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Effect of different organic mulches and *in situ* green manuring on soil properties and yield and economics of maize in south-eastern dry zone of Karnataka

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Abstract

A field experiment was carried out in Alfisols of eastern Dry Zone of Karnataka at University of Agricultural Sciences, GKVK, Bangalore. During *kharif* 2010 this study was conducted to know the effect of different locally available mulches on soil properties and crop performance in maize. Soil was red sandy loam in texture, slightly acidic and low in available Nitrogen, medium in available Phosphorous and Potash. The experiment consisted of 9 treatments namely, application of additional FYM (Farm Yard Manure), Mulching with straw, mulching with coir pith, mulching with coconut fronds, application of tank silt, sunhemp insitu green manuring, Glyricidia green leaf manuring, Horse gram intercropping and control replicated thrice were laid out in RCBD. The treatment insitu green manuring with sunhemp has recorded the highest soil moisture content both at 15cm (16.37%) and 30cm (16.13%) soil depth almost at all growth stages. While, the same treatment recorded significantly lower soil temperature at all growth stages statistically significant and numerically higher infiltration rate (9.68cm h^{-1}) and bulk density (1.42g cc^{-1}) have observed respectively in insitu green manuring incorporated through sunhemp. Significant improvement in available soil nutrients (N, P and K) and organic carbon content due to insitu green manuring with sunhemp resulted in higher maize yield of 5269 kg ha^{-1}. Higher net income of Rs 30098 ha^{-1} and B:C 2.53 also realized in the same treatment.

Key words: *Green manuring, Farm yard manure, Organic mulching, RCBD, Soil moisture content, Soil nutrients.*

Introduction

Soil moisture and oxidation of soil organic matter are the major limiting factors for crop production under rainfed situation. So moisture conservation and addition of organic matter is important to achieve higher yields and economic returns. Among the various soil moisture conservation practices, mulching is one of the technology is assuming greater importance. Mulching is the process of covering the surface soil with various mulching materials such as straw, dry leaves, stubbles, cut grasses, polyethylene etc. In general, mulches have favorable effect on physical, chemical and biological properties of soil by stabilizing soil, aggregates, enhancing soil organic matter, soil nutrients and reducing run off and soil erosion by intercepting rain drops. Further, mulching reduces evaporation, checking down weeds and there by enhance infiltration of water. Further it moderates wide fluctuation in soil temperature too. Green manuring also play an important role in soil and moisture conservation and improvement of soil properties.

Eighty per cent of the total maize area is under rainfed situation. Erratic and uneven distribution of rains affects maize yields to a greater extent. Maize being an exhaustive crop depletes the soil moisture and nutrients rapidly resulting in loss of productivity if it is continuously grown. A sustainable yield can be achieved through soil moisture conservation and addition of organic matter. As a result of its high yield potentiality and higher returns, farmers resorted for continuous mono cropping of maize coupled with lack of application and adequate quantity of organic manures. This practice has lead to deterioration in soil fertility and impeded the soil physical condition resulting in accelerated erosion causing loss of nutrients as well as reduced moisture retention. The sustainability of yield and prospects of higher yields of rainfed maize are threatened by moisture stress at critical stages, soil compaction, low levels of organic carbon and extensive mono-cropping and monoculture in the study region. Keeping this in back ground, a field experiment was carried to find out the effect of different mulches and green manuring on soil properties and yield of maize in South-Eastern Dry Zone of Karnataka.

Material and Methods

A field experiment was carried out in Alfisols of Eastern Dry Zone of Karnataka at University of Agricultural sciences, GKVK, Bangalore during kharif season of 2010. The soil was red sandy loam in texture having 35.80, 34.20, and 17.80% of coarse sand, fine sand and clay, respectively. The soil was slightly acidic in PH (6.2), and low available N (202.9kg/ha),medium in available P2o5 28.80kg/ha and available k2o 201.80kg/ha. The experiment consisted of nine treatments, involves Application of additional dose FYM (T1) Mulching with coconut coir pith (T2), Straw mulch (T3) Tank Silt application (T4) Mulching with coconut fronds(T5),Insitu green manuring with sunhemp (T6), Green leaf manuring with glyricida (T7), Intercropping of horesgram (T8) and Control. The treatments were laid out in complete randomized block design and replicated thrice. The intercrop for insitu green manure crop and horse gram were sown along with main crop in 1:1 and green manure crop was incorporated at 30DAS row ratio without altering the maize population .The additional dose of FYM and tank silt (10t/ha) were

