50cmol/kg, exchangeable magnesium ranged from 0.3 to 4.2cmol/kg, exchangeable potassium ranged from 0.1 to 2.7cmol/kg and exchangeable sodium ranged from 0.1 to 0.6cmol/kg. Total exchangeable bases ranged from 3.34 to 8.56cmol/kg. Effective cation exchange capacity (E.C.E.C) ranged from medium to high (4.83 to 15.5cmol/kg). Sodium absorption ration was low (0.05 to 0.56%). Exchangeable sodium percentage ranged from 0.84 to 8.51cmol/kg. Percentage base saturation ranged from 35.36 to 97.25%. The fertility status of the floodplain is moderately high and expected to support cultivation of rice and other cereals. For maximum yield of crops on sustainable bases over long period of cultivation, fertilizer application program should be considered.

Key words: Floodplain, Savannah, Agro-ecological zones, Fertility Status.

Impact of Irrigated Agriculture on Soil Properties of Arable Land in Jhunjhunu District of Rajasthan

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Field survey was undertaken in irrigated arable lands of Jhunjhunu, Chirawa, Surajgarh and Buhana tehsils in Jhunjhunu district of Rajasthan. The area is under intensive cultivation and mainly cropped for pearl millet, cluster bean, wheat, mustard, chickpea and with occasional cultivation of seasonal vegetables at few sites. The cotton, groundnut, sesame crops were also cultivated in Chirawa and Surajgarh tehsils. The crops are being cultivated using ground water irrigation with recommended dose of nitrogen and phosphorus through manure and fertilizers. The soils were mapped as association of Chomu, Bassi and Naurangpura series classified as Typic Torripsamments, Typic Haplocambids and Typic Torrifluents as sub-group, respectively. The soils of the surveyed area were very deep, generally fine sand to sandy loam, single grained fine to medium weak sub-angular blocky structure, alkaline in reaction (pH; 7.65 to 9.30) without any salinity hazard (EC; 0.06 to 0.43 dS/m), and low in organic carbon (0.05 to 0.21%) and cation exchange capacity (4 to 11Cmol$_c$/kg). The soils are low to medium in available phosphorus (5 to 26 kg/ha P) and potassium (80 to 280 kg/ha K). The soil organic carbon (16-19%), electrical conductivity (62-67%), phosphatases activities (24-37%) were increased whereas available soil phosphorus (28-35%) and potassium (16-21%) were decreased in the irrigated land in comparison to soils under rainfed cultivation. In general higher total soil phosphorus was recovered in irrigated (227 to 550 mg/kg) than rainfed (207-441 mg/kg) and total potassium in rainfed (340-1240 mg/kg) than irrigated (240 to 910 mg/kg) land uses. Further characterization of these soil nutrients also revealed same trend for different P and K fractions under irrigated and rainfed land uses. Generally higher soil enzymes activities viz. dehydrogenase, fluorescine diacetate, phosphatases etc. were observed in irrigated than rainfed land use. Thus accumulation of soluble salts (EC), phosphorus depositions and enhanced availability to plants, overall depletion of soil potassium etc. are some important implications of irrigated land use in these arable land needs to be addressed suitably for their sustainable use.

Key words: Soil properties, Land use, Arable lands, Jhunjhunu district

Assessment of Nutrient Ratios of Sugarcane under Various Soil Quality Zones to Maximize the Productivity in Theni District, Tamilnadu

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Soil quality defined in short, as the capacity of the soil to function is rather dynamic and can affect the sustainability of land use and productivity of crops. This has sparked interest in the concept of soil quality assessment during a period where the factor productivity of major crops like sugarcane are continuing to decline under intensive cropping systems. In more recent times, the plateauing sugarcane productivity has been clearly associated with soil quality degradation. Sugarcane cultivated in an area of 4427 hectares of Theni district over a period of more than 15-20 years is recently facing declining yields which is mainly attributed to soil fertility decline and that prompted this research study. The key physical, chemical and biological indicators of soil quality were assessed in the surface (0-15 cm) and subsurface (15-30 cm) samples of each of this zone and weightages were assigned to each soil quality attribute through Principal Component Analysis (PCA). The yield range of sugarcane in low, medium and high soil quality categories were 50 to 75, 80 to 100 and 97.5 to 140 t ha^{-1} respectively. The analysis of leaf nutrients revealed that about 65 and 76 percent of the leaf samples from low soil quality zone possessed low concentration of N (less than the critical value of 1.80%) and low concentration of S (less than the critical value of 0.13%) respectively as against 35 and 15 percent of leaf samples from high soil quality category. Computation of nutrient ratios for sugarcane at its grand growth stage implied that the mean N/P, N/K and N/S ratios of 8.31. 1.60 and 15.0 respectively in the third leaf of sugarcane in the high productive zone resulted in maximum cane yields compared to relatively higher ratios in the top dewlap leaves from soils low soil quality category which indicates that maintenance of high quality in sugarcane soils influences crop nutrient uptake, optimum nutrient ratios and thereby the yield and quality of sugarcane. The results also emphasised the need for reducing the dosage of P and K fertilizers in light of higher available status of these nutrients. The role and essentiality of sulphur application in view of the wider prevalence of its deficient status in low soil quality category need much focus and immediate attention for maximizing the cane yield. Hence more attention should be given towards integrating the scientific results of soil quality assessment with the farmers knowledge of soil quality degradation in research and development activities in order to increase the chance of adoption of integrated nutrient management technologies and improved soil quality enhancement techniques by the sugarcane growing farmers of this region to maximize the sugarcane productivity and sustain the environmental quality for future generations.

Key words: Soil quality, Crop nutrient ratios, Productivity, Sugarcane

Use of Agro-Industrial Wastes for Improvement in Soil Health and Sustainable Farming System

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Agriculture and Agri-based industries generate large quantities of residues per year. The dispose off of these generated wastes are main problem for numerous industries. In India, the total waste generation is approximately 60-65 million tonnes per annum, out of which only $1/5^{th}$ is actually treated. However, the approach for the solid waste management is still instinctive in our country. The collection efficiency of solid waste in our county is around 70 percent, while it is almost 100 percent in the developed counties. Huge portion of solid waste is dumped indiscriminately on the outer side periphery of cities or towns without any prior treatment even today in the country. These wastes, if released to the environment without proper disposal procedure, may cause environmental pollutions and detrimental effects on soil, yield of crops, human and animal health.

These wastes can be of use as an alternative source for the production of different products like bio-fuels, bio-gas and mushroom production as the raw material in different farming, industries and researches. The use of agro-industrial wastes as the raw materials can be helpful to lessen the cost of production and moreover reduces the environmental pollution load. The agro-industrial wastes are these days used for manufacturing of antibiotics, antioxidants, biofuels, enzymes, vitamins, animal feed and other chemicals through solid state fermentation (SSF) technique. Use of press mud or filter cake, bagasse, rice milling industry wastes, by-products from distillery (e.g mint) and spent wash affects the physical, biological and chemical properties of soil. Use of Agro-Industrial wastes in soils significantly increased soil organic carbon (SOC), pH, EC and bacteria, fungus and actinomycetes populations in soil and enhanced the soil fertility status (N, P, K and Zn, Cu, Mn, Fe). Pressmud @12.5 tonnes per hectare recorded better growth and yield, followed by composted coir pith @ 12.5 tonnes per hectare in finger millet crop.

Agro-industrial wastes which are rich in bio-active compounds and valuable nutrients composition. Such waste comprises variability in compositions like minerals, sugars and proteins; accordingly, they should be considered as “raw material” as a substitute of “wastes” for the other industrial processes. The amount of such nutrients in these residues offers suitable conditions for the creative growth of micro-organisms. The micro-organisms have vast potential to re-use the waste as raw materials for their growth through fermentation processes. The agro-industrial wastes can be used as solid support in SSF processes for the production of a range of significant agri-beneficial compounds. The use of agricultural and agro-based industrial wastes as a source of raw materials can help to reduce the production cost, bio-multiplication of microorganism and contributed in recycling of waste as well to make the environment eco-friendly farming.

Key words: Agro-industrial wastes, Crop, Soil properties, Nutrient, Yields

Assessment of Soil-Humus Stability in a Long-term Integrated Nutrient Management Experiment

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Soil humus stability has been quantified for three depths (0-15cm, 15-30cm and 30-60cm) in five different treatments namely; T1= No fertilizer and no organic matter; T2= 100% recommended dose of NPK by chemical fertilizer; T3= 50% recommended dose of NPK by chemical fertilizer+ 50% N by farm yard manure (FYM); T4= 50% recommended dose of NPK by chemical fertilizer+ 50% by N through wheat straw incorporation; T5= 50% recommended dose of NPK by chemical fertilizer+ 50% by N through sun hemp (*Crotalaria juncea*) as green manure (GM) in the rice-wheat cropping system of a thirty one year's long term integrated nutrient management experiment being carried out in black soils (*Typic Haplustert*) of JNKVV farm, Jabalpur, Madhya Pradesh, India. The stability of soil–humus was determined by sequential extraction of humus using sodium pyrophosphate and estimating the carbon extracted. This was a batch technique, where the desorbed humus was removed every two hours to avoid back ward reaction, if any, so that the rate of release remained unaffected wherein re-adsorption of humus on the clay surface was avoided. The carbon concentration in the extracts was measured by Schollenberger method. From the carbon concentration of the extract at different times, the cumulative desorption of humus carbon per unit amount of soil-humus complex was determined and subtracted from the original soil-humus carbon content to get remaining carbon, C_t at time t. Carbon content of a soil humus complex, C_t, at a time t, after desorption of humus from soil-humus complex was fitted to a simple first order equation

$$C_t = C_o \exp(-kt)$$

Where, C_o is the initial carbon content and k is the humus desorption rate constant. The inverse of k will give the retention time i.e. stability of soil humus carbon. It has been observed that Walkley Black carbon (WBC) content was significantly different with depth among all the treatments but no significant difference in WBC content among the treatments was observed. Total organic carbon (TOC) content was also significantly different with depth among all the treatments. Treatment T5, showed significantly higher TOC than all other treatments. Soil humus stability was quantified in three depths in all the treatments and was observed that GM treated soils had highest humus stability followed by straw incorporation and FYM addition. The study indicated that 50% Nitrogen substituted through incorporation of GM can help in sequestering soil organic carbon in rice-wheat cropping system of central plateau region of India.

Key words: Black soils; Humus stability; Long-term INM; Carbon sequestration

Effect of Different Re-Usable Organic Materials on Bioavailability of Cadmium, Lead and Zinc – The Pot Scale Experiment

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Metal pollution in soil has geogenic sources, and is also caused by anthropogenic activities including sewage sludge application, mining and smelting operations and application of commercial fertilizers. Plants are the main recipients of heavy metals (HMs) in soil, and they are also responsible for their transfer further up to the food chain. The total content of HMs in soil is a very poor indicator of their bioavailability, thus looking for their available forms is crucial. The search for methods that limit the availability of HMs to plants is currently advancing.Organic matter (OM) has been considered to immobilize high amounts of bioavailable HMs in soil.Re-usable organic materials such as biochar and brown coal wastesare reported as good sources of OM that could be applied to soil to reduce HMs bio-availability.

The aim of the study was to assess the efficiency of selected re-usable organic materials to reduce the bioavailability of HMs in soil. The experiment wasconductedin pots (125 g air dry soil). Soil samples used originated from Haplic Luvisols, according the World ReferenceBase for Soil Resources (WRB), formed from loamysand on light clay (7% clay, 6% silt, 87% sand). Brown coal waste,wood chips biochar and farmyard manure were applied to soil in two doses: 5 and 10% C_{tot}in dry mass of soil (w/w).Soil was spikedwith HMs by mixing up with the liquid form of salts: cadmium as $Cd(NO_3)_2 \times 4H_2O$, lead as $Pb(NO_3)_2$ and zinc as $ZnSO_4 \times 7H_2O$,which after blending led to the following concentrations in soil (in mg kg^{-1}): 100 and 700 (Zn), 70 and 500 (Pb), 1 and 3 (Cd). After 3, 6 and 9 weeks of incubation the bioavailable forms of HMs were determined by extraction with chelating reagents: 0,05 M EDTA(0.017M $EDTAH_4$ + 0.01135M $Ca(CH_3COO)_2 \times 2H_2O$ + 0.019M $C_3H_4(OH)(COOH)_3 \times H_2O + NH_3$, pH 7.3) and 0.01 M $CaCl_2$.

Reduction of bioavailable fractions of all HMs from soil amended with wood chips biochar, brown coal waste and farmyard manure compared to control samples ranged from 18 to 35%.The amounts of bioavailable Cd, Pb and Zndepended on the dose of re-usable organic materials,and were the lowest in soil amended with brown coal waste.Although the addition of OMto soilcannot change the total content of HMs in soil, but it can significantly reducetheir bio-availability.HMs adsorb onto OM,and stable complexes are formed leading to their reducedmobility and bioavailability.Soil treatment with re-usable organic materials maytherefore be considered as an effective way of reducing HMs bioavailability in soil and,consequently of lowering theirfurther transfer up thefood chain.

Key words: Wood chips biochar, Brown coal waste, Farmyard manure, Bioavailability, Cadmium, Lead, Zinc

Restoration of Soil Functions by Cyanobacterial Inoculation of Surface: Building Strategies to Overcome the Current Practical Challenges under Field Conditions

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Soil inoculation with cyanobacteria has recently emerged as a promising biotechnological tool for restoring soil functionality in degraded drylands. Cyanobacteria show several key attributes that have contributed to this interest: i) their pioneer character, with capacity to inhabit harsh environments; ii) their role improving soil water availability; iii) their ability to fix carbon and nitrogen and thus to increase soil fertility; iv) or the stability they confer to the surface of the soils they colonize, preventing erosion.Therefore, our team in the last few years have being working to evaluate the aptitude of native cyanobacteria strains to restore different types of soils. For that, we started identifying and isolating soil cyanobacteria strains representative from different ecosystems in SE Spain and we selected key strains to evaluate their effects on different soil types under laboratory conditions. As result, we found an excellent performance of some individual strains such as *Nostoc commune* and a mixture of cyanobacteria species in developing a new biocrust and improving key soil properties of different soil types in the short term. We have also identified the key factors affecting inoculum soil colonization. However, that was only the first step, because to fully exploit this biotechnology on a large scale,new challenges had to be overcome. So, the next step was to be able to produce the necessary biomass for field inoculations at low cost and on short time periods, that is, optimizing its production. We demonstrated that it was possible to culture our cyanobacteria strains in reactors with media made by agriculture fertilizer, instead of chemical made media, reducing the cost of the production. Moreover, the quality of the biomass produced with fertilizers reached higher growth rates and promoted higher soil improvements than conventionally produced biomass. Finally, we are currently evaluating their effects on soils under field conditions. We already know that the inoculation may fail before promoting the new biocrust, because inoculum can be removed by wind or water erosion or not surviving before its establishment. We are exploring different strategies that reduce environmental stresses after inoculation, and we are obtaining promising results.

Key words: Soil restoration, Biocrust, Cyanobacteria

Influence of Zinc Oxide Nanoparticles on Saffron Yield and Nutrient Composition in North West Himalayas

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Crocus sativus L. (saffron), a well known cash crop of North western Himalayas (India), have high quality stigma, that contributes to its great commercial value. The attributed reasons behind such quality may be geographical conditions, temperate climate and well drained soil, favourable for their growth. Since saffron is a perennial crop, its repeated cultivation in an area leads to depletion of essential nutrients from the soil responsible for setback to saffron production. The present study aims to determine the nutrient levels of the treated and untreated soilof *Crocus sativus* L in presence of the zinc oxide nanoparticles (ZONp). The nutritional composition analysis of the treated (ZONp) and untreated soil (control) showed overall increase in the nutrient composition of the treated soil. ZONp also showed a positive effect in the yield of stigma and cormlets of *Crocus sativus* L. Thus data suggests that ZONp nanoparticlescan alter the nutritional uptake in Saffron crop.

Key words: Zinc oxide, Nanoparticles, Nutrient, Stigma, Cormlets, Temperate

Monitoring of Soil Quality of Pandoga Sub Watershed Catchment Area Implementated on Swan River (Una), Himachal Pradesh, India

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Soil is a natural resource entity on which our agricultural productivity based. Climate change has the potential to effect soil properties and processes. In order to mitigate losses in agricultural productivity due to seasonal climatic changes there is a need to monitor physical-chemical properties of soil as it has a direct impact on soil health. This requires relevant and reliable indicator functions under given agro-climatic and socio-economic circumstances. The catchment area of Swan River (main river of Una district) faces same agro ecological problems as of Shivalik foot hills *i.e.*, fragile and vulnerable to soil erosion. Pandoga sub watershed was the one of the sub watershed implemented in the Swan River catchment area to control erosion of soil and to improve soil quality. This site was randomly selected to monitor soil quality and physico chemical results were applied to one paired t- test and two paired t-test. Results show fluctuation with the season and with the sites. Interpretation results of macronutrients with the methods manual of soil testing in India (2011) show low to medium range in pre monsoon season while in post monsoon season it ranged from low to high with the sites. One sample t- test shows significant relationship of all parameters with both the seasons and site. Paired sample t- test shows that there was significant relationship of sand, with site1-site2and site1-site3; clay and Av.K show significant relation with all sites; Av. N and BD show significant relationship site1-site3and site2-site3;MC show significant relationship with sitesite1-site2and site2-site3 while OC, OMC, AV.P show significant relationship with only site2- site3 in post monsoon season while in pre monsoon season BD, Avon and Av. K show significant relationship with the site1-2 and site2-site3; EC and Av. P show significant relationship with site1-site3 while MC show significant relationship with the site1-2 and site2-site3.

