Crop Residue Management to Conserve Soil,Water and Nutrients for Sustainable Production in the Vertisols of Semi-Arid Tropics of South India

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Abstract: Runoff and soil loss was reduced to minimum in sorghum+legume incorporated into the soil and sorghum + legume grown for grain purpose. Maximum runoff and soil loss was observed under control (sorghum) with no disturbance to soil. Higher soil moisture in top 45 cm soil profile was observed in plots under sorghum + legume incorporated into the soil. Highest sorghum grain (2,073 kg • ha^{-1}) was recorded in sorghum + legume incorporated into the soil followed by sorghum + legume used as mulch (1,870 kg • ha^{-1}) was as a result of higher values of yield components in sorghum. The treatment where sorghum + legume grown for seed purpose recorded significantly higher sorghum grain equivalent (2,696) over rest of the treatments except sorghum + legume incorporated into the soil. At the end of four seasons, soil analysis indicated that organic carbon, available N, P, K and mean weight diameter of aggregates was higher in treatments where legume was grown or incorporated into the soil with sorghum compared to rest of the treatments. Growing up of legume with sorghum for grain purpose or incorporated into the soil improved the soil physico-chemical properties, crop growth and yield and reduced runoff and soil loss.

Keywords: runoff, soil loss, moisture, nutrients, legume, crop residues

1 Introduction

Crop residue is an important renewable resource that can be used to conserve non-renewable soil and water resources and sustain crop production. Water induced erosion affects about 50 per cent of geographical area in India causing annual loss of 5,334 million tonnes (16.4 t • ha^{-1}) soil and 5.37 to 8.4 million tonnes of nutrients (Dhruvanarayana and Rambabu, 1983). Management of land cover at surface and above ground has proved a powerful tool to control beating action of rainfall, detachment as well as transport of soil particles and losses of soil, water and nutrients, which are crucial for sustainable production. Improve in canopy cover by strip or intercropping, surface land cover through mulching and crop residues are known for erosion control (Singh *et al*., 1979). However, availability of mulching material due to competition for cattle fodder poses serious limitation in India. The soils of the region are clayey with poor structure, low infiltration, highly erodible, alkaline in reaction and cracks heavily on drying. In these soils dryland/rained agriculture is the major land use and as such they remain devoid of vegetative cover during most part of the year and are more prone to erosion resulting in dimnished crop yields.

Earlier studies have revealed that *in situ* decomposition of organic matter helps to improve soil structure, organic matter content and availability of nutrients. In drylands because of low rain fall, moisture is the major limiting factor for decomposition of organic residues. However, if small tender leaves of leguminous plants or materials having low C∶N ratio are added by adopting appropriate farming systems, the added organics will decompose faster and thereby improve the physical conditions of the soil apart from increasing availability of nutrients and crop yields. Further, crop residues also conserve water by reducing runoff and evaporation which is paramount for economic crop production in the drylands of semi-arid tropics. Past experience has shown that climatic limitations under Bellary conditions do not permit raising any crop during *kharif*, the crop residue which could be utilized for either incorporating or for mulch purpoose. Hence, it is planned to generate on-farm organic matter by raising intercrops during *rabi* season itself which could serve the purpose and hence the present study was initiated to know the effect of residue management on soil erosion, moisture conservation, physico-chemical properties of soil and crop production.

2 Materials and methods

The experiment was carried out at the research farm of the Central Soil and Water Conservation Research Centre, Bellary during 1998—2001. The soil at the experimental site belongs to Bellary series and are classified as fine montmorillonitic, gypsiferrous, hyperthermic, typic pellusterts (Vertisols). The experiment was conducted on deep soil and the clay content in the soil increased with increase in soil depth from 45 per cent (surface) to 51 per cent (60 cm—90 cm depth).The soil pH ranged from 8.4 to 8.7 with available nutrient content of 150 kg N, 22 kg P_2O_5 and 650 kg K_2O per ha.