applied 15 days prior to sowing crops as per treatment details. In case of organic mulching treatments, the mulching was done with different locally available organic mulches at 30 days after sowing of crops. The recommended dose of fertilizers (100:50:25 Kg NPK/ha) and common spacing 60x30cm was followed as per package of practices. Fifty percent of nitrogen and full dose of phosphorus and potassium were applied at sowing and remaining 50% N applied splits at 30 and 50 DAS. The soil moisture content was measured at different growth stages at 30cm depth through gravimetric method. Weed biomass was estimated from each net plot by selecting 1sq.m randomly and used to calculate weed control efficiency and weed index. Data on crop growth, yield components were collected at regular interval.

Results and Discussion

Effect on soil Physical properties

Soil moisture content (%): The soil moisture content measured at 15 cm depth varies significantly only at 75 DAS. Here, *in situ* green manuring with sunhemp recorded the highest soil moisture content of 16.37 percent which was on par with *exitu* green leaf manuring with glyricidia (16.13%) and intercropping of horse gram (15.87%). The control treatment recorded the lowest soil moisture content at all stages due to more exposure of soil to solar radiation (Table 1). While, at 30 cm depth treatments differed significantly at all stages except at 60 DAS. However, at 60 DAS, *insitu* green manuring with sunhemp recorded numerically higher soil moisture content of 16.13 per cent. At remaining stages, *insitu* green manuring with sunhemp recorded significantly higher moisture content of 18.66, 15.83 and 20.63 percent at 75, 90 and 105 DAS, respectively, At all growth stages, *insitu* green manuring with sunhemp, *exitu* green leaf manuring with glyricidia and intercropping of horse gram are in the order of merit. Higher soil moisture content in green manure incorporated plots and intercropping of horse gram in maize was due to covering effect on soil as a result less evaporation, reduced runoff and more infiltration.

Table 1. Soil moisture content at 15 cm in maize as influenced by different organic mulches

Treatment	Soil moisture content (%) at 15 cm depth				Soil moisture content (%) at 30 cm depth			
	60 DAS	75 DAS	90 DAS	105 DAS	60 DAS	75 DAS	90 DAS	105 DAS
T1	13.27	14.63	12.90	16.80	15.03	16.33	14.16	18.66
T2	12.30	12.73	11.88	16.07	13.63	14.23	13.50	17.83
T3	12.60	13.63	12.03	16.03	14.13	15.10	13.33	17.80
T4	12.50	14.23	12.53	16.10	14.13	15.80	13.90	17.76
T5	12.73	13.30	12.37	16.43	14.13	14.76	13.70	17.80
T6	14.07	16.37	13.83	18.33	16.13	18.66	15.83	20.63
T7	13.30	16.13	13.13	18.00	15.20	18.80	14.76	20.06
T8	13.37	15.87	13.00	18.03	15.06	17.90	14.36	20.03
T9	12.20	12.43	12.07	15.90	13.36	13.76	13.13	17.43
Mean	**12.93**	**14.38**	**12.64**	**16.86**	**14.55**	**16.15**	**14.07**	**18.67**
S.Em +	0.70	0.84	0.80	0.87	0.88	1.03	0.85	1.05
CD (p=0.05)	NS	2.52	NS	NS	NS	3.10	2.54	3.17
C.V. (%)	9.36	10.11	10.90	8.90	10.55	11.11	10.46	9.81

***Soil Temperature*:** The soil temperature recorded at 10 cm depth did not influence significantly among different organic mulches. However, the treatments where sunhemp grown as inter crop in between crop rows and incorporated as *in situ* recorded numerically lower temperature of 24.16, 24.93, 26.66 cm at 10 cm, respectively. At both the depths the control treatment registered highest temperature at all stages. (Table 2). The dense canopy created an environment of low temperature, poor light penetration and high humidity.

Bulk density (g/cc): Bulk density of the soil estimated after the harvest of the crop revealed that the treatments were found non significant. But numerical variations were there with lowest bulk density of 1.42 g /cc recorded by sunhemp *insitu* green leaf manuring and horse gram intercropping (Table 2). The highest bulk density of 1.47 g /cc was noticed in tank silt application treatment. This may due to addition of organic matter through incorporation of suhhemp as *in situ* and glyricidia leaves and horse gram intercropping.