Key words: Agro-climate, Ecology, Fragile, Shivalik foot hills, Watershed

Adoption of Saline Soils Management Practices by the Farmers

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The study was an "*expost-facto*" research carried out in Belagavi district of Karnataka State during the year 2017- 18. In Belagavi district, three taluks were selected based on the highest area under salinity. The total sample size was 150. The results revealed that large majority (80.00%) of farmers have adopted surface drainage followed by growing salt tolerant crops (69.33%). The overall adoption of saline soils management practices by the farmers showed that 42.67 per cent of the respondents belonged to medium level of adoption of saline soils management practices followed by low (36.00%) and high (21.33%). The probable reasons might be that adoption of saline soils management practices requires precise and full knowledge and utmost care. Majority of the farmers have completed primary school education, high farming experience, medium extension contact and mass media exposure. All these factors might have influenced the adoption of saline soils management practices. Hence, there is an immediate need to improve the adoption behavior of farmers by developing a strategy for the supply of inputs on cost effective basis, if not on subsidized rates.

Key words: Salinity, Surface drainage, Sub-surface drainage, Bio-drainage, Adoption

Correlates of Saline Soil Management by the Farmers of Belagavi District

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The study was an *"expost-facto"* research carried out in Belagavi district of Karnataka State during the year 2017- 18. In Belagavi district, three taluks were selected based on the highest area under salinity. The total sample size was 150. The data was collected by personal interview method with help of structured schedule. Out of 10 variables studied, the variables education, annual income, mass media exposure, extension contact, organizational participation, training received and farm resource base exhibited positive and significant relationship with knowledge of farmers on management practices of saline soils. The variables age and farming experience showed positive but non-significant relationship with knowledge level of farmers on management practices of saline soils. Nearly half of the farmers belonged to middle age category. More than one fourth of farmers were had formal education up to primary school and 20.67 per cent of them were illiterates. More than two fifth of the respondents were having medium farming experience. More than one third of farmers belonged to medium annual income category. More than one third of the respondents had medium mass media exposure. Nearly two fifth of the respondents had medium extension contact. More than one third of the respondents had medium level organization participation. Nearly one fifth of farmers have undergone training on salinity management, 14.67 per cent have undergone training on land development activities and 10.00 per cent have undergone training on irrigation management. In *Kharif*, more than half of farmers were growing cotton-sorghum whereas more than two fifth of farmers were growing cotton-Bengalgram and sugarcane alone. We observed that nearly one fourth of the farmers were growing cotton-safflower-groundnut while one fifth of farmers were growing greengram-jowar. Nearly half of the farmers were belonged to medium farm resources.

Key words: *expost-facto*, Management practices and saline soils

Use of Urban Compost, Sewage Sludge, Poultry Manure in Brinjal -Cauliflower Cropping System

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The experiment was carried out with 14 treatments which involved the use of two levels of each sewage sludge, urban compost, poultry manure at two levels each *viz*., 2.5 and 5.0 t ha^{-1} and their combination with 75% RDF besides one treatment receiving only inorganic fertilizers (100% RDF) and a control (no manure or no fertilizer). The soil physical properties did not show change by the application of different levels of manures and fertilizers. Combined application of manures and fertilizers did not show any significant change in soil reaction, electrical conductivity and cation exchange capacity. Organic carbon of the soils was not significantly influenced by the manure and fertilizer applications in both the seasons. The highest benefit cost ratio was obtained with sewage sludge application at the rate of 5.0 t ha^{-1} along with 75 per cent recommended fertilizers. Application of poultry manure and organic wastes like urban compost, sewage sludge for soil application improves soil physical, chemical properties and enzymatic activities and helps in maximising yields.This study suggested, that to get higher income (Rs.295119/ha), application of sewage sludge applied @ 5.0 t ha^{-1} along with 75 per cent RDF for brinjal – cauliflower cropping sequence is recommended.

Key words: Organic waste, Soil health, Physical properties and yield

Bio-char Potential for Improving Crop Productivity under Acidic Soil of North Eastern Region

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Soil acidity is one of the major constraints in crop production through-out the world. In India, approximately one-third of the cultivated land is affected by soil acidity. Majority of these soils are concentrated in North-Eastern Region (NER) of India where approximately 95 per cent soils are acidic, with nearly 65 per cent soils under strong acidity with pH less than 5.5. Crop productivity on such soils is mostly constrained by aluminium (Al) and iron (Fe) toxicity, phosphorus (P) deficiency, low base saturation, impaired biological activity and other acidity-induced soil fertility and plant nutritional problems. To maintain an adequate supply of plant available P, liming and regular application of P fertilizers are the conventional practices, but over liming can cause P fixation by calcium, and excessive or unbalanced use of P fertilizers may result in eutrophication. Liming may also not be economical in regions where it is expensive. The NER produces huge quantity of crop residue/weed biomass which is traditionally burned to provide a fast way to clear the agricultural field facilitating further land preparation and planting. However, in addition to loss of valuable biomass and nutrients, it leads to release of toxic gases including GHGs. There is an immense scope for converting millions of tones of crop residues/ weed biomass into bio-char that can be utilized for managing soil acidity and enriching soil carbon. Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops supporting the livelihood of many vegetable growers in the NER. Therefore, a field experiment was conducted during *rabi* season of 2017-18 at Research Farm of School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences (CPGS-AS), Umiam, Meghalaya to optimize the dose of bio-char (B) in combination with Vermicompost (V) and graded recommended doses of N, P, K fertilizers (F) to maximize tomato cv. Megha Tomato-2 productivity and improving soil acidity indices. Sixteen combination of treatments as control T_1 (without B, V and F), T_2: B (2 t/ha), T_3: B (3 t/ha), T_4: B (4 t/ha), T_5: B (2 t/ha) + 75% RDF (Recommended nitrogen, phosphorus and potassium (NPK): 120, 80 and 60 kg/ha), T_6: B (3 t/ha) + 75% RDF, T_7: B (4 t/ha) + 75% RDF, T_8: B (2 t/ha) + 100% RDF, T_9: B (3 t/ha) + 100% RDF, T_{10}: B (4 t/ha) + 100% RDF, T_{11}: B (2 t/ha) + 75% RDF + V (2.5 t/ha), T_{12}: B (3 t/ha) + 75% RDF + V (2.5 t/ha), T_{13}: B (4 t/ha) + 75% RDF + V (2.5 t/ha), T_{14}: B (2 t/ha) + 100% RDF + V (2.5 t/ha), T_{15}: B (3 t/ha) + 100% RDF + V (2.5 t/ha), T_{16}: B (4 t/ha) + 100% RDF + V (2.5 t/ha) were tested in RBD and replicated thrice. The results indicated that plant height, number of fruits/plant, fruit size and fruit yield of tomato was significantly higher with the application of B (4 t/ha) + RDF (100% NPK) + V (2.5 t/ ha) and soil acidity indices also improved significantly over control. Hence, application of bio-char (4 t/ha) in combination with vermicompost V (2.5 t/ha) and inorganic fertilizers (100% NPK) may be recommended for Meghalaya farmers to enhance tomato productivity, and improving soil acidity.

Key words: Biochar, acidic soils, north eastern region, tomato productivity, soil acidity indices.

Soil Fertility Status of Regional Research Station, Kapurthala, Punjab, India

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For the present investigation, 40 soil samples from 0-15 cm depth collected from different blocks (A-H) of Punjab Agricultural University's Regional Research Station (RRS), Kapurthala. Soil samples were analyzed for different macro and micro nutrients. *viz.* pH, electrical conductivity (EC), Soil organic carbon (SOC), available phosphorus and potassium. Soil analysis revealed that 82.5% of soil samples had normal pH (6.5 -8.7) and 17.5% soils were alkaline in nature with pH varying between 8.7 to 9.3. About 92.5% soil samples were non-saline (E.C. <0.8 m mho cm^{-1}) and only 7.5% soil samples had EC> 0.8 m mho cm^{-1}. Data showed that 87.5% samples had low soil organic carbon (SOC<0.4%) while 12.5% soils had SOC in the medium range (0.4-0.75%). About 5, 30 and 65% soil samples were categorized as low, medium and high in available-P, respectively. Majority (~75%) soil samples were high in available-K. Of the total soil samples, ~15,12.5 and 20% soil samples were deficient in DTPA- zinc (Zn), iron (Fe) and manganese (Mn), respectively while copper (Cu) observed to be in sufficiently higher level at the station. Parker nutrient index (PNI) values for SOC was in lower range (1.11), while available-P (2.75) and K (2.07) were in the medium range. Therefore, to meet the nutrient requirements of the plants grown for seed production in a judicious and climate smart way, soil test based fertilization is a must.

Key words: Soil fertility, Kapurthala, SOC, EC, PNI, Micronutrients

Phosphorus Adsorption-Desorption Characteristics of Different Layers of Weathered Granite and Effects of Different Soil Properties on Phosphorus Sorption

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Highly weathered acidic soils tend to have high phosphorus adsorption rates. Studying the phosphorus adsorption and desorption characteristics of these soils is of great significance for improving phosphorus utilization and reducing soil phosphorus loss in agricultural management. The weathered granite soils (TL (tillage layer), LL (laterite soil layer) and SL (sand layer) eroded by slope runoff and interflow severely in Anji, Zhejiang Province were selected for batch experiment. The impact of pH, clay content and specific surface area on phosphorus adsorption was also studied. Compared with the Freundlich model, the Langmuir model can better describe the adsorption isotherm of phosphorus. Derived from the adsorption isothermÿthe maximum absorption capacity of phosphorus in TL soil (420.4 mg / kg) was greater than that of LL (351.1 mg / kg) and SL soil (222.8 mg / kg), and the phosphorus adsorption capacity of the three soils reached the maximum. For a pH of 4.3-5.0, the adsorption amount increases again after continuously decreasing to pH value of about 8. The desorption ratio of soil in SL is 23.6%, which is larger than LL (16.5%) and TL soil (15.9%). The increase of the three soils decreased first and then gradually flattened. When the adsorption amount reached or reached the maximum value, the desorption ratio increased again. There was a significant positive correlation between soil clay content, specific surface areaÿinitial phosphorus content and maximum phosphorus adsorption. Higher clay content and specific surface area correspond to greater phosphorus adsorption and smaller phosphorus desorption ratio. We conclude that the order of three soil adsorption capacities is TL> LL> SL, and SL has the highest desorption ratio. Soil clay content, specific surface area and pH are the most important factors affecting phosphorus adsorption and desorption. Aluminum compounds are key intermediates in the phosphorus fixation process. The reduction of soil surface clay content is an important factor in the change of phosphorus adsorption with soil depth. This study can provide a theoretical basis for soil phosphorus adsorption research in Zhejiang province, and provide reference for soil phosphorus management.

Key words: Adsorption capacity of phosphorus, Isothermal model, Clay, Specific surface area, Weathered granite soil

Variation in Soil Organic Carbon of Red and Black Soils in Kopal District of Northern Karnataka, India

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Thirty pedons representing red (17 pedons) and black (13 pedons) soils developed on granite gneiss and alluvium in the semiarid region of Koppal District in the northern Karnataka, India were studied morphologically and were analyzed for physico-chemical properties using standard methods. There is large variation in colour, structure, texture and physico-chemical properties of the soils between these two parent materials. Soils developed from granite gneiss were non-calcareous, whereas soils developed from alluvium were calcareous in nature. The significant increase in clay content in subsoil horizons and occurrence of clay films were the characteristic feature in soils developed from granites. The clay content also varied with soil types in the order of 55% and 35% for alluvial and granite soils respectively. Soils developed from granite are taxonomically classified at subgroup level as (Paralithic) Rhodustalfs, Typic Rhodustalfs, Rhodic Paleustalfs, Typic Paleustalfs and (Paralithic) Ustorthents; whereas alluvial soils were classified as (calcareous) Typic Haplusterts, Sodic Haplusterts, Vertic Haplustepts and (calcareous) Fluventic Haplustepts. The SOC level in the surface 0.15 m and sub surface up to one metre depth varied between different soil types. Descriptive statistics were used to establish the relationship between soils of two parent materials with respect to soil organic carbon levels. Results showed that the average SOC levels were 0.51% and 0.45% for alluvium and granite soils respectively. The SOC level at 0.64% and 0.56% were observed in the surface (0.15 m); whereas 0.42% and 0.52% in the sub-surfaces (upto 1 m) of granite and alluvial soils. Parent materials influenced the organic carbon storage through its control on soil texture. The ranking of SOC storage in different soil orders was in the order of Inceptisols (0.54%) > Vertisols (0.49%) > Alfisols (0.47%). It is concluded that the soil organic matter in the study area is mainly determined by parent materials, texture and soil types.

Key words**:** Soil Organic Carbon, Black soils, Red soils, Soil texture, Soil Orders

Dynamics of Soil Nitrogen and Phosphorus vis-a-vis Nutrient Regimes in Lowland Rice Cultivation

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Nitrogen (N) and phosphorus (P) are essential macronutrients for growth and development of plants. Excess N & P in soils causes environmental problems and their deficiency or toxicity in soils causes various physiological issues in plants. The understanding of the labile pools of organic carbon, N and P in the soil matrix as plant growth medium is needed for enhancing productivity and to reduce the nutrient losses. Physical and chemical properties of soils vary spatially due to the nature of soil parent material and soil position in the landscape and water table fluctuations while temporal variation in soil nutrient labile pools is one of the most dynamic features of nutrient cycling in flooded ecosystems. Patterns of variation in N are related to Organic Carbon content and mineralization processes in the soil; while that of P was affected by flood-induced anaerobic conditions and soil pH. Besides, Rice (*Oryza sativa* L.) crop requires large amount of N and P for their potential growth and yield. So, the application of N and P through external inputs is inevitable to meet the nutrient demand during the crop growth stages. However, due to flooded conditions in lowland paddy fields and heavy rains in places like NE regions, a large amount of the labile pools of nutrients very often gets diluted. As a result, this solution N and P labile pools may vary with different depths and crop growth stages which ultimately affect its growth and yield. Thus, the research was aimed at the availability of soil solution N and P in low land rice cultivation which is found to be variable at time scale and has relationship with crop uptake and growth. Thus, this experimentation was done to collect the solution water at different depths and periodic intervals through installation of PVC pipes. The variable amounts of available N and P in solution form which seep-down into different depths, especially after heavy rainstorms were recorded over time factor. The results indicated low to moderate percolation through clay loam soil leading to significant N losses whereas P losses were comparatively less.

Key words: Deficiency, dynamics, physiological, solution, temporal, toxicity

Integrated Nutrient Management in Groundnut (*Arachis hypogaea* L.) in NEH region

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Groundnut is an important oilseed crop grown all over India. It is cultivated for its kernel which is rich in oil (45-50%) and protein (20-25%) along with thiamine, riboflavin, nicotinic acid and vitamin-E. The NEH region is a non-traditional area for groundnut production but the crop has been gaining popularity among farmers due to its multiple benefits as food, feed, oil, cover crop and restoring soil fertility. However, the yield of groundnut in farmers' field is low due to lack of improved technology available with them and improper nutrient management.

According to study, crop yielding 1.9 t ha^{-1} removed 170 kg N, 30 kg P_2O_5, 100 kg K_2O, 39 kg Ca, 15 kg S, 20 kg Mg besides other micronutrients. No single source is capable of supplying plant nutrients in adequate amount and balanced proportion. Therefore, for sustaining soil fertility, and to supply plant nutrients in balanced proportion for optimum growth, yield and quality of crop in an integrated manner in a specific agro-ecological situation is to practice integrated nutrient supply through combined use of biological and organic sources of plant nutrients. Plant nutrient sources like organic manure, fertilizers, bio-fertilizers, weed biomass, etc. can be applied to the soil in such a way that nutrient removed by the crop are less than that compensated and there is gradual increase in soil reserve. The beneficial effect of application of *Rhizobium* and phosphate solubilising bacteria in groundnut in terms of yield, nutritional quality and net returns and was also reported previously by many researchers. Similarly, the effect of combined application of organic and inorganic sources of nutrients on enhanced growth and yield of groundnut as well as improvement of soil quality was also reported by many researchers.

Key words: Integrated Nutrient Management, Groundnut, NEH region

Attribution of Organic Carbon Fractions and Soil Aggregating Elements in Soil Aggregation under Different Land Uses in Acid Soils of Meghalaya, India

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The land use is an important factor affecting soil organic carbon (SOC) accumulation and storage in soils. The study was conducted at two different areas, Bhoirymbong and Umsning of Ri-Bhoi District, Meghalaya in eight (8) different land use systems *viz. Jhum*, Upland Rice, Terrace Rice, Rice mono-culture, Rice-Potato, Pineapple, Mixed forest and Broom grass. The soil organic carbon (SOC), particulate organic carbon (POC), soil microbial biomass carbon (SMBC) and hot water extractable carbon (HWEC) were measured in soil of different land uses. Aggregates were fractionated using a wet-sieving procedure to obtain the distribution of water-stable aggregates. Mean Weight Diameter (MWD) is found highest in Upland Rice (2 mm) and Terrace Rice (1.72 mm) at 0-10 cm and 10-20 cm depth, respectively in the study areas. Furthermore, higher MWD in surface soil was obtained from Upland rice which indicated that as the Upland rice cultivation is traditionally a mono-culture activity without much soil manipulation the aggregation might not have broken in the cultivation process. Carbon fractions influence the aggregate formation and its different size fractions. SMBC, SOC, POC and HWEC show significant ($p \leq 0.05$) and strong positive correlation with MWD at both depths of the study sites. At 0-10 cm depth, highest positive correlation with MWD was shown in SMBC (Bhoirymbong) and SOC (Umsning). And, at 10-20 cm depth, highest positive correlation with MWD was shown in SMBC in the study areas. So, from the findings of this study clearly shown that the proper selection of land use according to the state of soil aggregating elements for better soil sustainability.