Five treatments consisted of (1) control (sorghum) without disturbance of soil (2) sorghum+legume for grain purpose (3) sorghum + legume used as mulch (4) sorghum + legume incorporated into soil and (5) sorghum with interculture (soil disturbance). The experiment was laid out in a randomized block design with five replications. The size of net plot was 8.0 m $\times$ 5.4 m. Sorghum (Cv.SPV-86) and *dolichos* (Cv.CO-7) were sown with the onset of northeast monsoon during September and were harvested on different dates depending upon maturity with recommended package and practices. Sorghum was sown at 60 cm spacing and two rows of *dolichos* were raised in between sorghum in treatments (2,3 and 4). Cropping season rainfall was 275.8 mm,154.2 mm and 175.9 mm during 1998—1999,1999—2000 and 2000—2001 respectively. Observations on moisture were recorded at 30 days interval from sowing till harvest. In treatment (2) the legume was grown for grain purpose and at harvest legume residue was incorporated. Whereas legume crop was cut at 45 days after sowing (DAS) and used as mulch in treatment (3) Legume was cut and incorporated into soil at 45 DAS in between the sorghum rows in treatment (4). Interculturing thrice was carried out in treatment (5). Observations on yield and yield components of sorghum were recorded at harvest. For the purpose of effective comparison between the treatments, based on the prevailing rates the yields of sorghum and *dolichos* were converted into sorghum grain equivalent. Surface soil samples (0 cm—15 cm and 15 cm—30 cm) were collected from the experimental plots after the harvest of the each crop and analysed for organic carbon, (Walkley and Black’s method) total nitrogen (Kjeldhal method), available phosphorous (Olsen’s method) as described by Jackson (1967). Available potassium content was analysed by extracting with natural normal ammonium acetate photometrically (Black, 1965).

3 Results and discussion

Runoff and soil loss: During post sowing period, there were nine runof causing events in 1998—1999 and eight runoff causing events in 1999—2000 and 2000—2001. Total runoff causing rain rainfall was 257.9 mm, 297.5 mm and 288.5 mm during 1998—1999, 1999—2000 and 2000—2001 respectively. Minimum runoff (118.1mm) and soil loss (3,825 kg • ha^{-1}) occurred in the sorghum + legume incorporated into the soil (Table1) followed by the treatment sorghum + legume and sorghum + legume used as mulch. The treatment sorghum + legume incorporated into the soil has improved physical conditions of soil and in sorghum + legume (*dolichos*) crop provided good cover till the harvest of crop. Hence, minimum runoff and soil loss were observed in these treatments. Maximum runoff (131.8 mm) and soil loss (4,979 kg • ha^{-1})occurred under control (sorghum) with no disturbance to soil.

Table 1 Runoff and soil loss as influenced by residue management

Treatment	Runoff (mm)				Soil loss (kg • ha^{-1})			
	1998—1999	1999—2000	2000—2001	Average	1998—1999	1999—2000	2000—2001	Average
T1 Control (Sorghum) Without disturbance of Soil	129.3	141.8	124.3	131.8	5 286	5 526	4 424	4 979
T2 Sorghum + Dolichos (grain purpose)	121.8	134.2	101.5	119.2	4 134	4 381	3 154	3 890
T3 Sorghum + *Dolichos* As mulch	126.6	135.8	103.1	121.8	4 798	4 571	3 627	4 332
T4 Sorghum + *Dolichos* Incorporated into soil	124.1	130.7	99.4	118.1	4 184	4 149	3 141	3 825
T5 Sorghum with interculture (soil disturbance)	127.6	140.3	106.7	124.9	4 932	5 007	3 650	4 530

Runoff causing rainfall = 257.9 mm (1998—1999), 297.5 mm (1999—2000), 288.5 mm (2000—2001).

Grain yield: Higher sorghum grain yield of 27,691,787 kg • ha^{-1} and 1,662 kg • ha^{-1} were recorded in sorghum + *legume* incorporated into the soil during 1998—1999,1999—2000 and 2000-2001 respectively. In the pooled data, higher sorghum grain (2,073 kg • ha^{-1}) and straw yield (3,149 kg • ha^{-1}) was recorded in sorghum + legume incorporated into the soil with similar trend being observed in the individual years of study (Table 2).Similarly, inorporation of subabul loppings proved beneficial over FYM and vermicompost for sorghum in the vertisols of Bijapur (Patil, 1998). The next best grain yield was observed in the treatment wherein the legume was used as mulch (1,870 kg • ha^{-1}) in the pooled data and 2,531 kg • ha^{-1}, 1,584 kg • ha^{-1} and 1,662 kg • ha^{-1} during 1998—1999, 1999—2000 and 2000—2001 respectively. The treatment with sorghum+legume used for grain purpose, the sorghum yield was higher compared to control in the pooled data (1,588 kg • ha^{-1}). From the above results it is clear that the treatment with incorporation of legume proved beneficial compared to rest of the treatments by conserving higher moisture and nutrients in the soil profile for obtaining higher yields (Fig. 1). The yield components also showed similar trend as that of grain yield (Table 3). Higher sorghum yield was observed in the treatment with legume as incorporated was mainly attributed to higher dry matter accumulation in the panicle with higher 1,000 seed weight and larger panicle size (length) compared to the rest of the treatments. Higher straw yield is also due to better plant growth with higher soil moisture in the above treatment compared to the rest. Sorghum + *dolichos* grown for grain purpose recorded significantly highest sorghum grain equivalent (2,696) which was higher by 79 per cent cover control (1,509) in the pooled data. Similar trend was also noticed during all the years of study.