Infiltration rate (cm/hr.): Infiltration rate of soil did not vary significantly among the treatments. However highest infiltration rate of 9.68 was registered in sunhemp *in-situ* green manuring which was numerically superior over the others (Table 2). This is attributed to rain drop interception by the crop canopy under the treatment as a result of reduction in runoff.

Table 2. Soil temperature at 10 cm depth as influenced by different organic mulches

Treatment	Soil temperature at 10 cm depth			Bulk density (g cc^{-1})	Infiltration rate (cm ha^{-1})
	60 DAS	75 DAS	90 DAS		
T1	24.66	25.46	27.20	1.443	9.06
T2	25.73	26.56	28.40	1.457	9.20
T3	25.20	26.03	27.83	1.453	9.36
T4	24.83	25.63	27.40	1.470	9.00
T5	25.00	25.50	27.60	1.447	8.58
T6	24.16	24.93	26.66	1.420	9.68
T7	24.26	25.10	26.83	1.437	9.55
T8	24.43	25.26	26.96	1.420	9.53
T9	25.60	26.50	28.33	1.463	8.73
Mean	**24.87**	**25.66**	**27.47**	**1446**	**9.19**
S.Em ±	1.41	1.45	1.51	0.019	0.48
CD (p=0.05)	4.24	4.37	4.55	NS	1.43
C.V. (%)	9.85	9.84	9.57	2.24	9.00

***Effect on Soil Chemical Properties*:** Soil Organic carbon content did not vary significantly among treatments due to mulching treatments. However, sunhemp *in-situ* green manuring recorded numerically higher organic carbon of 0.47% closely followed glyricidia green leaf manuring (0.46%) and horse gram intercropping (0.46%). All treatments have registered numerically higher organic carbon content than the control plot (0.4%),This may be attributed to the addition of dry matter to the soil as a result of addition of organic matter through green manuring and nitrogen by sunhemp and horse gram intercropping in maize. Significant amount of organic matter (Up to 3654 kg per ha) was added as a result of *insitu* green manuring (Table 3) justify the changes in organic carbon status. Wani, *et al* (1994) reported 67% (in 22 years) higher carbon content of top 15 cm soil layer in case of pigeon pea based intercropping system as compared to non legume system. Paustian *et al*. (1997) too recorded higher soil carbon input with the continuous cropping, particularly when fertilizers were applied and legumes were included in the system.

Table 3. Soil fertility status as influenced by different organic mulches in maize

Treatment	Organic Carbon (%)	Available nutrients (kg ha^{-1})		
	60 DAS	Nitrogen	P_2O_5	K_2O
T1	0.43	259.90	68.0	115.7
T2	0.42	252.0	75.2	133.3
T3	0.43	257.8	74.5	123.3
T4	0.44	260.4	69.8	132.5
T5	0.44	260.6	68.9	136.0
T6	0.47	280.8	77.8	135.6
T7	0.46	274.9	74.5	135.2
T8	0.46	272.1	77.8	133.7
T9	0.40	237.6	74.4	111.5
Mean	**0.443**	**261.60**	**74.4**	**129.5**
S.Em ±	0.0093	5.70	1.75	2.40
CD (p=0.05)	0.028	17.10	5.25	7.19
C.V. (%)	3.69	3.78	4.13	3.21

***Effect on Soil fertility*:** In this investigation, significant differences were found among the various treatments, with regard to soil nutrients (nitrogen, phosphorous and potassium) at the end of experimentation at harvest, the data on available nitrogen, phosphorus and potassium as influenced by different mulching treatments indicated the superiority of sunhemp *in-situ* green manuring on available soil nitrogen (280.8 kg ha^{-1}), phosphorus (77.8 kg ha^{-1}) over others (Table 3) while mulching with coconut fronds (136 kg ha^{-1}) has recorded higher available soil potassium closely followed by sunhemp *in situ* green manuring (135.6 kg ha^{-1}), green leaf manuring with glyricidia (135.2 kg ha^{-1}) which are on par.

