An ecosystem approach to restoring and conserving soil and water in degraded lands of the pacific island of Guam. *Golabi M.H., S.A. El-Swaify, C. Iyekar, and Edward Paulino. College of Natural and Applied Sciences, University of Guam and the University of Hawaii in Monoa. mgolabi@guam.uog.edu

Abstract:

Severely eroded lands of southern Guam are referred to as badlands. These are actively eroding areas of very deep, well–drained saprolite derived from tuff and tuff breccia. These badlands are exposed to overland flow, wind and rain causing sever erosion as the result of rapid runoff from the pitted, sloping sites that are void of vegetation.

In order to control the accelerated soil erosion and restore the land resources in southern Guam, an integrated approach is designed to evaluate a variety of options, including the effect of conservation tillage, crop rotation with leguminous plants, and residue management for soil surface cover. The objectives of this project are: 1) To evaluate cropping rotation and tillage management for increasing the organic matter content and improve the overall quality of these severely eroded soils (2) To evaluate the restoration of the productivity of eroded soils and (4) To assess the effects of conservation practices and restoration techniques on water runoff and infiltration.

In this presentation, the methodology as well as up-to-date data will be presented to illustrate the effect of restoration and conservation strategies on the severely eroded soils of southern Guam.

The problem: Accelerated erosion as a consequence of poor soil quality threatens both the soil resource base and downstream environment in the island of Guam. These threats are manifested more seriously in the southern part of the island. The challenge facing soil and agricultural scientists therefore is to develop conservation strategies that restore the soil and improve their quality for crop production and environmental quality. In this investigation, the effectiveness of the applied conservation techniques on controlling runoff and hence reducing soil erosion is being evaluated. Cropping systems such as no-till and reduced till planting as soil erosion control techniques on a typical degraded soils in southern Guam are being evaluated. Also sunnhemp is being used in rotation to the corn crop to maintain surface cover between planting and also as green manure in order to improve the quality of soils under study. The principal method of controlling soil erosion and its accompanying rapid water runoff is to maintain adequate vegetative cover at all times which is the main objective of this project.

Objectives: The overall objective of this project is to evaluate the effectiveness of conservation practices on the control of soil erosion. In this investigation the effectiveness of surface residue management for controlling runoff hence, erosion on these soils will be evaluated. In a companion study the effect of land application of composted organic waste is being evaluated and reported as part of overall ecosystem approach for restoring and conserving soil quality in degraded lands of southern Guam.

FIELD EXPERIMENTATION AND METHODS

A set of twelve field plots (28ft X 33ft) were set up at the University of Guam Ija and Inarajan Experiment Stations in Southern Guam for this project. Plots were planted with sunnhemp seeds to provide nitrogen source and surface cover before corn planting in November of 2002. Control plots however were left fallow and without cover at all times before planting. Sunnhemp was cut using bush cutter after it reached flowering stage. The sunnhemp residue was tilled in just before the corn was planted.

In order to avoid problems associated with irregular rain events, irrigation lines were laid out immediately after the sunnhemp was cut and before the corn seeds were planted. Soil samples were taken and analyzed for initial chemical and physical property evaluations (table 1). Corn was planted on July of 2003 and rotated with sunnhemp year round ever since. Attempt was made to plant irrigated corn during the dry season and sunnhemp during the wet season.

In order to evaluate the effectiveness of conservation techniques on these soils degraded by erosion the following regimes was practiced:

a) No-Tillage (NT)
b) Reduced Tillage (RT)
c) Conventional Tillage with Sunnhemp Rotation (CT/SH)
d) Conventional Tillage without sunnhemp (CT) (control)

These regimes represent a wide range of practices that are being evaluated as conservation and restoration techniques. The conventional regime consists of tilling before and after planting and will serve as control treatment. These regimes will consist of conventional tillage without sunnhemp meaning no sunnhemp will be planted prior to corn, and conventional tillage with sunnhemp in which sunnhemp will be planted as rotation crop to corn. The conventional tillage without sunnhemp will be the yardstick for erosion measurements and of potential and is considered as control treatment for comparison with all the other treatments. The no-tillage treatment with zero tillage will represent the most effective treatment in term of erosion control technique. In reduced tillage, the soil surface is left un-disturbed after each harvest and tilled only before planting for bed preparation.