Table 2 Grain and straw yield of sorghum (kg • ha^{-1}) as influenced by residue management

Treat Ment	Grain yield (kg • ha^{-1})				Straw yield (kg • ha^{-1})				Sorghum grain equivalent (SGE)			
	1998—1999	1999—2000	2000—2001	Pooled	1998—1999	1999—2000	2000—2001	Pooled	1998—1999	1999—2000	2000—2001	Pooled
T1	1,794	1,046	991	1,277	3,163	1,562	1,480	2,068	2,111	1,202	1,213	1,509
T2	2,159 +405	1,352 +301	1,253 298	1,588 +335	3,742	1,982	1,842	2,522	3,418	2,307	2,364	2,696
T3	2,531	1,584	1,496	1,870	3,810	2,354	2,223	2,796	2,912	1,821	1,830	2,188
T4	2,769	1,787	1,662	2,073	4,422	2,597	2,427	3,149	3,211	2,045	2,027	2,428
T5	2,243	1,407	1,333	1,661	3,503	2,145	2,032	2,560	2,593	1,621	1,638	1,951
SEm±	-	-	-	-	-	-	-	-	108	98	93.0	99.5
CD(P=0.05)	-	-	-	-	-	-	-	-	322	293	280.0	298.6

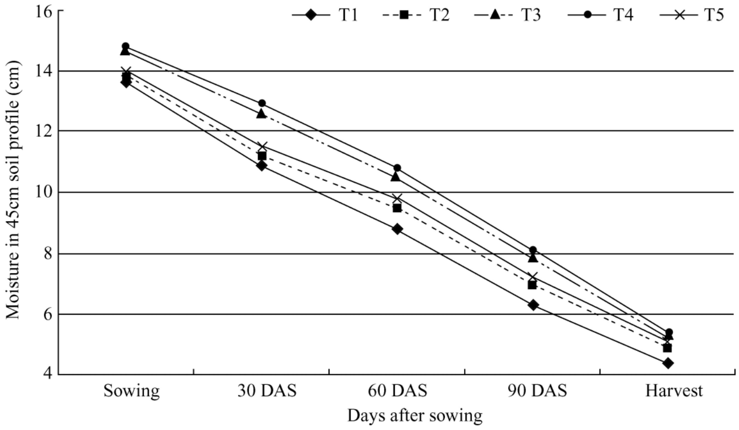

Fig.1 Soil moisture (cm) in top 45 cm soil profile as influenced by residue management (2000—2001)

Table 3 Growth and yield components as influenced by residue management in *rabi* sorghum

Treatments	Plant height (cm)			Panicle length (cm)			Panicle diameter (cm)		
	1999—2000	2000—2001	Pooled	1999—2000	2000—2001	Pooled	1999—2000	2000—2001	Pooled
T1	138.4	133.5	135.9	13.5	12.7	13.1	11.1	11.6	11.4
T2	145.1	141.5	143.3	15.6	15.6	14.8	12.3	13.2	12.8
T3	144.5	142.9	143.7	18.3	18.3	16.3	14.4	14.1	14.3
T4	146.1	149.5	147.8	19.8	19.8	17.6	15.6	15.8	15.7
T5	137.3	144.7	141.0	16.8	16.8	15.5	13.7	14.1	13.9
SEm±	4.54	6.34	5.44	0.29	0.29	0.37	0.31	0.46	0.38
CD (P=0.05)	NS	NS	NS	0.86	0.86	1.11	0.94	1.39	1.16