Key words: Soil aggregation; Microbial Biomass Carbon; Soil Organic Carbon; Particulate Organic Carbon; Hot Water Extractable Carbon

Impact of Deforestation on Soil Fertility and Quality

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Deforestation means the conversion of forest to other land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold. It includes areas of forest converted to agriculture, pasture, water reservoirs and urban areas. The causes of deforestation are hurricanes, natural fires, pests, agricultural expansion, cattle ranching, logging, un-priced forest goods and services, concentration of land ownership, weak or non-existent ownership, population growth and density and economic growth. The soils under natural forest showed higher sand and lower clay and silt fraction's than that of soils under cultivation. A pattern of increased bulk density and decreased porosity values was observed for the samples of cultivated sites compared to those of the adjoining forest soils. The rainfall runoff experiments indicate that runoff content of the natural forest soils was higher than the garden and cultivated land soils. pH values was high under cultivation than the forest soils. The cultivated soil manifested a considerable increase in the values of C: N ratio with the adjoining forest soils. The conversion of forest land to the cropland induced a drop in the amount of CEC. Soil organic C, POC, and MOAC losses under longer periods of cropping are probably due to decreases in the above ground net primary production (ANNP), increases in the mineralization rate due to higher temperature and aeration. The microbial community *i.e.,* the fungal and bacterial population was also significantly lower in both surfaces (0-10 cm and 10-20 cm) of hill positions in the deforested land compared to natural forest. Microbial/biochemical indicators showed perceptible deterioration in the topsoil due to deforestation. In general, deforestation provides some advantages to human but it deteriorates soil fertility and quality significantly. So we need to stop deforestation and search for new way for our mankind.

Key words: Deforestation, soil physical, chemical and biological properties

Direct and Residual Effect of Organic Source of Nitrogen on Rice based Cropping System

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Rice is one of the most important staple food crops in the developing countries including India as well as in many different parts of the world. After the green revolution country has faced several problems with the sustainable agriculture, national food security, decline in production and productivity growth rates, deterioration of soil fertility, increased production costs which lead to non-viable enterprise. With the current awareness of food safety sustainable and eco-friendly agriculture, organic farming became significant to minimize those problems. In an experiment conducted during winter season, it was found that the cumulative effect of farmyard manure (FYM) and green manuring (GM) were more effective than the direct and residual effects. GM was found to be significantly superior to FYM which increased the productivity, nutrient uptake, grain quality in rice-wheat cropping system. However, highest productivity, grain quality and nutrient uptake were observed when N was supplied through GM + FYM + Biofertilizers. It was also observed that the effect of organic nitrogen (N) along with bio-fertilizers gave the highest rice grain equivalent yield, benefit cost ratio, etc. Supplying nitrogen through Biological Nitrogen Fixers (BNF) was one of the major emphases internationally for sustainable environmental development as it can be used as the potential source of N in agriculture. The combined application of NPK along with organic manures (GM or FYM) also significantly increased the paddy and straw yield of rice. Integrated fertilization showed significant residual effects on grain and straw yield of wheat. The application of organic manures NPK + FYM showed both direct and the residual effects on rice and wheat yields.

Key words: Eco-friendly agriculture, organic farming, FYM, green manure, bio-fertilizers, rice-wheat cropping systems, biological nitrogen fixers, integrated fertilization

Effect of Integrated Nitrogen Management on Fertility Status of Soil in Acid Inceptisol

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Nitrogen (N) is the key nutrient element and plays an important role in increasing crop production. It is one of the most limiting nutrient for crop production because N is very mobile and susceptible to losses through runoff, ammonia volatilization, leaching, de-nitrification and fixation by clay minerals. The substantial improvement of soil N was laid to addition of fertilizers alone or combination with organic manure for sustainable agriculture, therefore a field experiment was carried out during rabi season 2017-18 at research farm, College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya (India) with the treatments such as T_0- Control, T_1- 100% N through urea, T_2- 100% N through FYM, T_3- 50% N through urea + 50% N through FYM, T_4- 75% N through urea + 25% N through FYM, in randomized block design (RBD) design with four replications using a test crop *Brassica campestris* L. (variety M 27). The results revealed that application of organic manure alone i.e. T_2 or in combination with inorganic fertilizers i.e. T_3 and T_4 improved the physico-chemical properties of post harvest soils compared to application of inorganic fertilizers alone. The soil pH, electrical conductivity (EC), bulk density (BD) were not significantly affected with the treatments. However, maximum increased in the soil pH, reduction in BD and EC of post harvest soil were observed with the application of treatment T_2. The highest soil organic carbon (SOC), available N, available P_2O_5, and available K_2O content in post-harvest soil was observed with the application of treatment T_2 (100% N through FYM) which was at par with T_1, T_3 and T_4 and the lowest SOC, available N, P_2O_5, K_2O were found in treatment T_0 (control).

Key words: Nitrogen losses, FYM, urea, *Brassica*

Multi-nutrient Mixtures Sampoorna KAU Multi Mix Developed for Foliar Application in Rice, Banana and Vegetables

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Management of agricultural systems should revolve around the soil to feed the plant Soil test based nutrient management plan was developed for different agro ecological zones of Kerala as a part of a network project implemented jointly by various organizations and institutions in Kerala analyzing 2 lakh soil samples. Wide spread deficiency of boron, potassium and magnesium were evidenced in the composite samples collected from the fields of farmers all over the state. The over dominance of iron in Kerala soils result in the physiological deficiency of other cations. Moreover, the acid, leaching environment is not conducive for the retention of majority of the nutrients. Besides, multi-nutrient deficiencies are occurring very commonly in almost all the crops in recent years. The objective of the study was to develop multi-nutrient mixtures for foliar application in different crops and to evaluate their suitability for correcting the nutrient deficiencies and improving yield. Multi-nutrient mixtures were developed at RARS Pattambi using nutrient carriers for foliar application in rice, banana and vegetable crops. Initially, compatible chemicals were identified by considering the mixing compatibility, solubility and storage properties. The nutrient uptake by the crops, status of available nutrients in Kerala soils and the optimum, sufficiency and toxic ranges of the nutrients in the particular crop were considered while fixing the proportion of the compatible chemicals in the mixture. The dosage is fixed based on the requirement and uptake of the nutrients by the crops and pot culture and field experiments were conducted to evaluate the performance. The multi-nutrient mixtures contain potassium, magnesium, sulphur, zinc, copper, boron and molybdenum. The experimental results indicate that foliar application of the mixtures could improve crop productivity. Toxicity testing trials were also conducted to ascertain the safety of usage of these mixtures. Based on this, the mixtures for foliar application were released into market under the name Sampoorna KAU Multimix. The multii-nutrient mixtures are beneficial for foliar application for correcting micronutrient deficiency. As foliar application decreases the nutrient load in to the environment, multi nutrient mixtures offer a sustainable option for management of nutrient deficiencies. These nutrient mixtures were being popularized by different stations and krishi vigyan kendras of Kerala Agricultural University. The technologies has been transferred to various agencies on payment of fee set for transfer of Tchnology by the University.

Key words: Multi-nutrient mixture, foliar application, vegetable crops, micronutrients

Ferti-fortification for Enrichment of Wheat and Rice Grains with Zinc and Iron

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The enrichment of rice and wheat grains through ferti-fortification (foliar application) of Zn and Fe during reproductive growth stages is high priority area of research and it will contribute to minimizing Zn and Fe deficiencies related health problems in common population. The enrichment of staple foods produced from rice and wheat with Zn and Fe which could solve Zn and Fe deficiencies, are the two of the most serious nutritional problems which affect plants, animals and human beings. Tackling the problem of Zn and Fe malnutrition to human health is the serious challenge for the scientists in the new millennium. A field experiments were conducted at Farm research area of Department of Soil Science, Punjab Agricultural University, Ludhiana, for three consecutive years on rice–wheat system for ferti-fortification of rice and wheat with Zn and Fe. For this different wheat (durum and aestivum) and rice cultivars were used to investigate the extent of ferti-fortification. In wheat, it was observed that irrespective of durum or aestivum varieties, the results of the study indicated that 17.3-38.8 % enrichment with Zn and 13.1-30.3 % of Fe was possible through foliar application of inorganic sources of Zn ($ZnSO_4.7H_2O$) and Fe ($FeSO_4.6H_2O$) respectively. The data further showed that foliar application each of Zn (0.5 %) and Fe (1.0 %) at different stages of wheat growth significantly increased the grain yield and concentration of Zn and Fe in grains. Foliar application of Zn and Fe separately at different stages of wheat growth significantly increased the grain yield of wheat and the maximum grain yield of 63.1 q ha^{-1}(PBW 550)and 62.5 q ha^{-1}(PBW 343) were reported with Zn which were 8.2 and 4.3 per cent higher than control, respectively. Four foliar applications of 0.5% of Zn and 1.0 % of Fe separately at different stages of wheat growth significantly increased the grain yield of wheat. On the other hand, four foliar application of Fe increased the grain yield up to 61.4 q ha^{-1}(PBW 343) and 60.6 q ha^{-1}(PBW 550)which were 2.5 and 2.2 per cent higher than control, respectively.

Ferti-fortification of paddy with Zn (0.5 %) and Fe (1.0 %) resulted in 7.0 and 8.6 per cent increase in paddy yield respectively, over control. Foliar application of 1.0 % Fe significantly increased the yield of paddy cultivars varying from 6.9-10.3 per cent. Irrespective of cultivars, the results of the present study indicated that 30.8-44.8 per cent increase in Zn concentration and 22.3-38.2 per cent of Fe concentration is achievable through foliar application of inorganic sources of Zn ($ZnSO_4.7H_2O$) and Fe ($FeSO_4.6H_2O$), respectively. Brown rice can accumulate higher Zn (47 mg kg^{-1}) than its husk (29 mg kg^{-1}) whereas, paddy husk can translocate higher Fe (378 mg kg^{-1}) than brown rice (24 mg kg^{-1}). Our results reported that the paddy husk could retain 16 times more Fe than its brown rice (without husk) whereas, brown rice had 1.6 times more Zn than its husk part. Similarly five paddy cultivars showed differential response to yield and concentration of Zn and Fe with their foliar sprays.

Key words: Biofortification, Zn, Fe, wheat, rice grains

Potassium Dynamics of Soil under NaCl-induced Salinity over Long Term Saline Water Irrigation

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Potassium uptake by plants can be affected by high salinity as well as sodicity. Higher NaCl induced potassium deficiency in rice plant. Exclusion of Na from the plant through K fertilisation is not possible under extremely high salinity conditions. Thus an incubation experiment was carried out for 30 days with periodical analysis of 0, 5, 10, 20 and 30 days. The incubation experiment had forty eight treatments involving four salt treatments viz. NaCl added to achieve nascent salinity of 40 mmol L^{-1} (C1), 80 mmolL^{-1} (C2) and third treatment (C3) consisting of sample collected from field under long term saline water irrigation, control (unamended) (C4). The crop residue treatments were control (unamended) (T1), rice straw @ 6 t ha^{-1} to wheat (T2) and rice straw and wheat straw @ 6 t ha^{-1} each (T3) and four fertilizer levels were control (K1), potassium applied @ 40 mg K kg^{-1} of soil (K2), potassium applied @ 80 mg K kg^{-1} of soil (K3) and potassium applied @ 120 mg K kg^{-1} of soil (K4). Average water soluble and exchangeable K content however decreased gradually with increase in incubation period across all treatments. Water soluble as well as exchangeable K significantly increased with addition of K fertilizer in all days of incubation showing low fixation of K but reverse trend was noted after 30 days of incubation. The integration of crop residue with inorganic fertilizers increased the water soluble K more than the inorganic fertilization alone. Among all the treatment combinations, the highest water soluble K content was observed in C2T3K4 treatment. Available K (water soluble plus exchangeable) was more in the induced salinity of 80 mmol l^{-1} (C2) compared with 40 mmol l^{-1} NaCl. Incorporation of rice straw in the field contributed to more soluble K. However decrease in exchangeable K in all treatments over time was evident that exchangeable K gets converted gradually to non exchangeable K. A declining trend in soil non exchangeable K (NEK) was observed under nascent salinity induced by NaCl addition. Irrespective of any treatment NEK value increased with time of incubation. The mean value of NEK followed the order of C4> C3> C1> C2. Differences in total K content of soil due to irrigation water quality and crop residue treatments with increasing K fertilizer levels were observed to be non significant.

Key words: Potassium deficiency, rice, salinity, non-exchangeable K

Effect of LCC Based Nitrogen Management in Maize + Ground nut Intercropping and Its Residual Effect on Black gram

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As the times passes, the art of agriculture has been changed from hunting & gathering to use of fertilizers & chemicals in field for self sufficiency & trading of food grain. Now we are in such a state where soil health holds same importance as sufficient food production for the entire population. Now it's a high time to take a step closer towards the lesser use of chemicals and more use of residual soil nutrients and organic nutrients with the help of changing the traditional cropping pattern. LCC (Leaf colour chart) is a simple tool which helps us to determine the time of Nitrogenous fertilizer application by indicating different shades of green colour of leaf which is directly related to the Nitrogen level in soil. Intercropping is an agronomic practice by which we can grow more than one crop at the same field in a same time without decreasing the normal yield. It can also be use to intake nutrients from different soil depth by merging two crops of different root length. By taking one or two pulse crops in a cropping system, we can enhance the soil health and sustainability. An experiment was conducted during 2017-18-19 at Kamakhyanagar to study the combine effect of the above principles (LCC, Intercropping and inclusion of pulse crop) on soil health and farm income. In that experiment maize and ground nut were taken as sole crops and as intercrops in 2:2 row ratio (in *kharif*) and tested N application at full dose (120 kg / Ha), no application i.e control plot (0 kg/ Ha) and at 3 critical point of leaf colour shade i.e 3,4 & 5. It showed drastic yield advantage in case of intercropping. Intercropping also showed a positive effect on soil health. More over use of LCC has shown its desired effect by lowering the total dose of N application. As a succeeding crop black gram has been taken in *Rabi* season which also gave decent yield at 50% of fertilizer dose application.

Key words: Intercropping, LCC, sustainability, N use efficiency, soil health, cropping system

Impact of Bio Inputs on Yield, Soil Nutrient Status and Quality of Khasi Mandarin (*Citrus reticulata*, Blanco)

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An experiment was carried out in twelve years old Khasi mandarin (*Citrus reticulata* Blanco.) orchard at the farm of Citrus Research Station, Tinsukia of Assam during 2013-2018 to study the effect of bio-inputs on yield, quality and nutrient content of Khasi mandarin. The experiment was laid out with 5 m Ì 5 m spacing along with 4 replications and 5 treatments as T1: Control; T2:100% Vermicompost (on N equivalent basis of RDF); T3:75% Vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/L as spray); T4: 75% Vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/L as spray) + *Pseudomonus fluorescence*(30-40 ml/plant); T5: 50% Vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/L as spray) + *Pseudomonus fluorescence* + *Azotobacter chroococcum* (30-40 ml/plant). The experiment was designed with Randomized Block Design (RBD). The result revealed that application of 75% Vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/L as spray) + *Pseudomonus fluorescence* (30-40 ml/plant) were found effective in improving the yield, soil nutrient status and quality of Khasi mandarin with B: C ratio (3.75). Among the five different treatments tested, the treatment (T_4) having 75% Vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/L as spray) + *Pseudomonus fluorescence* (30-40 ml/plant) was found to be effective for improved vegetative growth as compared to other treatments. Results revealed that maximum plant height (4.69 m), stem girth (39 cm) and canopy volume (32 m^3) were observed in treatment T_4. Regarding, fruit qualities, higher juice content (48.6%), TSS (11.2^0Brix) and maximum number of fruits per tree (510) were observed in above mentioned treatment (T4). Maximum soil nutrient status (402 kg/ha Av. N, 21.9 kg/ha Av.P2O5, 217.6 kg/ha Av.K2O) and higher organic carbon content (1.38%) were recorded under the same treatment. Significantly higher soil fertility status, maximum microbial population and superior N, P, K content on leaf were observed under this treatment.