Following each round of harvest corn crop is being used for yield evaluation and soil samples are being analyzed for soil property evaluation. Also in this investigation rainfall simulator are used to measure runoff in order to evaluate the effect of conservation techniques for water erosion control on the soils under study.

Preliminary Results:

As stated in the objectives, improving the soil quality for the purpose of soil conservation and sustainability is the overall goal of this project. As shown in Table 1., preliminary result indicated that the pH was low in all plots. Required lime was applied to correct the pH at acceptable level of 6.5.

Table 1. : Ija Soil Residue Management Project: Some Physical and Nutrient Base Data (Short version of table 1)

Treatment	Bulk Density (g/cm^3)	pH	OM (%)	o-PO4 (mg/kg)	NO3 (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
NT	1.34	5.36	4.12	1.38	0.80	347	1878	2128
RT	1.23	5.32	3.80	1.27	0.59	327	1947	1227
CT	1.25	5.42	4.43	1.50	0.64	312	1897	2809
CT-SR	1.26	5.32	3.90	1.17	0.62	312	1879	2645

CT = Conventional Till (Control) RT= Reduced Till
CT-SR = Conventional Till with Sunnhemp Rotation NT = No-Till

Characterization of soil quality indicators and changes as a result of restoration will be carried out following the recent crop growth cycle. Rainfall simulator is being used to evaluate the effect of conservation techniques on water infiltration and runoff for each individual plots (Fig. 1).

Yield data from 2005 harvest indicated that although there was not significant difference between the treatments, the conventional treatment produced the highest and the no-till treatments produced the lowest yield as compared with other treatments. The high yield under the conventional tillage treatment can be contributed to the absent of weeds in conventional till plots due to frequent tilling. The low yield from the No-till treatment however, is due to number of factors namely; degradation of soil quality due to low aeration, compaction, and aggressive weed growth typical of no-till practices. It is expected that the no-tillage treatments will produce higher yield as the soil quality improves gradually under persistent and long-term no-till treatments.