Table 4 Yield components as influenced by residue management in *rabi* sorghum

Treatments	Panicle weight (g)			1000 seed weight (g)		
	1999—2000	2000—2001	Pooled	1999—2000	2000—2001	Pooled
T1	25.3	20.8	23.1	22.80	22.50	22.65
T2	36.3	31.7	34.0	25.24	26.60	25.92
T3	53.3	37.2	45.3	26.76	27.50	27.13
T4	62.8	48.1	55.5	27.86	28.40	28.13
T5	47.8	37.9	42.9	25.86	26.90	26.38
SEm±	1.48	1.72	1.60	0.72	0.75	0.73
CD (P=0.05)	4.44	5.16	4.80	2.14	2.25	2.19

4 Soil properties

Changes in physico-chemical properties of soil as a result of different treatments have been analysed and are presented in Table 5. The difference in soil properties was observed with various treatments at the end of four seasons. However the significant difference was noticed only in respect of pH, organic carbon, available nitrogen and mean weight diameter of aggregates in the surface soil (0—15 cm).

Table 5 Physico-chemical properties of soil as influenced by residue management

Treatments	pH (1：2.5 H_2O)	Ec ($dS \cdot m^{-1}$)	Organic carbon ($g \cdot kg^{-1}$)	Available nutrients ($kg \cdot ha^{-1}$)			MWD of aggregates (microns)
				N	P_2O_5	K_2O	
0—15 cm							
T1	8.8	0.276	3.7	165	28	514	582
T2	8.5	0.249	3.9	199	36	540	688
T3	8.7	0.243	3.8	198	34	533	685
T4	8.5	0.229	4.0	202	37	559	696
T5	8.6	0.231	3.6	183	30	520	589
Sem±	0.03	0.013	0.011	8.7	2.0	20.7	11.80
CD (P=0.05)	0.09	NS	0.033	26.0	NS	NS	35.34
15—30 cm							
T1	8.9	0.283	3.3	160	26	461	561
T2	8.7	0.259	3.4	167	30	481	583
T3	8.8	0.253	3.4	153	28	482	601
T4	8.8	0.241	3.5	167	30	492	602
T5	8.8	0.268	3.3	165	25	472	569
Sem±	0.02	0.008	0.1	8.9	2.0	14.9	16.24
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

The treatment sorghum + legume incorporated into the soil and sorghum+legume grown for grain purpose decreased the pH significantly over control by 0.3 unit which was mainly attributed to the production of acids on decomposition of organic residue and due to their acidic residual effect (Alok Kumar and Yadav, 1993). Electrical conductivity did not vary much with different treatments. The pH values ranged from 8.5—8.8 and EC varied from 0.231 to 0.276 $dS \cdot m^{-1}$ in surface. Irrespective of treatments, pH and EC in the soil increased with advancement of depth from 0—15 cm to 15 cm—30 cm. Organic carbon content was significantly higher in sorghum + legume incorporated into the soil (4 $g \cdot kg^{-1}$) followed by sorghum + legume used as mulch (3.8 $g \cdot kg^{-1}$). Increase in organic carbon might be attributed to addition of organic manures and high root activities and their addition (Prasad and Singh, 1980). Similar trend was observed under 15 cm-30 cm depth. Organic carbon available N, P_2O_5, K_2O and mean weight diameter of aggregates were also found to decrease with increasing depth of soil. Available N content was significantly higher (202 $kg \cdot ha^{-1}$) in sorghum + legume incorporated into the soil, followed by sorghum + legume for grain purpose(199 ha^{-1}) as compared to control (sorhum) without distrubance to soil. Similar trend was observed with mean weight diameter of aggregates which was maximum in sorghum +legume incroporated into the soil. The results are in conformity with findings of Badnur *et al.*, 1990.

At the end of four seasons. Soil analysis indicated that organic carbon, available N, P_2O_5 and K_2O content was higher in the treatments where legume was grown or incorporated into the soil with sorghum compared to rest of the treatments (Table 5). Availability of nutrients was lower in control. Incorporation of crop residues of redgram/cotton improved water holding capacity, infiltration rate and fertility status of soil in vertisols of Raichur (Patil *et al.*, 1995). The mean weight diameter and percentage of stable aggregates was also higher under sorghum +legume incorporated into the soil and lower under control. From the above results it is clear that when sorghum crop was grown along with legume for grain purpose recorded highest profit, whereas when sorghum grown along with legume and incorporated into soil recorded highest sorghum grain yield due to efficient moisture and nutrient conservation and utilization.

5 Conclusion

Growing up of legume with sorghum for grain purpose or incorporated into the soil improved the soil physico-chemical properties, crop growth and yield and reduced runoff and soil loss.

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