Key words: Khasi mandarin, bio-inputs, organic, yield, quality, nutrient status

Experimental Study on the Pathways of Phosphorus Loss on the Weathered Granite Sloping Land of Southeast China

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Understanding the hydrological dynamics and transport pathways of phosphorus (P) loss is essential for predicting and mitigating eutrophication and improving the aquatic environment. The method of indoor artificial rainfall simulation was applied to study the effects of different slope gradients (8°, 15°) and rainfall intensities (1.0, 1.5, 2.0, 2.5 mm/min) on the pathways of P loss on the weathered granite hillslopes of Southeast China. The results showed that the surface flow and sediment yield processes showed an increasing trend with the increasing rainfall intensity and slope gradient. The runoff rate increased over time with the prolongation of rainfall while the sediment yield increased firstly and then decreased. The subsurface flow yield showed a changing trend of single-peak curve with maximum values appearing under the rainfall intensity of 1.5 mm/min and there was no obvious changing regularity under different slopes. The P lost from the hillslopes was mainly in the form of being carried by sediment, and the proportion accounted for 54.23%-95.62%, and the amount of P loss increased with the increase of rainfall intensity and slope gradient. The mass concentrations of TP, DP and PP in runoff decreased with the prolongation of rainfall. The loss of P mainly consisted of DP, most of which reached more than 50%. Surface flow was the dominant pathway of P loss via runoff and it presented a positive correlation with rainfall intensity. It was necessary to attach great importance to the mass concentrations of P lost via subsurface flow, though the total loss amount was negligible comparing to that via surface flow and sediment. These results could provide underlying insights into the P loss characteristics in the erosive weathered granite areas.

Key words: Phosphorus loss; slope gradient; rainfall intensity; artificial simulated rainfall; weathered granite soil

Impact of Drying-wetting Cycles on the Soil Aggregate Stability of Alfisols in South Western China

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Drying-wetting cycles are important environmental factors controlling potential changes in aggregate stability.However, the relationships between soil aggregate stability and drying-wetting cycles under different breakdown mechanisms are not clear. We conducted a simulation study toinvestigate the effects of drying-wetting cycles on aggregate stability under the three main breakdown mechanisms (slaking, microcracking and mechanical breakdown) without soil organic matter inputs. Four initial aggregate size classes (i.e.,1–2, 2–3, 3–5, and 5–7 mm) within a clay-loam soil, which undergoes intense drying-wetting cycles, were selected and subjected to eight levels of drying-wetting cycle (i.e., 0, 1, 2, 3, 5, 7, 10, and 15 cycles). Aggregate stability was measuredwiththree treatment methodsinvolvingfast wetting (FW), slow wetting (SW), and shaking after pre-wetting treatments (ST). Our study showed higher resistance to mechanical breakdown and lower resistance to slaking. Compared with the mean weight diameter (MWD), the normalized mean weight diameter (NMWD) was a better indicator of comparing the susceptibility of different initial size aggregates to breaking up into smaller aggregates. The values of NMWD for1–2, 2–3, 3–5, and 5–7 mm aggregates were 0.1, 0.1, 0.09 and 0.09, respectively,for FW; 0.35, 0.34, 0.33 and 0.32, respectively,for SW; and 0.46, 0.45, 0.44 and 0.42, respectively,for ST.This indicated that as initial aggregate size increased, aggregates were more prone to breaking down. The effects of drying-wetting cycles on aggregate stability varied greatly among different aggregate breakdown mechanisms. For 1–2, 2–3, 3–5, and 5–7 mm size aggregates, drying-wetting cycles decreased MWD by 61, 67,70, and 53%, respectively, for SW and 69, 72, 80 and 78%, respectively,for ST. For FW, MWD increased by 5, 7, 8 and 36% after the first two cycles, respectively, while it decreased by 36, 36, 44 and 15% after 15 cycles.The results showed that different aggregate breakdown mechanisms influence the effects of drying-wetting cycles on aggregate stability. This study provides an important basis for better soil management practices, and yieldsinsights for an improved understanding of the role of drying-wetting cycles on aggregate stability.

Key words: Drying and wetting cycles, Aggregate stability, Aggregate breakdown mechanisms, Le Bissonnais method, Initial aggregate size

Impact of Integrated Nutrient Management with Mycorrhizal Bio-Fertilizer on Physical and Bio-Chemical Properties of Soil in Planted and Ratoon Crop of Sugarcane

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A field experiment was conducted at Agronomy research farm of Narendra Dev University of Agriculture & Technology, Kumarganj Faizabad (U.P.). The experiment was conducted in randomized block design with three replications and twelve treatments. The treatments consisted of three rates of MBF mycorrhizal Bio-fertilizer@ 10, 15 and 20 kg/ha at the time of planting and same amount MBF after three months of planting in combination with three levels of RDF (100, 75 and 50% RDF). These treatments were evaluated in three replications with Sugarcane (*var*. COS- 88230) during 2013-15 on plant–ratoon in sequence to study the impact of integrated nutrient management on soil fertility sugarcane. Microbial population (bacteria, fungi and actinomycetes) and higher availability of nutrients were recorded with treatment T_3 MBF @ 20 kg/ha at the time planting and three months after planting) + 100% RDF which was showed impressive improvement in microbial population and availability of nutrients ahead sustainable manner with nature through use of MBF-MBF in combination with inorganic fertilizers.

Key words: Plant-Ratoon Sugarcane, Integrated nutrient management, Soil fertility

Status of DTPA-extractable Micronutrient in Soils of Rajouri District of Jammu Region

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A study was undertaken to assess the status of DTPA-extractable micronutrients in soils of Rajouri district of Jammu region. The district is having agro-climatic zones varying from high altitude temperate to sub-tropical type. The zones have different land use pattern. Total 250 representative surface soil samples (0-15 cm depth) were collected randomly from areas with different land use patterns from whole of the district using global positioning system (GPS). The process of digitization and generation of maps was carried out with ArcGIS 10.3. Five land use systems, namely forest, pasture, wasteland, horticulture and agriculture were considered for the study. The collected soil samples were analyzed for available micronutrients (Zn, Fe, Cu, Mn and B) and chemical properties viz., electrical conductivity (EC), soil reaction (pH) and organic carbon. The results revealed that soils of Rajouri district are mildly acidic to moderately alkaline in reaction with low soluble salt content. Organic carbon was observed high in major portion of the district whereas few areas of Sunderbani tehsil had low organic carbon content. Also organic carbon was observed highest under forest soils as compared to other land use systems. The results revealed that available boron content varied from low to medium in the district whereas DTPA extractable Zn content was medium to high in major part of the district but it was observed low in some parts of Nowshera, Kalakote and Rajouri tehsils. DTPA extractable Fe content varied from low to high in the district and it was found to be highest in agriculture land use system. DTPA extractable Cu and Mn varied from traces to high in different land use systems of the district. The mean values of extractable micronutrients (mg kg^{-1}) i.e. boron, zinc, copper, iron and manganese were 2.32, 0.68, 0.08, 10.28 and 10.48 under forest soils, 3.06, 1.29, 1.46, 14.82 and 4.14 under horticulture soils, 1.81, 1.05, 0.82, 21.84 and 19.12 under agriculture soils, 1.84, 0.97, 0.71, 23.86 and 15.03 under pasture lands and 1.87, 0.81, 0.25, 12.81, and 16.61 under wasteland soils, respectively. Thus the study revealed that the available micronutrients were higher under agriculture, horticulture and forest land use systems. Wastelands had lowest content of micronutrients as compared to other land use systems.

Key words: Micronutrients, Global positioning system (GPS), land use systems

Response of Integrated Nutrient Management on Soil Health under Ginger-cauliflower Cropping Sequence in North-Western Himalayas

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An experiment was conducted to investigate the response of soil health and ginger-cauliflower cropping sequence to integrated nutrient management in North-Western Himalayas during 2015-16, 2016-17 and 2018-19 at Solan, HP. Ginger-cauliflower sequence is the one largely followed by the farmers of sub-tropical to sub-temperate regions of Himachal Pradesh. However, the irregular, excessive and imbalanced application of fertilizers deteriorates the soil health and also the quality of the produce. In order to curb the ill effects of imbalanced fertilization and combine mulching with INM to optimize soil hydro-thermal regimes, the present investigation was undertaken with 'Himgiri' variety of ginger and cauliflower var. 'PSB K–1' with 14 treatment combinations along with grass and pine mulches, replicated thrice in Randomized Block Design. Grass mulch recorded higher moisture contents by an average of 2.35 to 2.87 per cent over pine mulch and 6.99 to 7.29 per cent over unmulched control. In both the crops, grass mulch raised minimum soil temperature by 0.6 to 0.9 ! over pine mulch and 1.6 to 1.8 ! over unmulched control, respectively. In ginger, pine mulch lowered maximum soil temperature by 0.9 and 3.6 !over grass mulch and unmulched control, respectively; while it was lowered by 1.6 and 3.4! by grass mulch over pine mulch and unmulched control, respectively, in cauliflower. Application of 100% NPK thorough FYM + no mulch, recorded lowest ñ$_b$ (1.24 and 1.22 g cm^{-3}), highest SOC (19.1 and 19.4 g kg^{-1}), ƒ (50.0 and 50.8%), MBC (322.0 and 325.4 µg g^{-1} soil) and microbial activities in ginger and cauliflower, respectively. Available N (449.8 and 479.0 kg ha^{-1}), P (218.0 and 236.0 kg ha^{-1}) and K (517.2 and 553.0 kg ha^{-1}) contents in ginger and cauliflower, respectively, were found to be significantly highest under 100% RDF and recommended dose of FYM + grass mulch. Integration of organic and inorganic sources significantly affected all micronutrient cations (Mn, Cu and Zn) contents except Fe. Integration of nutrient sources also significantly improved soil aggregation and moisture retention by increasing the percentage of macro aggregates and porosity. Application of 75% RDF + 25% N on equivalent basis through VC, recorded superior growth, yield and quality characteristics in both the crops. It also significantly increased NUE, AE, nutrient harvest indices, crop harvest index and net returns in both the crops. Organic mulching along with INM also strengthened the C-sequestration potential of the soil. Hence, it can be concluded that dose of 75% RDF + 25% recommended N through FYM and VC along with organic mulching could be recommended to the farmers as a cost effective nutrient module for getting higher yields of superior quality under ginger-cauliflower cropping sequence on sustainable basis and for improving soil health on a long term basis.

Key words: Integrated nutrient management, Ginger, Cauliflower, Mulching

Soil Nutrient Index of Mango Orchards for Better Food Security and Resource Utilization

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Harnessing the benefits of resource utilization for sustainable food production is the only key issue for coming days. Continuous nutrient depletion in mango orchards over the periods of fruit production is now very alarming. Impact of present day climatic aberrations on the soil physico-chemical and biological reactions becomes challenging issue to the scientists/policy makers and finally growers. Sound knowledge on role of nutrients limiting the productivity is important issue to deal in the present day situations. Two hundred soil samples were collected from growers mango orchards consisting 10 villages (Gulabkhera, Dugauli, Mujasa, Habibpur, Mehmoodnagar, Mandauli, Sanyasibag, Sahilamau, Naibasti, Allupur) surrounding to the ICAR-CISH, Rehmankhera, Lucknow premises during 2017 and 2018. Generally majority of mango orchards were producing lower yields (<10.0 t ha^{-1}) compared to other foreign mango producing countries. These samples were subjected to laboratory analysis. Soil nutrient analysis showed deficiency resulting into lower yields as compared to other mango producing countries. Thus, soil nutrient index for each nutrient was developed and fertility ratings were assigned. Soil available Zn and K were recorded as low category whereas P and Mn in medium category. These nutrients were obviously being required for better yield and fruit quality. SNI values for Zn, K, P and Mn was 1.41, 1.18, 1.85 and 1.99 respectively. Very large variation of micronutrients contents Zn (0.26 to 1.22), Cu (0.46 to 3.34), Mn (3.62 to 19.82) and Fe (4.46 to 19.36 mg kg^{-1}) was recorded. Similarly, soil reaction varied between 6.11 to 8.47 along with P (1.72 to 35.7) and K of (60.45 to 213.10 mg kg^{-1}) across these orchards. Low soil fertility is responsible for lower productivity suggesting into adoption of hi-tech horticultural intervention for better input use efficiency. Soil nutrient index based on nutrients application through drip and fertigation is being advocated to the mango growers in the respective villages.

Key words: Soil nutrient index, Fertility ratings, Mango orchards, Food and livelihood security

Role of Micronutrients in Fruit Crops

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Micronutrients are special lubricants which required for variety of energy transfer mechanism within the plants. The seven micronutrients, including boron, copper, chlorine, iron, manganese, molybdenum and zinc are no less important to plant growth that are the macronutrients. To have better growth, yield and quality in plants, micronutrients are essential. They are usually found in association with larger molecules such as cyto-chromes, chlorophyll and proteins (enzymes). About 40-55% of Indian soils are moderately deficient in Zinc and 25-30% deficient in Boron. Deficiency of other micronutrients occurs under 15% of soils. Micronutrients happen to improve quality, size, colour, taste and earliness of fruits. They enhancing the market appeal of fruits, improve input use efficiency of NPK fertilizers and water, provide disease resistance, thereby reducing dependence on plant protection chemicals. They increase the post-harvest life of fruits by avoiding physiological disorders and increase marketable yield.

Fruits like citrus, banana, mango, guava, papaya etc. are highly susceptible to various disorders caused by deficiency of micronutrients. Most of the micronutrients participate in the functioning of number of enzyme system. There is considerable variation in the specific functions of the various micronutrients in plant and microbial growth processes. For example, copper, iron and molybdenum are capable of acting as electron carriers in the enzyme systems that bring about oxidation-reduction reactions in plants. Such reactions are essential steps in photosynthesis and many other metabolic processes. Zn and Mn function in many plant enzyme systems as bridges to connect the enzyme with the substrate upon which it is meant to act. Hence judicial application of micronutrients especially zinc, copper and boron may prove to be an effective tool for sustainable fruit production. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth in fruit crops.

Key words: Micronutrients, enzymes, integrated nutrient supply

Assessment of Soil Quality Indicators under Rice Ecosystem of Assam using Statistical Approaches

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Rice (*Oryza sativa* L.) is the major food crop grown in Assam and major part of rice growing area is under mono crop. Existing (*in field*) soil management practices influences the changes in soil quality parameters, and can be directed towards the current status of low productivity of rice soils in Assam. Soil quality indices (SQI) under rice ecosystem of AESR 15.4 located in Assam, were assessed using different statistical approaches like principal component analysis (PCA) and expert opinion (EO). The soil parameters were selected according to the soil functions of interest and defined management goals for rice ecosystem, and. Soil samples (73 nos.) were collected from humid and sub humid alluvial flood free and flood prone areas under rice cultivation. Assessment was carried out integrating 21 soil physical, chemical and biological attributes (soil enzymes, microbial biomass carbon and microbial population) which were considered as minimum dataset while computation of SQI. Rice yield data were recorded from selected farmers of the study area. 65% of rice cultivation sites corresponded to very low amount of usage of nitrogenous fertilizers (<20 kg N ha^{-1}) and organic inputs (< 3.0t ha^{-1}), and the average rice yield obtained was 4.26t ha^{-1}. Despite using low amount of chemical fertilizers, the recorded average yield might be due to higher levels of organic carbon (>0.75%) in 67.12% of the soils with medium levels of available N in 79.45% of the study sites.The PCA-SQI value ranged between 0.76 and 0.43 with a mean of 0.58 (±0.069) for the soils. Fluorescein di-acetate (FDA) activity, a soil enzyme, contributed the highest (25.86%) towards mean value of SQI (0.58), out of the seven key indicators selected using PCA. Under EO-SQI, soil functions like nutrient cycling and water availability accounted for 73.02% towards the mean (0.63±0.06) value, and showed a high degree of relationship (r=0.700**) with PCA-SQI. The EO methodology involved consensus from the experts' recommendations in literature and from common management concerns of the AESR 15.4 rice soils. The SQI and rice yield obtained, illustrated that EO-SQI explained a high degree of relationship followed by PCA-SQI. Study indicated that 80% or more of existing rice yield (5.20t ha^{-1}) could be sustained with optimum values of 0.55 and 0.61 computed for PCA-SQI and EO-SQI respectively, in AESR 15.4.

Key words: Soil quality, minimum dataset (MDS), expert opinion (EO)

Cyanobacteria as Priming Options to Improve Soil Quality and Enhance Seedling Vigor of Elite Maize Inbreds

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Cyanobacteria are unique microbial inoculants, which can improve crop and soil productivity, through their plant growth promoting and nutrient-enriching abilities. Being pioneers in diverse habitats, their growth in soil leads to enhanced quality, through accretion of photosynthetic biomass, redox changes and improved soil structure and fertility. With a focus to understand the priming effect of cyanobacterial inoculation (consortium BF 1-4 and as biofilm An-Tr) on nutrient dynamics, soil microbial communities and growth of two elite maize inbreds (V6: HKI323PV, V7: HKI161PV), mesocosm studies were undertaken. Significant beneficial effects were recorded when An-Tr biofilm was used, as compared to uninoculated or cyanobacterial *Anabaena-Nostoc* consortium BF 1-4 at both stages (7 and 21 DAS, days after sowing). A significant increase of more than 20% in seedling attributes along with 5-15% increment in seed enzyme activities was recorded. Microbial biomass carbon (MBC) was enhanced as result of inoculation, with an almost 1.2 fold increase over uninoculated treatment and 3-4 fold enhancement at 21st day, over 7th day. More than three to five fold higher values in nitrogen fixation and C-N mobilizing enzyme activities with highest values of soil biological parameters and plant growth attributes were observed with V7-An-Tr biofilm inoculation. Community profiles of soil samples generated using phospholipid fatty acid analysis (PLFA), revealed significant changes due to inoculation, particularly, in lowering the abundance of AM fungi and actinomycetes at both observation stages (7 and 21 DAS). Significantly strong positive correlation of amounts of total PLFA with soil nitrogen fixation, (0.85, $p< 0.05$), soil chlorophyll (0.86, $p< 0.05$) and microbial biomass carbon (0.9, $p<0.05$) was observed. This investigation highlighted the promise of cyanobacteria as valuable priming options to enhance plant growth and vigor, besides favourably modulating the abundance of various soil microbial communities and improving soil quality by C-N enrichment.