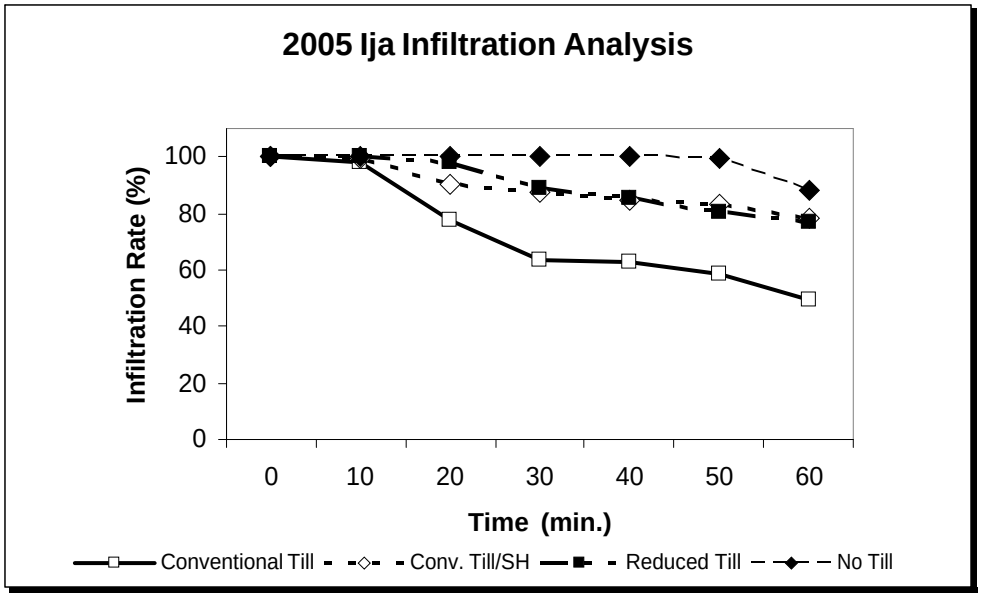
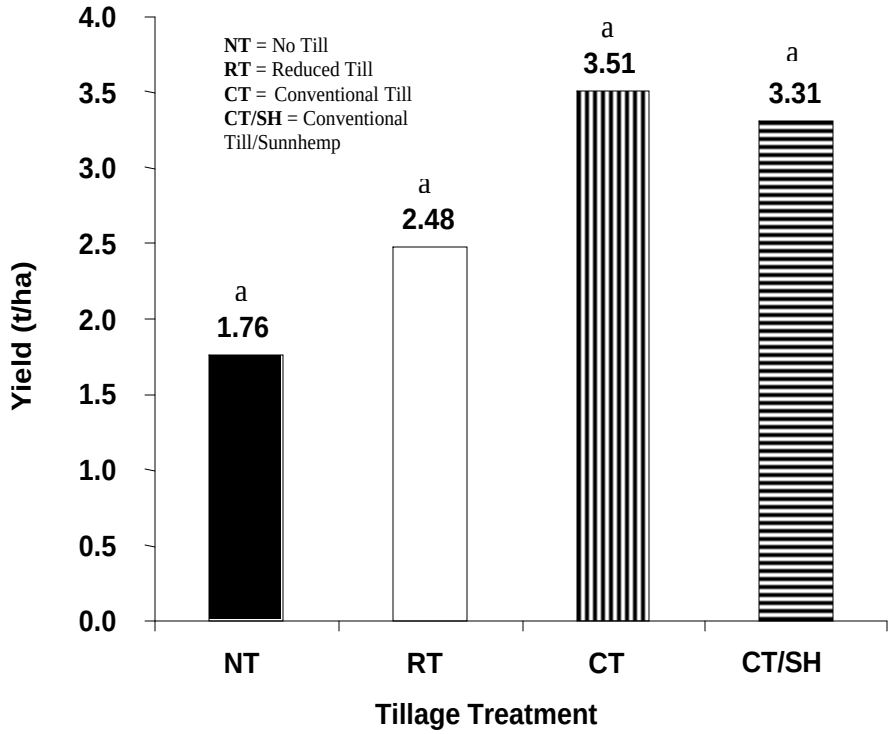


Fig. 1: Infiltration (%) measured under different tillage treatments

Fig. 2.: 2005 Ija Harvest Average Yield per Tillage Treatment



*Bars represent treatment means based on Fisher's t-test.
*Letters represent t-grouping based on LS means (P<0.05).

Impact: An integrated approach is designed to evaluate the effect of conservation tillage, crop rotation with leguminous plant for organic matter build up, and residue management for soil re-habilitation and restoration of the badlands in Southern Guam. In our companion study we are using composted organic waste not only as organic amendments for enhancement and maintenance of soil quality and productivity but also for reducing the erodability of these degraded soils. We anticipate that the results of these two companion studies not only provide good database for assessing the extent of soil erosion but the data will provide information on effectiveness of the restoration techniques being applied for soil conservation on these and other similar soil condition in the Western Pacific islands.

The educational impact of these projects already have proven to be of a great value since some farmers started to consider rotating their corn crop with sunnhemp and use sunnhemp as green manure and cover crop during the rainy season. Also some farmers have started using compost as soil amendments and are pleased with the results. The educational impact of this investigation will prove to be of great value not only to farmers but also to ranchers and the other members of the communities of the pacific islanders whom are concerned about the degradation of soils and the natural resources of these islands.