This may be due to nitrogen fixation by root nodules (rhizobium) and mineralization of N from organic matter accumulation through improved beneficial microbial population. Also might be due to residual effect of added fertilizer nutrients. More respiration and more microbial activity resulted in more net mineralization under intercropped situation compared to sole stand (Rutherford and Juma, 1989) and reduced nitrate leaching in intercropping systems and treatments. Significant increase in available soil nitrogen also obtained by Padhi and Panigrahi (2006) in their study on maize based intercropping systems in all intercropping systems and irrespective of row ratios compared to initial and post-harvest available

soil N content than sole maize. Similarly, Ngo Huu Tinh, (1990) have obtained higher humus content and total nitrogen and improvement in soil fertility following intercropping in maize compared to sole crop of maize. The higher P solubilizer population of 15.66 CFU x 10^4 and 14 CFU x 10^4 was noticed, respectively, in sunhemp *in situ* green manured and glyricidia leaf manured plots. The mineralization of native P in soil due to root exudates and organic acids released during decomposing of organic matter in legume cropping systems could also be the reason for higher available P noticed. Inal, *et al*. (2007) reported significantly higher acid phosphatase activity in rhizosphere of intercropped maize than sole cropping with maize. Increased biological and chemical activity in rhizosphere might have resulted in higher available 'P' under *in situ,* glyricidia leaf manuring and intercropping with legumes. More available nutrients in above said treatments also reason out for weed suppression due to smothering effect.

***Effect on yield*:** The highest grain yield of maize (5269 kg ha^{-1}) was realized from plots which received *insitu* green manuring with sunhemp (Table 4). The next best yields were noticed in glyricidia leaf incorporated plots (4651 kg ha^{-1}). These treatments were found statistically superior over others. Extent of yield increase in maize over control in treatment plots varies from 15.5-54.3%. Improvement in yield compared to control plot was to an extent of 54.3 per cent in sunhemp green manured plots. The plots which received glyricidia leaf manure (36.1%) and maize + horse gram intercropping (34.9%) are next in the order. Eighteen per cent yield improvement due to mulching was reported by Girijesh *et al*. (2011) in maize. Better soil moisture availability and addition of organic matter might have caused for higher translocation of photosynthesis to grain which may be the reason for higher grain yield in plots where green manuring and mulching was done. Higher Soil moisture content in these treatments also caused for higher yields. The moisture conservation through mulching to stressed plants resulted in raise in leaf water potential, stomatal conductance and in turn net photosynthesis. The highest relative leaf water content was noticed in plots which received sunhemp as *insitu* green manuring (82.5%), maize + horse gram intercropping (82%) and glyricidia leaf manuring (81.3%) (Table 4). The results are in line with the findings of Singh and Singh (1992). Further, Sen *et al* (1953) have also recorded 79 per cent higher seed yield of maize and maize equivalent yield than control in maize + pigeon pea intercropping system due to mulching. The least maize grain yield was obtained in control treatment (3416 q ha^{-1}).

Table 4. Yield and yield components of maize as influenced by different organic mulches

Treatment	Grain yield kg ha^{-1}	% yield increase over control	Relative leaf water content (%)	Net income	B:C
T1	4189	22.60	80.7	20,198	2.12
T2	3946	15.53.	81.3	18,139	1.94
T3	4178	22.34	78.5	19,485	197
T4	4292	25.67	79.0	23,368	2.36
T5	4081	19.48	80.0	19,709	2.04
T6	5269	54.30	82.5	30,098	2.53
T7	4651	36.10	81.3	25,570	2.39
T8	4607	34.90	82.0	24,018	2.36
T9	3416	00.00	74.3	16,099	1.99
Mean	**4292**	**-**	**-**	**-**	**-**
S.Em ±	241.2	-	-	-	-
CD (p=0.05)	723.0	-	-	-	-
C.V. (%)	9.73	-	-	-	-

Rajendar Kumar *et al*. (1996) have also obtained significantly less number of grains per cob, gain yield and harvest index due to moisture stress. They attributed poor yield and yield attributes to shriveling of pollens and restricted fertilization because of moisture stress.

***Effect on Economics*:** The highest gross and net income and B:C of Rs. 49,788 per ha and Rs. 30098 per ha and 2.53, respectively, was obtained with the plots which received sunhenmp *in-situ* green manuring and the next best was glyricidia leaf manuring. The higher profitability of these treatments was due to higher grain yields obtained as a result of improvement in soil physical and chemical characters, better moisture conservation and low weed population. The least gross (Rs. 38,289 ha^{-1}) and net income (Rs. 16009 ha^{-1}) was recorded in control plot.

Conclusions

From the investigation, it can be inferred that introduction of one row of sunhemp in between maize rows as addition and incorporating at 30 days after sowing found superior with respect to yield and economic returns and also caused for overall soil improvement with respect to soil productivity and fertility.

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