Key words: Cyanobacteria, nutrient dynamics, biofilm, PLFA, soil microbial communities

Effect of Inorganic and Organic Nitrogenous Fertilizers on Soil Nutrient Status, Plant Growth and Yield of Apricot (*Prunus armeniaca* L.)

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The present experiment was undertaken to study the effect of inorganic and organic nitrogen fertilizer applications on soil nutrient status, plant growth and yield of apricot at research farm of the Department of Soil Science and Water Management, Nauni Solan during 2015 and 2016. The experiment constituted of 11 treatments replicated thrice in a randomised block design. The highest organic carbon (1.34, 1.21%) was recorded with treatment T_{11} consisting of 100% urea enriched compost + 0% Ca $(NO_3)_2$ at 0-15 and 15-30 cm depths. There were significant variations in the available N, P and K status of soil after crop harvest among different treatments. Maximum available N and P contents were recorded under treatment T_7 (urea 100% + lime 708 g/tree) while maximum K was in T_1 which indicated that available N, P and K increased by 16.95% and 16.58%; 34.83% and 32.36%; 19.98% and 12.76% over the values recorded before execution of experiment, respectively at 0-15 and 15-30 cm depths. Significantly highest available Ca (4.46 and 4.11[cmol (p^+) kg^{-1}]) was recorded under T_1, Mg (2.11 and 1.95 [cmol (p^+) kg^{-1}]) under T_6 and available S contents (56.46 kg $ha^{-1}$and 51.67 kg ha^{-1}) under T_9 at surface and subsurface depths, respectively. Available Zn, Cu, Fe and Mn were significantly highest under treatment T_6 (urea100%+ 0%Ca $(NO_3)_2$). Tree height significantly improved by application of various nitrogenous fertilizers. Maximum increase in tree height (0.40 m) was observed under treatment T_7 (urea 100% + lime 708 g/tree). Trunk girth increased appreciably with the application of various sources of N and highest increase in trunk girth (0.50 cm) was recorded under treatment T_7 (urea 100% + lime 708 g/tree). Similarly, maximum fruit yield (30.03 kg/tree) was recorded with application of urea 100% + lime 708 g/tree. From the present investigation, it may be concluded that application of urea urea100%+ lime 708 g/tree helped in obtaining optimum tree height, trunk girth and yield during both the years of experimentation. Further, it also improved available nutrients in soil.

Key words: urea enriched compost, tree height, trunk girth, yield

Relationship between Langmuir Adsorption Parameters and Various Soil Properties of Different Textured Soils of Himachal Pradesh

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Sulphur (S) adsorption was studied in the present investigation entitled "Relationship between Langmuir adsorption parameters and various soil properties of different textured soils of Himachal Pradesh" to assess the S adsorption behaviour of the soils of different textures. Eighty soil samples (0-0.15 m depth) were collected from different districts of Himachal Pradesh varying in soil pH, organic carbon (OC), cation exchange capacity (CEC) and clay content and their S adsorption behaviour was studied. The textural classes ranged from sandy loam to clay. Data on the relationship among various soil properties and Langmuir adsorption parameters revealed that there was non-significant and negative relationship between soil pH and adsorption maxima but positive relationship of soil pH with maximum buffering capacity and bonding energy constant. Bonding energy constant 'k' and maximum buffering capacity 'MBC' had negative and significant relationship with sand, while a negative and non-significant relation was obtained between adsorption maxima and sand. Bonding energy constant and MBC showed a positive and significant relationship with clay except adsorption maxima. All the Langmuir adsorption parameters and had significant and positive relationship with silt. Non-significant and negative relation was exhibited by all the Langmuir adsorption parameters with CEC except for bonding energy. All the adsorption parameters *i.e.* adsorption maxima, bonding energy constant and maximum buffering capacity showed a non-significant and negative relationship with organic carbon.

Key words: Sulphur, Adsorption, Different textured soils

Possible Utilization of Organics and Bio-organics with Nitrogen Fertilization on Growth and Productivity Parameters of Tomato in Relation to Physico-Chemical and Biological Properties of Soil

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A field experiment was conducted at Aligarh Muslim University Research Farm for three consecutive seasons of 2014-2017 to assess the nutritional potential of bio-industrial waste such as neem seed cake and bio-organics like *Azotobacter chroococcum* and *Azospirillum brasilense* singly as well as concomitantly alongwith different recommended dosages of inorganic nitrogen on the growth and productivity parameters of tomato (*Solanum lycopersicum*) in relation to physico-chemical as well as biological properties of soil. Significant improvement was observed in growth as well as productivity parameters such as length of plants, fresh as well as dry weights, percent pollen fertility, number of flowers, green fruit per plant, green fruit yield per plant, ascorbic acid content and chlorophyll content of tomato in different treatments as compare to untreated control plants which seems to be due to the presence of growth promoting substances in organic matter and bio-organics. Concomitant inoculations of neem seed cake and bio-organics alongwith different recommended dosages of inorganic nitrogen significantly influenced the physico-chemical properties in terms of bulk density, electrical conductivity, water holding capacity and organic carbon as well as biological properties of soil. Population of beneficial microbes was found increased in all the treatments with soil amendments in the neem seed cake which seems to be due to conversion of organically form of nitrogen into inorganic form. Agronomic parameters such as plant nitrogen, phosphate and potash and available soil nitrogen, phosphate and potash also found increased in combined inoculations of organic matter as well as bio-organics. This study suggests that application of organics and bio-organics in soil are not only the source of macro- and micronutrients but they also supplement growth promoting substances that sustain organic food production in this country without altering the existing harmony in our natural bio-resources. Such method of organic farming can be used as an economic and eco-friendly alternatives to hazardous agro-chemical fertilizers.

Key words: Neem seed cake, *Azotobacter chroococcum*, *Azospirillum brasilense,* Growth parameters, Tomato

Response of Vermicompost and Levels of Nitrogen on Growth, Yield and Yield Attributes in Pea (*Pisum sativum* L.) Rhizosphere

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The present investigation "Effect of vermicompost and levels of nitrogen on growth, yield and yield attributes in pea (*Pisum sativum* L.) rhizosphere"Pot experiment was conducted in completely randomizeddesign with eight treatments and three replications. Details of treatments are as under T_1 - Control, T_2 -N_{40}:P_{60}:K_{50} (Kg ha^{-1}), T_3 -N_{20}:P_{60}: K_{50} (Kg ha^{-1}), T_4 -Vermicompost @ 5t ha^{-1}, T_5-enriched Vermicompost @5t ha^{-1}, T_6-N_{20}:P_{60}:K_{50} + vermicompost @ 2.5tha^{-1}, T_7-N_{2O}: P_{60} : K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}, and T_8- N_{10}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}. Based on the experimental results, it may said that enriched vermicompost contained higher mineral element content than normal vermicompost. Treatment T_7-(N_{2O}:P_{60}:K_{50}+enriched vermicompost @ 2.5 t ha^{-1}) was found to be superior to all other treatments in increasing growth, nodulation and yield of the pea. Nodule count and pod yield with this treatment were 12.09% and 7.33% higher than those recorded with RDF.

Key words: Pisum sativum, Enriched vermicompost, NPK, Yield

The Residual Effect of Fine Glauconite on The Second Successive Crop (Faba Beans) Grown in Sandy Soils of Egypt

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In Egypt, huge resources of glauconite are found in many localities in the Western Desert, New valley Governorate. Egypt is an agrarian economy and as such requires fertile soils for attaining and maintaining the self-sufficiency in food production. Egypt is dependent on imports to meet its annual requirements of K. In order to reduce the dependence on imported K, glauconite as a K mineral, has been identified as an indigenous alternative source of K. Pot experiment was carried out in Soil Sci. Dept., Faculty of Agric., Minia Univ., Elminia, Egypt. to study the residual effect of glauconite on the second crop (faba beans) grown in the same pots that were previously used with corn without new addition of glauconite. The previous rates were 0, 2, 4, 6, 8, and 10 g kg^{-1}. In this experiment, faba bean seeds (*Vicia faba*) were planted in each pot. In general, treating the sandy soil with the different application rates of glauconite increased the vegetative growth parameters (plant height, fresh and dry weights), water use efficiency and uptake of N, P, and K by faba bean plants grown in the treated sandy soil, compared with the untreated control. The increase in almost the studied parameters, was proportional to the increase in the application rate of glauconite up to 6 g kg^{-1}. It could be concluded that it is possible using the glauconite at application rate of 6 g kg^{-1} as an alternative source of low release potassium fertilizer and as a soil amendment for sandy soils in Egypt. Also, it is possible to use glauconite once for its initial effect on the first crop and to its residual effect on the successive crops grown in the newly reclaimed sandy soils in El-Minia Governorate, Egypt.

Key words: Sandy soil, Glauconite, Potassium and faba beans

Effect of Water and Nitrogen levels on Yield and Water Productivity of Cotton and Cluster bean in Indira Gandhi Nahar Pariyojana (IGNP) Stage – I

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A field experiment was conducted at research farm, Agricultural research sub-station, Hanumangarh, a unit of Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif*, 2016 to study, "Effect of Water and Nitrogen levels on Yield and Water Productivity of Cotton and Cluster bean in Indira Gandhi NaharPariyojana (IGNP) Stage – I". *Bt* cotton variety Sriram- 6588 BG II with seed rate of 1.8 kg ha^{-1} and Clusterbean variety RGC- 1055 with seed rate of 16 kg ha^{-1} was planted using 3 levels of irrigation (200, 400 and 600 mm for cotton and 100, 200 and 300 mm for cluster bean) and 4 levels of nitrogen (0, 75, 150 and 225 kg ha^{-1} in cotton and 0, 20, 40 and 60 kg ha^{-1} in cluster bean)analyzed in split plot design with three replication.

Results showed that irrigation at 400 mm gave significantly higher Leaf area index and CGR during most of the stages, dry matter accumulation at 60 DAS and RGR during 60-90 DAS, number of branches, number of bolls plant^{-1}, boll weight, seed cotton yield (2568 kg ha^{-1}), lint yield (734 kg ha^{-1}) and seed yield (1834 kg ha^{-1}), nitrogen content in seed and stalk, net returns and B: C ratio. Further, LAI at harvest, dry matter accumulation at 90, 120 and harvest stages, CGR during 90-120 DAS stage, RGR during 90-120 DAS and 120-harvest stages, seed index, stalk yield (4947 kg ha^{-1}), biological yield (7599 kg ha^{-1}), Nitrogen content in lint, nitrogen uptake by seed, lint and stalk and total nitrogen uptake and Agronomic nitrogen use efficiency were improved significantly up to irrigation at 600 mm in comparison to all other irrigation levels.However, harvest index and total water productivity of Bt cotton was significantly decreased with the progressive increase in irrigation levels.

Results further showed that nitrogen @ 225 kg ha^{-1}significantly improved the LAI at harvest, dry matter accumulation at 90, 120 and harvest stages, CGR during 60-90 and 90-120 DAS, RGR during 90-120 DAS and 120-harvest stages, number of branches, boll weight, seed index, seed cotton yield (2813 kg ha^{-1}), lint yield (803 kg ha ^{1}), seed yield (2010 kg ha ^{1}), nitrogen content in lint and stalk, nitrogen uptake by seed, lint, stalk and total nitrogen uptake. Leaf area index at 30, 60, 90 and 120 DAS, dry matter accumulation at 60 DAS, CGR during 30-60 and 120-harvest, RGR during 30-60 DAS, number of bolls per plant, nitrogen content in seed, agronomic nitrogen useefficiency, total water productivity, net return and B: ratio of Bt cotton were improved significantly 150 kg N ha^{-1} and remain statistically at par with its higher rate. However, harvest index of Bt cotton was not affected significantly with the progressive increase in nitrogen levels.

Combined effect of irrigation at 600 mm and nitrogen rate @ 225 kg ha^{-1} ($I_{600}N_{225}$) improved the dry matter accumulation at harvest, bolls plant^{-1} seed cotton yield (3345 kg ha^{-1}), stalk yield (7320 kg ha^{-1}), total nitrogen uptake, agronomic nitrogen use efficiency and highest net return of

Rs 1,26,338 ha^{-1} and proved significantly superior to other treatment combinations for Bt cotton. However, Irrigation at 200 mm in combination with nitrogen rate 150 kg ha^{-1} ($I_{200}N_{150}$) recorded significant and maximum total water productivity of Bt cotton.

Results showed that Irrigation at 200 mm significantly improved the Leaf area index at 60 DAS, dry matter accumulation at 60 DAS and at harvest, CGR during 30-60 and 60-harvest, RGR during 60-harvest, number of pods plant^{-1}, number of seeds pod^{-1}, grain yield (1624 kg ha^{-1}), straw yield (3645 kg ha^{-1}), biological yield (5270 kg ha^{-1}), net returns (Rs 31179) and B: C ratio (2.09) in comparison to irrigation at 100 mm, whereas, LAI at harvest, number of branches, test weight, nitrogen content and uptake in seed and straw, its total uptake and agronomic nitrogen use efficiency were significantly enhanced up to irrigation at 300 mm. However, LAI at 30 DAS, dry matter accumulation at 30 DAS, CGR and RGR during initial stage, plant stand at harvest and harvest index remained statistically at par with respect to irrigation levels. In contrast, Total water productivity of cluster bean remained significantly higher with irrigation at 100 mm.

Results further showed that nitrogen rate @ 40 kg ha^{-1} gave higher Leaf area index at 60 DAS and harvest, crop growth rate and relative growth rate at almost all stages, branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, test weight, grain yield (1668 kg ha^{-1}), straw yield (3696 kg ha^{-1}), biological yield (5364 kg ha^{-1}), harvest index, nitrogen uptake by grain, agronomic nitrogen use efficiency, total water productivity, net return (Rs 32273) and B:C ratio (2.12) in comparison to 0 kg N ha^{-1}. Dry matter accumulation at both stages, nitrogen content in grain and straw, its uptake by straw and total uptake were show their significance up to higher level of nitrogen.

Significantly highest dry matter accumulation at harvest, maximum number of pods plant^{-1} (51.02), highest grain (1744 kg ha^{-1}) and straw yield (3766 kg ha^{-1}), total nitrogen uptake, agronomic N use efficiency and highest net return of Rs 35342 ha^{-1} were recorded with combined application of irrigation at 200 mm and nitrogen rate @ 40 kg ha^{-1} ($I_{200}N_{40}$) in comparison to other treatment combinations.

The crop Syst model predicted the yield of cotton and clusterbean reasonably well.

Key words: Nitrogen, cluster bean, N use efficiency, irrigation

Conservation Agriculture for Sustaining Soil Health and Crop Productivity

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Anthropogenic activities have been the prime cause of global warming later in the middle of 20th century. Intensive tillage and highly mechanized traditional agriculture production system has been identified which are responsible for soil erosion hazards, pollution of surface and groundwater, and wasteful consumption of water. As a result, the agricultural production system is becoming unsustainable nowaday. To achieve the food security of an ever-growing population and alleviating poverty besides maintaining agricultural sustainability in the existing situation of degrading natural resources, undesirable effects of climatic inconsistency, continuously rising the price of inputs and instability in the marketing ofagricultural produce, most of the Asian countries have to face these major challenges. A drastic change in agricultural practices is required for achieving desirable productivity while nourishing the natural resources. In this situation, to address the sustainability of agriculture globally, the concept of Conservation Agriculture (CA) evolved. CA system is very effective for natural physical protection against weather parameters (rainfall, temperature, wind, dry or wet periodsetc.) and improving soil physical health like reducing bulk density and penetration resistance, increasing hydraulic conductivity and infiltration rate. Adaptation of CA can improve soil aggregation and helps in soil organic carbon sequestration. Retention of crop residue on soil surface can also moderate soil hydrothermal regimes.Reasonably better growth of plants in crop field, achieving higher yield and crop productivity depends on well-developed root system for improved uptake of nutrient and water from healthy soil. Environment becomes healthier and more sustainable through maintaining of environmental integrity and services for wider community because of the reduction of fossil fuels use, less consumptionof pesticides and other chemicals. It guards the surface and ground water from pollution and similarly lessensthe effects of climaticabnormalities. Henceforth, CA offers outstanding soil fertility, reduces cost of production, time and fossil-fuel consumption. CA system is an effective substitute to conventional agriculture by reducing its major disadvantages.

Key words: Conservation agriculture, Soil health, Sustainability, Crop productivity

Assessing the Effect of Irrigation and Integrated Nutrient Management under Bitter Gourd Production in New Alluvial Zone of West Bengal

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Natural resource management with a clear focus on environment quality enhancement leading to sustainable development and adaptation to climate change have become one of the pivotal issues to fight the instability in crop productivity and weather variations. For this, proper application of organic as well as inorganic fertilizers along with water management for better crop production lead to high income. On this regard, an field experiment was conducted during the summer season of March to July 2018, at the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to investigate the effect of irrigation and integrated nutrient management under Bitter gourd (Var. Pusa Vishesh) production. The experiment was laid out in split plot design having three main plot treatment (I_1 – irrigation at 7 days interval, I_2- irrigation at 10 days interval, I_3- irrigation at 15 days interval) and four sub plot treatment (N_1 –Inorganic fertilizer (100%) (NPK: 60, 40, 40), N_2 – Inorganic fertilizer (75%) + bio-fertilizer, N_3 – Inorganic Fertilizer (50%) + Organic manure + Bio-fertilizers, N_4 – Organic manure (FYM: 15t/ha) + Bio-fertilizer, with three replications. Results showed that the yield is increased with each treatment, attaining the highest value of 17.79 t/ha in treatment I_2N_3 which is 14.62% more than treatment I_1N_1. The moisture use efficiency of the crop was increased significantly by 90.05% in the treatment I_2N_3 over treatment I_1N_1. Thus the treatment I_2N_3 having the integration of both inorganic and organic nutrient suppliers had been proven more beneficial than any other treatments for improving the productivity of crop and also for improving soil properties and building up soil fertility.

Key words: Bitter gourd, Bio-fertilizer, Integrated nutrient management, Water use efficiency

Effect of Biochar on Bioaccumulation of Chromium in Rice (*Oryza sativa* L.)

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A pot experiment was conducted during *Kharif* season, 2018-2019 to study the Effect of biochar on growth and yield of rice (*Oryza sativa* L.) in chromium contaminated soil under greenhouse condition. Four levels of biochar (0, 20 40 and 60 tonnes /ha) and four levels of cadmium (0, 20, 40, 60, 80 and 100 ppm) were applied to rice. ^{1}s. Cr has a negative impact on the yield attributes like total tillers hill^{-1}, productive tillers hill^{-1}, grains panicle^{-1}, panicle length, and panicle weight of rice. With increasing concentration of chromium, the yield attributes of rice decreased respectively. The addition of biochar has significantly increased the growth parameters like plant height, number of tillers hill^{-1}, and productive tillers hill^{-1} of rice. Treatments with 60 t ha^{-1} biochar found to be more effective followed by 40 and 20 t ha^{-}The application of biochar reduced Cr toxicity to some extent but not completely. Decreasing trend of harvest index was observed with increasing the concentration of chromium but addition of biochar has significantly increased the harvest index. The highest Cr content of grain and straw of rice was observed with the treatment Cr100 and application of biochar significantly decreased the toxicity of Cr content in different parts of rice. The mean values of the translocation factor were greater than 1 which indicates that rice can hyper accumulate from roots to shoots. Upon application of biochar, there was an accumulation of Cr observed more in the roots, hence uptake of Cr into grains is reduced. Exposure of rice to chromium reduced overall growth, yield, nutrient content, and uptake. However, application of biochar restored the damage caused by heavy metal chromium and showed an increased in nutrient content. Biochar enhanced growth and yield parameters and accumulation of metal. It may be concluded that biochar can reduce the bioavailability and leachability of chromium in soil and improved soil fertility. Furthermore, the studies are needed to evaluate the efficiency of biochar amended bioremediation of highly heavy metal contaminated soils.

Key words: Biochar, bioremediation, heavy metal contamination

The Impact of Traditional Land Use Management on Soil Quality in Northeastern Himalayas (India)

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The impact of traditional land use management on soil physicochemical properties and soil quality indicators is a topic,not enough studied in the Northeast Himalayas (NEH) region. In these traditional landscapes, the four major conventional land uses are forest, crop phase, fallow phase and plantations, but little is known about their sustainability. Therefore, we assessed a dataset composed by eighty-eight soil samples in the Zunheboto district of Nagaland (India), in Northeast Himalayas (NEH) for four different land uses (forest, crop phase, fallow phaseand plantation) at different soil depths by conducting an ANOVA-one way, a principal component analysis (PCA) and calculating a soil quality index (SQIa). Our results confirmed that sand, bulk density, porosity, soil organic carbon (SOC), cation exchange capacity (CEC), exchangeable calcium and potassium showedstatisticallydifferences among soil depths. PCA results showed that soil texture, BD, porosity, SOC and exchangeable cations are the major indicators to define soil quality. After conducting the SQI, crop phase soils obtained the best results at the surface, while at 15-30 cm soil depth, fallow phase showed the best improvement. The study highlights that the conversion of natural forest to plantation does not hamper the soil quality but, their conversion into crop landmay increase soil quality. However, after 1-2 year of cultivation and conversion of crop land into fallowland, soil quality could be reduced. Using these indicatorsas a first approach, we were able to evaluate soil quality being more productive in terms of time- and money-consuming.

Key words: Land uses, Forests, Crop land, Soil quality, Northeast Himalayas

Impacts of Chiselling on Soil Properties and Direct Seeded Rice Yield

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Significant impact of tillage practices on soil properties and crop productivity were observed after long period of inception particularly under zero tillage practice. However, chiselling is such a tillage practice which showed immediate effects on soil properties, and crop productivity and its effect prevails even after discontinuing the practice. To test this hypothesis a field experiment was conducted at the Research Farm, Department of Soil Science, Punjab Agricultural University, Ludhiana, on direct seeded rice during *kharif* 2018 in a sandy loam soil. The study included three tillage practices i.e. conventional tillage (CT), chiselling for one year (CH1) and chiselling for two consecutive years (CH2) and two irrigation regimes i.e. 4 days interval and 8 days interval. Direct seeded rice was sown in first week of June with recommended fertilizer doses and harvested in second fortnight of October. The CH2 practice produced higher rice grain yield i.e. 5.9 t ha^{-1} followed by CH1 (5.7 t ha^{-}1) and minimum under CT (5.4 t ha^{-1}). The other yield contributing characters like plant height, tiller density and thousand grain weight were also found to be significantly higher under CH2, followed by CH1 and minimum in CT. Thousand grain weight (TGW, g) of rice was maximum in CH2 (22.7) followed by CH1 (22.1) and least in CT (21.6). Dry biomass yield was also found to be higher under CH2 followed by CH1 and minimum in CT. Among irrigation regimes, higher rice grain yield was recorded at 8 days interval (5.8 t ha^{-1}) level than 4 days interval (5.5 t ha^{-1}). Irrigation water productivity (IWP, kg ha^{-1} mm^{-1}) of direct seeded rice was also significantly influenced by chiselling practice, maximum IWP was recorded at CH2 followed by CH1 and lowest under CT. The chisel practice had also residual effect on soil penetration resistance at 15-30 cm soil depth with highest values under CT (3.1 M Pa) and lowest under CH2 (2.6 M Pa). Similarly, infiltration rate (IR) of soil was also affected by chisel practices, where maximum final IR was recorded under CH2 (1.6 cm hr^{-1}) followed by CH1 (1.3 cm hr^{-1}) and least in CT (1.2 cm hr^{-1}). It may be concluded that chiselling has residual effect on soil properties and rice productivity.

Key words: Direct seeded rice, conventional tillage, chiselling, residual effect, IWP

Soil Quality under Intensive Jute Growing Areas of Assam for Resilient Agriculture

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Jute is an important commercial crop of Assam. The most significant impact of the jute life cycle is carbon sequestration, which is directly related to soil hydro-physical characteristics. A study initiated to generate database on soil hydro-physical behaviour under various jute growing areas in Assam. Soil samples were collected from various locations of Rupohi block, Assam and their subsequent physico-chemical analysis were done. The soils are acidic (range: 5.35 to 5.85) in nature and clay loam in texture. The clay content of the soils varies in between 31.7 to 40.4%, highest being in Barghat Puranigudam. There is no significant variation in bulk density (BD) of the soils ranging in between 1.39 and 1.41 Mg m^{-3}. The organic carbon contents were significantly higher at all locations (range: 0.91 to 1.22%), the lowest being at Taliagaon and highest being at Keyagaon Puradigudam. The macro and micro-aggregates decreased with increasing soil depth owing to the lower content of organic matter in sub-surface soil. The water stable aggregate (WSA) and mean weight diameter (MWD) which are indices for soil structure showed that of all the locations has significantly higher aggregate stability (WSA range: 75.78-81.95%; MWD range: 0.83-1.10 mm). Saturated hydraulic conductivity (Ks) values revealed that there were wide variations at various locations and it varied between 0.44 and 1.38 cm hr^{-1}. Faster rate of steady infiltration was recorded in all locations (ranging in between 9.50-13.05 cm hr^{-1}, except in Boroma Rupahi, Rupahi district (6.43 cm hr^{-1}). The slow rate of infiltration in Boroma Rupahi, Nagaon indicated that the sealing of pores and broken capillaries inhibited the water movement within soil system. Available water content in various locations varies from 0.12 to 0.28 $m^{3\ -m3}$, lowest being at Taliagaon and Barghat puranigudam, Rupahi district. Based on the analysed soil parameters, it can be concluded that the soils under jute growing areas of Rupohi block are conducive for sustainable crop production.

Key words: Soil hydro-physical characteristics, sustainable crop production, WSA

Agronomic Measures for Soil and Water Conservation in North-Western Rajasthan

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The objective of this paper is to review the major agronomic practices and their role in soil and water conservation. Soil and water are the most important natural resources and physical base for all life supporting system as water sustains life where soil acts as a medium. Land degradation and Desertification are major problem in the dryland areas of India, affecting 173.64 million hectares. Rajasthan has little forest cover, but is rich in flora and fauna. Approximately 92% of the area in Rajasthan is currently affected by desertification. The review revealed that the agronomic measures for soil and water conservation arechoice of crops, growing of cover crops, strip cropping, mulching, contour farming, crop rotation, ridge and furrow, tied ridging and dead furrow.The soil surface covered by plant canopies and mulching reduce the soil erosion and improves soil moisture status by increasing infiltration and reducing evaporation from soil surface. Tillage practices also reduces the soil erosion and conserve soil moisture by it looses soil and thereby infiltration rate increased and therefore reducing runoff.

Key words: Soil, Water, Desertification, Natural resources

SPAD Meter can be the Promising Tool for Efficient Nitrogen Management in Wheat

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Fertilizer, N management in cereals is the major issue considering the sustainability in India. Around 75% subsidy in Urea made the fertilizer cheaper than other high analysis fertilizer. It was noted that application of N during sowing/planting to top dressing, there was asynchrony between need and demand. In this context investigation was carried out to analyze the effect of site specific N management using SPAD (Soil Plant Analysis Development)/Chlorophyll Meter on wheat productivity and N use efficiency on alluvial soil of eastern India. The experiment was carried out during the dry season (November to April) of 2015-16 in Bihar Agricultural College, Sabour, Bhagalpur using seven wheat cultivars. The experiment was laid out in split plot design with fourteen treatment combinations of two SPAD levels (42 and 44) as main plot and seven wheat cultivars (HD 2967, HD 2985, HI 1563, PBW 343, HW 1105, HD 3086 and Sabour Samriddhi) as sub plot treatments with basal dose of 40-60-40 kg N-P_2O_5-K_2O ha^{-1} in three replications. The growth attributes in SPAD 42 are comparable with SPAD 44 in most of the cases, with the saving of 19% N than used in SPAD 44. Even when compared with the state recommendation (120 kg N ha^{-1}), the SPAD based technology can also saved the N fertilizer without affecting the growth and yield of wheat. However, the growth and yield components are varied significantly among the wheat cultivars and in this regard cultivar HD 2967 and Sabour Samriddhi performed markedly over the others. Herein the study the highest grain yield (5172 kg ha^{-1}) was recorded in cultivar HD 2967 followed by Sabour Samriddhi (4817 kg ha^{-1}) and both these cultivars were significantly superior over the cultivar PBW 343 which had scored the lowest productivity among the sub plot treatments. Study confirmed that chlorophyll meter based N management, especially maintenance of SPAD threshold value of 42 with N application of 20 kg ha^{-1} in each top dressing could save substantial amount of N along with the positive impact on grain yield. The leaf N content and SPAD value at CRI and tillering stages were linearly correlated and the optimum SPAD values for these growth stages were measured as 45.3 and 42.0, respectively for maximization of grain yield. The partial factor productivity of applied N (PFPN) decreased steadily with increasing the rate of N top dressing. The highest PFPN (54.05 kg kg^{-1}) value was recorded in HD 2967, which was significantly superior over all other cultivars except HD 2985. Overall, HD 2967 recorded 12.8% higher value of PFPN than that of other cultivars. The internal N use efficiency (IEN) was also noted highest in HD 2967 (42.6 kg kg^{-1}) and it was statistically superior over the Sabour Samriddhi which had noted the lowest IEN among the sub plot treatments. The productivity and N use efficiency remained non significant with the SPAD thresholds. Hence, from soil health, environmental sustainability and economic point of view SPAD 42 based N management strategy was found very promising in efficiently managing N fertilizer for maintaining wheat productivity and increasing N use efficiency in eastern part of India.

Key words: Crop productivity, N use efficiency, SPAD based N management, Wheat

Effect of Calcium Nitrate on Flower Drop and Yield of Byadgi Chilli as Influenced by Foliar Application of Calcium Nitrate in a Vertisol

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An experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and 12 treatments. To study the effect of calcium nitrate foliar spray on flower drop and yield of Byadgi chilli during kharif season of 2016 in the farmer's field at Agadi village (Tq: Hubbli) in Dharwad district, Karnataka, India. Two different levels of calcium nitrate were sprayed (1% and 1.5%) at different growth stages of the crop. The results revealed that highest number of branches (25.02), lowest flower drop percentage (10.02%) and dry fruit yield (21.76 q ha^{-1}) were recorded due to three foliar sprays of $Ca(NO_3)_2$ at1.5 per cent and differed significantly from all other treatments. Control which did not received foliar spray of calcium nitrate recorded highest flower drop (21.97%) and lowest dry fruit yield (12.76 q ha^{-1})

Key words: Calcium nitrate, Chilli, Flower drop, Yield

Potassium Management for Enhanced Rice Growth and Yield in Eastern India

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In rice crops recommended doses of fertilizer application is now showing signs of fatigue as negative balance of the primary nutrients exists, particularly for potassium. Potassium is one of the primary essential nutrients for plant growth and development and lack of potassium causes yield reduction. Application of potassium in rice crop has received least attention, even though potassium accounts for a greater share of total nutrients removed from the soil, reason being (a) the Indian soils are considered to be rich in potassium (b) low external application of potassium followed by common practice of removing cereal residues from fields (c) the complete dependence on import of potassic fertilizer and (d) heavy subsidy on nitrogenous fertilizer further exacerbate the problem. As a result soil is continuously mined of their available potassium reserve as its removal is much higher compared to replenishment. Thus, this study aimed to know proper recommended dose of potassium to provide correct guidance on the rate of application, when to apply both relative to plant and soil. In 2017-18 at BAU farm, Sabour Bhagalpur the experiment was laid out in split plot design with 3 replications consisting of three potassium levels K_1-100% RDK, K_2-150% RDK and K_3-200% RDK and four different split applications *i.e.* S_1 (basal), S_2 (50% basal + 50% at max. tillering), S_3 (50% basal + 25% at max. tillering + 25% at PI) and S_4 (75% as basal + 1% spray at max. tillering and PI). Results revealed that with increase in level of potassium significant positive effect on all the growth parameters and yield attributes was observed. Doubling the potassium dose (200% RDK) *i.e.* 80 kg K ha^{-1}significantly increased the plant height (126.51cm), no. of tillers (16.53 at 60 DAT) and dry matter (1871.92 gm^{-2}) per unit area in rice crop. K_3also recorded significantly highest grain yield (4999 kg ha^{-1}) and straw yield (8488 kg ha^{-1}) compared to K_1 and K_2. Split application of potassium was advantageous to rice as increase in the no. of splits increased K content and uptake and yield of the crop. Splitting the dose at maximum tillering stage and PI stage showed better crop performance in terms of plant yield attributing characters and yield. S_3 recorded significantly high dry matter (1850.58gm^{-2}) and grain yield (5036 kg ha^{-1}) in comparison to basal and single split application. Splitting of potassium including foliar spray (S_{4-}) also gave better crop performance and was significantly at par with S_3 in terms of yield. Thus, levels of potassium in paddy may safely be increased up to 200% for maximizing yield potential and splitting the dose of potassium proves better utilization of potassium by the crop.

Key words: Negative balance of K, potassic fertilizer, recommended dose of potassium, split application of potassium

PLENARY SESSION-I

Land Degradation vis-a-vis Agricultural Development

Land Degradation under New Worldwide Extensive Industrial Agricultural Developments: Causes and Consequences

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The last decades have seen increasing demand and high market prices for food and energy crops, mainly soybeans and palm oil, that have led to drastic and unregulated changes in the use and management of large areas of land, resulting in new and worsening problems of soil and water degradation, including erosion. These changes are mostly happening on savanna and forested lands in tropical and subtropical regions of Asia, Africa and Latin America, under the initiative of large individual producers and corporations, usually seeking short term profit, with little concern for negative environmental or social consequences. Frequently, such cropland developments are justified under an apparent use of so-called “conservation agriculture” systems, mainly based on “no tillage” practices, supposedly leading both to improved production and to soil and water conservation, with decreased erosion and positive effects on the environment and climate change. There is clear evidence, however, that inadequate application of those “conservation agriculture” systems is increasingly degrading the soil and water resources, with negative environmental and socio-economic impacts at local and World-wide level. A new focus is required for research activities that seek solutions to soil and water conservation problems, taking into consideration the complex interactions between landuse and changing social and economic conditions, leading to more sustainable policies and decisions about land use and management. Soybean production in Argentina and Brazil is analyzed as case studies.

Key words: Soil erosion, industrial agriculture, land degradation, food production, conservation agriculture

Land Degradation in the Foothills of Jammu and Strategies for its Mitigation

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The foothills in Jammu region are part of the Himalayas, commonly called as lower Shivaliks. They are a fragile ecosystem facing widescale land degradation. Both natural and anthropogenic factors were identified and related with each other to create a cycle of events promoting land degradation and its influence on livelihoods and poverty in the foothills. Although the total annual rainfall seems to be sufficient, nearly 80% of it falls in July and August resulting in water scarcity for most part of the year. Soil erosion by water is the primary factor promoting land degradation in the region. This is mainly due to the undulating relief, which is largely mountainous, ranging from low hills to mid hills coupled with high intensity seasonal rainfall. Higher surface runoff leaves little for percolation, resulting in moisture stress during most parts of the year, and eventually poor productivity. The problem is further aggravated as the soil in the area is coarser and low in organic matter. The trends in local climatic conditions indicate increasing rainfall variability, with lesser rainy days but more number of storm events. Sustainable use of mountains depends upon conservation of soil and water resources, and usage of land according to its capability. It is possible that future climates already exist in different regions at present. Further, practices may have already been found effective in similar climatic conditions to combat ill impacts of climate variability. That is where the analogus approach comes in. Successful management practices, in terms of reduction of erosion risk and carbon sequestration, followed elsewhere, with similar climate conditions as expected in near future could be identified, modified and adopted to local condition in the form of a conservation agriculture.

Key words: Foothill, rainfall variability, erosion risk, undulating topography, climatic variability

Quantitative Assessment of Land Degradation Processes using Model-builder in GIS Environment

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Success in combating land degradation requires a better understanding of their causes, impact, degree and knowledge of climate, soil, water, land cover and socioeconomic factors. Land degradation assessment is therefore a major goal in the decision support system to reverse the deterioration. The study aims to determine the extent of dynamic land degradation for 50 years in the North Delta using the neural network method. The study area is located in North Delta (Kafr El-Sheikh governorate), Egypt. A spatial model was built for quantitative assessment of land degradation using ArcGIS 10.3 (Spatial Spatial Extension) to map land degradation in 1961, 2002 and 2016. Land degradation variables (salinization, alkalinization, compaction, lime content and water logging) Raster and record each data set on a scale of 1 to 5 (scale is very low, low, moderate, high and very high). The data sets were then weighted according to their effect on the overall model (weight gain = greater effect). The overall change in degradation of highly deteriorated soils increased over time from 1961 to 2016, while the rate of soil erosion has deteriorated considerably over time. However, the soil has increased low degradation over time, and each change has been at the expense of highly degraded soil due to reclamation and soil management.

Key words: Land Degradation, GIS, Nile Delta, GIS Builder

Land Degradation Drives the Influence of Ventilation and Pressure Tides in the CO_2 Exchange: A Case Study in Two Semi-arid Grasslands

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Soils are key components in the ecosystem carbon balance, where CO_2-enriched air can be stored or transported through soil pores and fissures and emitted to the atmosphere, mainly by diffusion processes. However, in semi-arid ecosystems the mechanisms of pressure tides (produced by changes in atmospheric pressure) and ventilation (produced by atmospheric turbulence driven by wind) are non-diffusive transport processes that may dominate the soil-atmosphere CO_2 exchange in shallower horizons and deeper soil layers. Land degradation processes, can alter the physical properties of petrocalcics soils and affect the permeability and connectivity of soils, leading to a higher interconnectivity between the unsaturated porous media and the atmosphereof these ecosystems. Consequently, interconnectivity could be considered as a pivotal factor defining the wind and pressure influence in CO_2 dynamics. Here, we examine how the CO_2 dynamics in the vadose zone are affected by changes in environmental and subterranean conditions by comparing two nearby semi-arid grassland sites with different degradation status. For that, we used the continuous wavelet transform analysis to describe the temporal variability, explore the spectral properties and investigate the cause-effect relationship between CO_2 efflux and environmental variables at a shallow horizon0.05 m and a deep 1.50 m soil layer during 3 years (2014-2016). Our results show that the vadose zone CO_2 dynamics are predominantly controlled by wind turbulence and atmospheric pressure abiotic factors. We also found that the effect of pressure tides and ventilation on the soil-atmosphere CO_2 exchange depends on the soil depth, ecosystem degradation status and seasonal period.

Our results suggest that soil conservation determines the drylands carbon balance especially in ecosystems with well aerated soils under dry and high-turbulence conditions, where degassing would represent a positive feedback to climate change.

Key words: Land degradation**;** Air pressure fluctuations; Ventilation; Arid grasslands; Wavelet analysis

PLENARY SESSION-II

Next Generation Nutrient and Water Management in Agriculture

Precision Fertilizer Nitrogen Management for Maintaining Soil Health in Smallholder Farms in Developing Countries

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India and China, the two most populous developing countries of the world used 24.7 and 15.9% of the global fertilizer N consumption, respectively. That 74.5% of the global population of 7.72 billion in July 2019 lived in developing countries, is one important factor for continuously increasing fertilizer N consumption in these countries. Smallholder farms (< 2 ha) occupy up to 40% of agricultural areas globally. It has been observed that 1% increase in farm size results in 0.3% decrease in fertilizer use. Due to the high costs of fixed inputs (such as machinery), smallholders tend to use more non-fixed inputs such as N fertilizers than fixed inputs.

Two most important soil health indicators are soil organic matter (SOM) and soil biota. While SOM positively regulates physical, chemical and biological properties of the soil, soil biota controls accumulation and decomposition of SOM and release of mineral nutrients in the soil ecosystems. Fertilizer N when applied in doses leading to optimum yield levels leads to SOM build up. But when applied in doses more than those leading to optimum yield levels, fertilizer N leads to loss of SOM by accelerated rate of decomposition of high C:N ratio organic inputs (such as crop residues) and SOM through stimulation of microbial activity. If a decline in SOM following the application of fertilizer N would have been a general phenomenon, it almost certainly would have major consequences for food production as it would have resulted in a spiral of decline in soil functioning and crop productivity.

Current fertilizer N management in developing countries consists of blanket recommendations formulated by averaging the crop response data collected over large geographic areas. The amount and timing of N applications are prescribed before planting so that blanket recommendations cannot take into account the dynamic spatial variability in indigenous N supplying capacity of soils during the crop growth period. Because these are designed to produce optimum yields in all the fields in the region, in many fields managing fertilizer N following blanket recommendations results in application of fertilizer N more than the requirement of the crop. On the other hand, precision or site-specific N management (SSNM) is designed for feeding crops with nutrients as per their need. It enables farmers to dynamically adjust fertilizer use to optimally fill the deficit between the nutrient needs of a crop and the indigenous nutrient supply. It strives to apply N at optimal rates and times as per need of the crop to achieve high yield and high N use efficiency. Precision site-specific N management strategies based on hand-held leaf colour charts, transmission meters and optical sensors are already available for use in smallholder farms. Thus it is a need of the time that in smallholder farms in developing countries precision fertilizer N management practices are urgently introduced for maintaining soil health and sustainable food production for future generations.

Key words: Nutrient management, crop productivity, fertilizer use efficiency

Plant Nutrient Management Strategies in Agriculture – Current Approaches and Future Strategies

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An ideal plant nutrient management strategy should reduce the inorganic fertilizer requirement, restore organic matter in soil, enhance nutrient use efficiency and maintain soil quality in terms of physical, chemical and biological properties. In order to ascertain soil health, the region-specific strategies for improving productivity and profitability having common elements related to soil characteristics, topography and management practices need to be decided. In India, due to idiosyncratic reasons the management practices may differ in the different strata of farmers. Nutrient management over time has specific syndrome which can be summarized by abuse of nitrogen, disuse of potassium, and generally coupled with overuse of phosphorus. It suggests inherent flaws in fertilizer application practices adopted by farmers that probably promotes imbalance in nutrient applications. The nutrient management adopted by farmers of India can be broadly categorized into (i) Blanket fertilizer recommendation, (ii) Fertilizer application based on own/peer perception, and (iii) Soil-test based fertilizer recommendation. Among these broad categories, the third one is science-led plant nutrient recommendation based on analysis of representative soil samples, correlation and calibration and finally fertilizer recommendation; the subsets include nutrient indexing approach, site-specific nutrient management (SSNM), use of QUEFTS model and STCR-based fertilizer recommendations.

With increasing costs for fertilizer inputs, farmers are interested in applying fertilisers precisely for optimal profit. This warrants use of sensor-based soil testing technology and ICT for plant nutrient recommendations. The data science and spatial data availability present in the institutional system can characterize the soil, crop and environment rapidly and cost-effectively and with greater precision scale. Such information is being used to develop ICT based tools for precision nutrient management as well as in-season adaptive management at an affordable scale. Precision nutrient management approach manages the soil variation, nutrient status and crop responses. The concept for optimizing the supply and demand of nutrients according to their variation in time and space. However, for scaling such approach ICT tool can be tailored to specific local conditions for precisely providing field specific nutrient recommendations to the farmers as web- and mobile phone based application/software. *Nutrient Expert®* is another effective tool that is based on the plant-based approach of SSNM. However, there is no denying fact that as on today we are mainly dealing with soil chemical fertility evaluation through soil testing which is only the tip of the iceberg. Moreover, the region-specific amalgamated technological prescriptions refined with targeted policy analysis are required for effective implementation and obtaining positive outcomes within a finite time horizon. This will provide a strong foundation for pragmatic policy formulation on natural resource conservation and combating climate change.

Key words: Nutrient expert, precision agriculture, STCR-based fertilizer recommendations

Integrated Water Management Strategy for Rice-wheat system in Northwest India

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Fresh water resources have been degrading and declining at a faster rate than in past, thanks to anthropogenic activities of mankind. The severity of already disturbed natural water cycle is expected to increase further due to global climate change/chaos. The challenge before the scientific community in the next few decades will be to keep pace with the still growing demand for food, while adopting technologies that are more efficient at using natural resources especially water. Rice-wheat systems are of immense importance for food security in India. While the intensification of rice-wheat system in northwest India has been a major contributor to food security, its sustainability is threatened by depletion and pollution of both ground and surface waters.

A range of resource conservation technologies is being advocated in rice-wheat system in the region with the sole objective of enhanced irrigation water productivity. These technologies include laser land leveling, dry-direct seeded rice with various degrees of tillage, wet-seeded rice into puddled soil, zero tillage for wheat, raised beds with furrow irrigation and stubble retention, etc. to various extents of water saving. The irrigation scheduling with respect to 'when' and 'how much' varies with a change in the cultural system. For example, the irrigation schedule being recommended in puddled rice may not hold good under unpuddled system (raised beds or direct-seeded rice) in *toto* as the soil water dynamics changes completely as we move from puddled to unpuddled system. Same is true with zero tillage in relation to conventional tillage.

Thus, simply advocating a particular water saving technology in one crop without defining the irrigation schedules may not help to improve water productivity of the system. Moreover, some techniques could be soil-, weather-, cropping system- and environment-specific and thus, need to be studied in an integrated manner and not in isolation. An effort has been made in this paper to describe an integrated strategy for overall field water management in rice-wheat system as a whole in northwestern region of India.

Key words: Water use efficiency, crop productivity, soil fertility

Soil Management for Climate-smart Agriculture

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Climate change can affect agriculture through their direct and indirect effects on the crops, soils, livestock and pests. Increase in atmospheric carbon dioxide has a fertilization effect on crops with C_3 photosynthetic pathway and thus promotes their growth and productivity. Increase in temperature can reduce crop duration, increase crop respiration rates, alter photosynthesis process, affect the survival and distributions of pest populations and thus developing new equilibrium between crops and pests, hasten nutrient mineralization in soils, decrease fertilizer use efficiencies, and increase evapo-transpiration. Climate change also have considerable indirect effects on agricultural land use in India due to availability of irrigation water, frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal lands, and availability of energy. Indian agriculture is highly prone to the risks due to climate change.

The Inter-Governmental Panel on Climate Change (IPCC), in its recent report of 2019, reiterated that the warming of the climate system is unequivocal. Agriculture sector is a major contributor to the enhanced greenhouse effect through emission of greenhouse gases (GHGs) i.e., carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Soil is a source and also acts as a sink of GHGs. It is intricately linked to the atmospheric–climate system through the carbon, nitrogen, and hydrologic cycles. Methane is produced in soil during microbial decomposition of organic matter under anaerobic conditions. Rice fields submerged under water are the potential source of CH_4 production. Continuous submergence, higher organic C content and use of organic manure in puddled soil enhance the methane emission. Burning of crop residues also contributes to the global methane budget.

Soil management offers opportunities for mitigation from supply-side and also from demand-side. The emissions can be effectively minimized by better soil-water-fertilizer-crop management interactions both under irrigated as well as rainfed agriculture. The supply-side opportunities include sustainable intensification with improved varieties, diversified crop rotations; improving nutrient, crop residue and water management; reducing emissions from enteric fermentation; reducing methane emissions from rice cultivation and improving manure management. The demand-side opportunities are sequestering carbon in agricultural systems including agro-forestry, bio-energy crops, biochar application, reducing foodwaste and shifting dietary trends.

Soil management offers promises for climate change adaptation through modifying crop management practices, improving water management, adopting new farm techniques such as resource conserving technologies, crop diversification and harnessing the indigenous technical knowledge of farmers. Loss of fertile soil and carbon and nitrogen along with eroded soils can be reduced by local specific soil management practices. Though, there are significant opportunities for GHGs mitigation and adaptation in agriculture, but numerous barriers need to overcome. A win-win solution is to start with such mitigation and adaptation strategies that are needed for sustainable development.

Key words: GHGs, C sequestration, adaptation

Smart Fertilizers and Technologies for Next-Generation Nutrient and Water Management

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To meet the food needs of the projected increase in population by 2050 and consumers' shift toward a meat-rich diet, agricultural production must increase by at least 60% relative to production levels in 2005. Will this be achieved in a sustainable manner? If current technologies, management practices, and waste levels (post-harvest, handling losses) are used to meet these demands, the impact of agricultural production systems will well exceed safe planetary boundaries by 2050 due to greenhouse gas (GHG) emissions, cropland use, blue water use, nitrogen application, and phosphorus application. Targeted delivery of water and nutrients through improved irrigation efficiency and fertilizer efficiency can help maintain or even increase yields while significantly reducing fertilizer application rates and minimizing negative impacts of agriculture on ecosystems and human health. Due to the impact of food production on all facets of life, a systems approach to understand the nature of interactions among different elements of the food and agricultural system must be leveraged to increase overall system efficiency, resilience, and sustainability.

Climate-smart fertilizers and nutrient management strategies designed to be sensitive to environmental concerns not only reduce the contribution of GHGs from fertilizers, they also contribute to nutrition-based crop resilience to stress conditions (drought, salinity, disease) that are experienced under various climate changing scenarios. GHG emissions can be reduced and nutrient use efficiency of mineral fertilizers can be improved by modifying production techniques, stabilizing the reactivity of specific fertilizers, producing balanced multi-nutrient synergistic fertilizers that contain secondary and micronutrients, and practicing best management practices. Ultimately, the improved products and practices should result in better synchronization of nutrient release with crop nutrient demand. Smart fertilizers can create more productive and sustainable crop production systems by identifying and harnessing the soil microbiome's capability to transform nutrients, increase nutrient bioavailability, and improve plant resilience to environmental stress and disease. The presentation will discuss the status of such on-demand nutrient release fertilizers in improving nutrient management, water use efficiency, and climate resilience as well as niche fertilizers and nutrient management.

While smart irrigation and fertilizer management can improve productivity and climate resilience, balanced fertilization remains a key bottleneck in most developing countries. A Soil-SMaRT approach to implement balanced fertilization relies on **S**oil analysis, **Ma**pping, **R**ecommendation development, and **T**echnology transfer (SMaRT) to improve understanding of the multiple steps involved in introducing the latest fertilizer technologies and practices to farmers and to encourage coordination of multiple actors across the fertilizer value chain. While all of the Soil-SMaRT steps are critical for successful implementation of balanced fertilization, this presentation will highlight the roles of soil analyses and the availability of customized balanced fertilizers.

The development and validation of precise, accurate, field-deployable sensors and biosensors that enable rapid detection and monitoring capabilities of soil and plant nutrient status will be game changers. This effort, however, requires public-private partnerships and data sharing to take advantage of data analytics and machine learning. Overall, the strengths and opportunities that come with the next generation of nutrient and water management can overcome the weaknesses and threats we face now.

Key words: Climate-smart, Nutrient efficiency, Irrigation, Soil-microbiome

Aakash Project: Challenge toward Clean Air, Public Health and Sustainable Agriculture

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We started an interdisciplinary study named "Aakash project" in Research Institute for Humanity and Nature. At present, the people's health is threatened by worsened air quality in most of developing countries, especially in India. This study tackles the issue of air pollution arising from large-scale rice straw burning after harvesting rice in the state of Punjab in India. The rice straw burning in Punjab has been linked with the heavily polluted air in Delhi and surrounding regions. To overcome the problem, we will take an interdisciplinary approach and pursue a pathway of social transformation toward clean air, public health and sustainable agriculture.

Human health in many developing countries, and especially India, is often threatened by declining air quality. This study tackles the issue of air pollution arising from large-scale burning of rice straw after harvest in the state of Punjab. Burning of rice straw in Punjab has been linked with significant air pollution in Delhi and surrounding regions. To address the problem, we will take an interdisciplinary approach and pursue a pathway of social transformation toward clean air, public health and sustainable agriculture.

Key words: North India, air pollution, straw burning

Eco-friendly farming technologies for reducing reliance on chemical fertilizers for rice farming

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The world has evolved to a state of selling the future to buy the present, and the current practice of agriculture, which heavily relies on nonrenewable resources is not an exception. Hence, taking measures to improve sustainability of agriculture is crucial. Optimizing fertilizer recommendations considering nutrient availability in soil and crop requirements as well as identifying different nutrient sources to partially or completely replace chemical fertilizers without compromising yield will help to improve sustainability of crop production systems. Research conducted in Sri Lanka indicated that nutrient availability in paddy rice cultivated soils is highly variable. From 52 experimental plots established in paddy cultivated farm fields a significant ($P < 0.05$) positive response was observed for the applications of N fertilizers. The response for P and K fertilizers were not statistically significant ($P > 0.05$), indicating the importance of adopting a site specific approach for nutrient management.

Biofertilizers are developed with microorganisms that improve nutrient mobilization in crop cultivation and therefore, these could be used to substitute chemical fertilizers. Microorganisms capable of fixing N_2 and mobilizing phosphate and potassium ions in soil are often considered for biofertilizers. In Sri Lanka, attempts have been made to partially replace chemical fertilizers with biofertilizers. Improving N availability for plant uptake using N_2 fixing cyanobacteria based biofertilizers (NFCB) has been successfully trialed. The field trials conducted for two seasons at one location indicated the ability to successfully reduce urea application by 25% when NFCB is applied along with urea in the first top dressing. Application of phosphate solubilizing bacteria (PSB) inoculum significantly increased ($P < 0.05$) plant available P fraction in soil at maximum tillering. However, the impact of applying PSB and P fertilizers on rice yield were significant ($P < 0.05$) only when the crop was managed under alternate wetting and drying conditions. The crop grown in the same soil was not responsive to P fertilization when managed under continuously flooded condition. Results confirmed that inherent soil characteristics and management of soil moisture level affect P availability in soil and effectiveness of PSB in managing P nutrition of rice. Further research is being conducted to evaluate the performance of PSB and NFCB in a wide range of environments using farmer participatory research approach and the possibility of including these in site specific nutrient management recommendations.

The activity of microorganisms and nutrient availability in soils are affected by inherent soil characteristics and management practices, especially those affecting moisture levels. Therefore, developing biofertilizers that would perform equally under different agroecological conditions and under different water management systems is challenging. Information generation is necessary for designing best management practices to promote biofertilizer application. Biofertilizers can be a promising alternative or supplement to chemical fertilizers but require more research to facilitate decision making for wide-scale adoption.

Key words: Rice, site specific nutrient management, biofertilizers

Interactive Effects of Organic Amendments, Mineral Fertilizers and Gypsum on Microbial Use Efficiency, Soil Structure, and Carbon Priming in a Dispersive (Sodic) Subsoil

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Subsoil sodicity is one of the main constraints to soil functionality, productivity and sustainability, particularly in arid and semi-arid regions. In recent years, the deep placements of amendments such as the integrated inputs of plant residues, mineral nutrients [i.e., nitrogen (N) and phosphorus (P)] and gypsum to ameliorate physicochemical constraints in dispersive (sodic) subsoils have received much attention. However, there are knowledge gaps on the role of these amendments and organic resources' carbon (C)-nutrient stoichiometry on soil structure (e.g., aggregation), as well as microbial C-use efficiency (CUE), and soil C storage in sodic-subsoils. To address these knowledge gaps, we conducted up to a nine-month laboratory incubation experiment (20°C). A sodic subsoil collected from under C_3-vegetation (δ^{13}C-SOC: –24‰; soil organic C content: 5.8 g C kg-1 soil) was uniformly mixed with C4-vegetation derived organic amendments (OAs) (δ^{13}C: –14‰; including sorghum stubble, sugarcane bagasse and mill mud and/or mill ash at the application rate of 6.2 g C kg^{-1} soil), with and without exogenous supply of nutrients or gypsum. A wet-aggregate sieving procedure was used to obtain four soil fractions: large macro-aggregates (2–6.5 mm), small macro-aggregates (0.25–2 mm), micro-aggregates (0.053–0.25 mm), and silt-clay (< 0.053 mm). Total C and OA-derived C in the aggregate-sizes have been analyzed. The results show that the cumulative OA-C mineralization ranged between 70 and 630 mg CO_2-C g^{-1} OA-C across the treatments over nine months. The CUE of OAs was the highest in the mill mud-treated subsoil (0.25–0.80) and the lowest in the sorghum stubble-treated subsoil (0.07–0.42). The inherently balanced C-nutrient stoichiometry of OAs (such as mill mud) enhanced CUE, whereas lowering the imbalanced nutrient stoichiometry of other OAs (sorghum stubble, sugarcane bagasse) *via* exogenous nutrient inputs increased microbial growth but not CUE. Over nine months, extra 0.7–8.3% of native soil organic carbon (SOC) was lost *via* priming across the treatments. In the first three months, the positive priming effect (PE) by the OAs was the highest in the sorghum stubble-treated subsoil, which was mainly driven by microbial co-metabolism and N mining. At the later stage, the balanced resource nutrient stoichiometry enhanced the PE. The input of OAs (with or without exogenous nutrients and gypsum) increased soil macro- and micro-aggregation, with the greatest increase (6–7 folds) when a combination of OAs, gypsum and exogenous nutrients was applied. The preliminary results showed that the increased microbial biomass and activities might have enhanced the association of OAs with soil minerals, leading to the improvement of soil aggregation. The dissolution of Ca^{2+} from gypsum

has also further enhanced the formation and stability of macro-aggregates. This study suggests that balancing the C-nutrient stoichiometry of OAs can increase bio-chemical processes, such as microbial degradation of OAs, microbial growth and positive SOC priming, which may enhance nutrient availability while improving soil structural stability during amelioration of sodic-subsoil constraints. Our study also provides insights on the role of decomposition process of OAs on soil aggregate formation, including aggregate-associated C storage, in the dispersive sodic-subsoil.

Key words: Soil constraints, Soil amelioration, Microbial biomass, Carbonisotope

Using ICT for Natural Resource Management for Smallholder Farmers: What Works and What Doesn't !!

Sheetal Sharma

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Information and Communication Technology is increasingly becoming a part of the solutions sought for different aspects in both rural and urban areas. It is helping to diminish the information divide that exists in the society in general and in agrarian society in particular. There are many tools which have been developed and are being used by the researchers and extension staff to access latest information as well as transfer those to the farming community. ICT for agriculture initiatives prove to be more beneficial for small holder farmers to meet the plot-specific requirements. These farmers need real time information on availability of quality seeds, fertilizer management, weather forecast, insect-pest attacks,and market prices. The existing extension system faces limitation in terms of personnel resources, infrastructure, skillsets, capacity, knowledge base and hence researchers, donors, policy makers and implementers have acknowledged the role of ICT tools in agri-extension. While ICT tools help in transferring these information to the farmers in a much faster way, the use of these information or the adoption of the technologies depends on the reliable and good quality of content,availability of the tool, ease of operations, visible results and benefit over the existing practices. In developing countries, as the internet and availability of smart phones is still limited, it restricts the scaling up of these tools. Even for the farmers with an access to internet and smart phones, many times the technical backup and support to fix the issues which arise while running the tool is not available. It results in frustration and discontinuation at the user end. In order to make the small holder farmers benefit from the ICT tool, their requirement and context should be taken into account right from the inception stage. The next step is to ensure capacity building of the existing extension system to provide awareness and technical backup. Once the technology is able to register its advantages and changes farmer's usage behaviour, the demand-driven approach can be applied to make it scalable. Researches have shown that any service is more valued if it comes with a price. On the similar line, International Rice Research Institute have been promoting the ICT tool "Rice Crop Manager" in India and till date around 1 lakh 75 thousand farmers have been reached. The tool provides site-specific recommendations in local language to the farmers based on their crop management practices. In order to scale out, the plan is to make the recommendation available at Common Service centers at a nominal price. Framers who have been following the recommendations have reported an economic gain of USD 188/ha per season in rice crop.

Key words: ICT tools, Rice crop manager, awareness

Evaluation and Refinement of Zinc Management Options for Site-Specific Nutrient Management in Eastern India

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Zinc (Zn) is now considered the fourth most crucial yield-limiting nutrient after, nitrogen, phosphorus and potassium, respectively. Its deficiency causes a significant decline in yield and quality of rice crop. The role of timing and dose of application of Zn that is pre-requisite for getting better crop yield and to improve its use efficiency. Zn management in rice crop requires serious attention as inappropriate knowledge of application rate and timing may result in imbalance application of commercial Zn fertilizers, a costly fertilizer for farmers. An on-farm study was conducted in the different districts of Odisha state, India in order to understand the effect of timing and dose of Zn application in site specific based nutrient management 95 farmers were selected from five districts of Odisha, India and nutrient management through rice crop manager (RCM) was provided. Following treatments were imposed in the field of these farmers: 1) 50 kg/ha zinc sulphate in nursery 2) 100 kg/ha zinc sulphate in nursery 3) 12.5 kg/ha zinc sulphate in transplanted field 4) 25 kg zinc sulphate in transplanted field 5) Compost in nursery (control).Data for crop cut from these treatments werecollected and analyzed. Treatment wise grain yield on an average is depicted in Figure 1. The highest yield was recorded in the application of 25 kg zinc sulphate in transplanted field, which was 0.38 t/ha significantly higher than control. Overall, an added return of 6670 INR/ha was observed in 25 kg zinc sulphate application in transplanted field over the control that is compost application in nursery. However, the timing and dose of Zn application did not show any significant difference in terms of grain yield among all Zn applied treatments. Zn management in nursery had saved a significant amount of Zn fertilizer over transplanted field.Overall, this study suggests that zinc management in nursery and half dose of blanket recommendation of Zn (25 kg zinc sulphate in transplanted field)is sufficient for rice growth and optimum yield and therefore, these can be better options for zinc management for site specific nutrient management in Eastern India.

Key words: Nursery management, Grain yield, Added returns, Precision nutrient management

Impact of Split Application of Potassium Fertilization on Partitioning and Availability of Potassium at Different Growth Stages of Rice in Calcareous Soil

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Imbalanced application of potassium is diminishing crop yield and mining the potassium (K) from the soil. The knowledge on periodic uptake, accumulation and allocation of potassium to different parts of a rice plant should receive urgent attention in order to implement K management practices for sustainable rice production. Therefore, a field experiment was conducted in calcareous soil (medium in available K) in split-plot design with two rice varieties (Inbred and Hybrid) in main plot and six combinations of potassium management [control, NP (-K); NP+K(100% basal); NP+K(50% basal + 50% tillering); NP+K(50% basal + 50% panicle) and NP+K(50% basal + 25% tillering + 25% panicle)] in sub-plot at Experimental Farm, RPCAU, Pusa, Samastipur, during *kharif* - 2017.

The results revealed that the potassium content and uptake increased significantly with the application of potassium in three splits (50% basal + 25% tillering + 25% panicle) as compared to the treatment where potassium was applied only as basal dose (recommended practice). The availability of K in the soil at different growth stages of rice was found to improve with split applications of potassium over basal application. At tillering stage, available K was highest in the plots receiving split applications of K *i.e.* 50% basal + 50% tillering, while, at panicle and milking stage, available K was highest in plots with split application of K *i.e.* 50% basal + 50% panicle. At maturity, it was highest in the plots with three split applications of K (50% basal + 25% tillering + 25% panicle).

Thus, it can be concluded that synchronization of split applications of potassium (50% basal + 50% panicle or 50% basal + 25% tillering + 25% panicle) with nitrogen can result in significantly higher yield of rice and K uptake compared to basal application. Although, the K rates for fertilizer recommendation need to be revised to account for the negative K balance in soil.

Key words: Nutrient omission plot, rice, maize, nutrient uptake

Performance Evaluation of AquaCrop Model for Rice Crop Grown Under Surface and Subsurface Drip Irrigation in Tarai Region of Uttarakhand

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The present study was carried out to investigate the performance of AquaCrop model under different irrigation methods for rice crop. Field investigation was carried out to evaluate the AquaCrop Model for rice crop grown under different methods of irrigation at Vegetable Research Centre (VRC), GBPUA&T, Pantnagar. It was noted from the literature that AquaCrop model released during 2009 has not been evaluated for simulating yield of rice crop. The AquaCrop model was calibrated for simulation of yield and biomass of rice crop for all treatments with the prediction statistical errors of $0.75 < E < 0.92$, $0.13 < RMSE < 0.27$, $0.92 < R^2 < 0.97$ and $0.58 < MAE < 0.99$ t ha^{-1}. The model was validated for rice crop yield and biomass with all treatment combinations with prediction statistical errors of $0.90 < E < 0.97$, $0.18 < RMSE < 0.09$, $0.90 < R^2 < 0.98$ and $0.48 < MAE < 0.50$ t ha^{-1}.

Key words: AquaCrop model, Water use Efficiency, Subsurface drip irrigation

Nutrient Management for Sustainable Rice Production under Rainfed Upland Ecology

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Rice is one of the most important crops globally and also significantly contributes to the food requirement of Indian population. In uplands (both unfavourable; *unbunded* and favourable; *bunded*) rice is cultivated as direct seeded crop (direct seeded rice; DSR) to address the water crisis in rainfed ecology with irregular rainfall pattern which is more acute in present climate change scenario. Average grain yield of upland rice are generally low in most of the regions due to many environmental stresses and use of low inputs by farmers. Productivity from rice and rice based cropping system (RBCS) can be increased with suitable soil management related to moisture conservation, soil fertility, acid soil amelioration etc. along with the some agronomic management practices. With this background a field experiment was conducted in rainfed upland (favorable) ecology with eight nutrient management options (inorganic, integrated and organic) under three (RBCS viz; rice sole, rice intercropped with pigeon pea and rice sequence cropped with chick pea). Varieties used for this experiment were Sahabhaghi dhan (rice), Birsa arhar-1(pigeonpea) and 24 carat gold (chickpea). Nutrient management options were selected to provide the optimum requirements from both inorganic and organic sources as well as integrated sources. The result of the first year experiment, revealed that 100% RDF resulted in significantly highest grain and straw yield of rice followed by integrated nutrient management (50% RDF + organic source of nutrients) and organic treatments. This experiment was formulated to see the effect of nutrient management on sustainable rice production while marinating the soil health as well. This needs further investigation with the ongoing experiment.

Key words: Upland rice, Nutrient management, System productivity, Soil health

Field Specific Nutrient Management in Rice using Crop Manager: An Aid to Improve Economic Status of Indian farmers

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Nutrient management in diverse rice growing areas is a big challenge and should consider the field and crop specific conditions. Rice Crop Manager (RCM) is a tool that advocates field specific rates of fertilizers and crop management options for rice. The RCM recommendation considers the adjustment of N rate for a target yield set higher than the yield reported by the individual farmer and lowers application of phosphorus and potassic fertilizers. Over one lakh RCM recommendations were generated and provided to the respective farmers in Odisha state of India for disseminating the concept of field specific nutrient management. Their fields were monitored and managed as per recommendations. However, under strategic and adaptive research, several trials (RCM vs FFP head to head trials, zinc management options trials, nutrient management trials in rainfed and stress conditions with locally cultivars and improved site suited stress tolerant cultivars, weed management trials, nutrient management trials in direct seeded rice, GIS tool based setting target yield trials) for refining nutrient and crop management in irrigated and rainfed conditions with various crop establishment methods like transplanted and direct seeded rice using locally available cultivars as well as improved situation specific stress tolerant cultivars with various nursery, soil and weed management options were conducted in different districts of Odisha with a GIS based target yield approach. Data from different crop cuts of various trials were analyzed and further used for refining RCM for the state. The results indicate a consistent yield gain in ranging from 0.5 to 2.5 t ha^{-1} with phosphatic and potassic fertilizer application at doses lower than the farmers' practice. The reduction in use of phosphatic fertilizers ranged from 40 to 60 per cent over the farmers' fertilizer practice (FFP). The additional return obtained due to increased rice yield and reduced fertilizer application an average of Rs 16,500 per hectare. Greenhouse gases (GHG) emissions attributed to fertilizer application were estimated using the CCAFS-MOT and found to be reduced by an approximate of 7.5 per cent using RCM as compared to FFP. It appears that field specific nutrient management in rice through RCM can bring prosperity in the life of Indian farmers by supporting the Indian government's ambitious target of doubling the income of farmers.

Key words: Precision nutrient management, Rice crop manager, Farmer fertilizer practice, Target yield, Rainfed condition

ABSTRACTS

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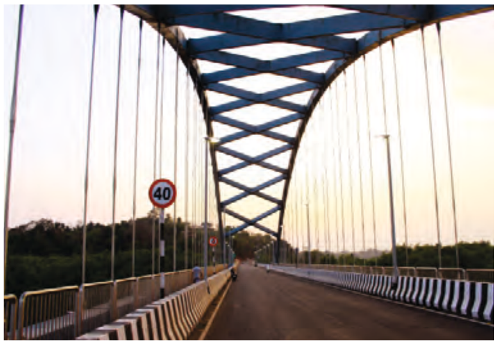

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