International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 862-865

Received: 05-09-2018
Accepted: 10-10-2018

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Effect of different organic mulches and green manuring on physical, chemical and biological properties of maize (*Zea mays* L.) in *Alfisols* of eastern dry zone of Karnataka

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Abstract
A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru to study the influence of different locally available organic mulches and green manuring on soil properties. The experiment consisted of 9 treatments namely, mulching with paddy straw, mulching with dry leaves, mulching with coconut fronds, mulching with saw dust, Horse gram *insitu* green manuring, sunhemp *insitu* green manuring, Glyricidia green leaf manuring, Pongamia green leaf manuring and control replicated thrice were laid out in RCBD. The result revealed that the treatment *insitu* green manuring with sunhemp has recorded the higher infiltration rate 5.80 cm hr^{-1}, lowest bulk density 1.42 g cc^{-1} and higher water holding capacity 47.51 % after harvesting. And the same Significant improvement in available p^H, soil nutrients (N, P and K) and organic carbon content due to insitu green manuring with sunhemp are 6.42, 227.00 kg ha-1, 28.67 kg ha-1, 133.78 kg ha-1 and 0.46 %. Similarly, significantly higher microbial population finds in the *insitu* green manuring with sunhemp.

Keywords: organic mulches, green manuring, chemical, biological, Karnataka

Introduction
Maize is the third most important cereal crop after rice, wheat and is an important staple food in many countries of the world. It is also known as the Miracle Crop or Queen of Cereals due to its high productivity potential in the poaceae family. Maize is extensively used in developed countries and is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for 200 million people. However, in a processed form it is also found as fuel (ethanol) and starch. Starch in turn involves enzymatic conversion into products such as sorbitol, dextrin, sorbic and lactic acid and appears in household items such as beer, ice cream, syrup, shoe polish, glue, fireworks, ink, batteries, cosmetics, aspirin and paint. In Karnataka, maize is grown over an area of 1.18 million hectares with production of 3.27 million tonnes and average productivity of 27.73 q ha-1 (Anon. 2016) [2].
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 led 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

Field experiment was carried out in Alfisols of Eastern Dry Zone of Karnataka at University of Agricultural Sciences, GKVK, and Bengaluru during kharif season of 2017. The soil was red sandy loam in texture having 36.16, 33.84 and 21.47% of coarse sand, fine sand and clay, respectively. The soil was slightly acidic in pH (5.80), and low available N (159 kg ha^{-1}), medium in available P_2O_5 17.6 kg ha^{-1} and available k_2O 109 kg ha^{-1}. The experiment consisted of nine treatments, involves mulching with paddy straw (T1), mulching with dry leaves (T2), mulching with coconut fronds (T3) mulching with saw dust (T4), Horse gram *insitu* green manuring (T5), sunhemp insitu green manuring (T6), Glyricidia green leaf manuring (T7), Pongamia green leaf manuring (T8) and control (T9) 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 30 DAS row ratio without altering the maize population.

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 spacing 60x30cm was followed as per package of practices of UAS, Bengaluru. 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 Water holding capacity of soil was determined by using Keens cup method (Piper, 1966) and Expressed in percentage. Bulk density of soil samples were determined after harvest of crop by clod method (Black, 1965) and expressed in g cc-1 Infiltration rate of soil was determined by using double ring infiltro-meter at the initially and after harvest of crop and expressed in cm hr-1.

Representative soil samples from each experimental plot at 0 to 30 cm depth were collected at harvest. Soil samples were dried in shade, powdered and passed through 2 mm sieve and chemically analyzed for pH, organic carbon, nitrogen, phosphorus and potassium. The rhizosphere soil samples collected from experimental site were analyzed for different soil micro-organisms *viz*. total bacteria, fungi, 'P' solubilizer, *Rhizobia* and *Azotobacter* using serial dilution and plate count technique and placing on specific nutrient media.

Results and Discussion

Soil physical properties: Infiltration rate of soil did not show significant variation among the treatments. However, the higher infiltration rate of 5.80 cm hr-1 was registered in sunhemp *insitu* green manuring which was numerically superior over the other treatments. Glyricidia green leaf manuring, horse gram intercropping, pongamia green manuring and mulching with paddy straw are in the next order of merit in improving the infiltration rate (Table 1.). This was mainly attributed to rain drop interception by the crop canopy under the treatment as a result of reduction in runoff. Further maize also produces prolific roots Better maize growth in these treatments besides porosity creation of *insitu* green manures facilitated higher infiltration rate. These results are in complimentary with the findings of Adekalu (2007).

Bulk density of the soil estimated after the harvest of the crop revealed no significant differences among different treatments. However, numerically lower bulk density (1.42 g cc-1) recorded by sunhemp *insitu* green manuring incorporation, green leaf manuring with glyricidia and horse gram intercropping (1.43, & 1.44 g cc-1 respectively) The higher bulk density of 1.49 g cc-1 was noticed in the control plot (Table 1.).

The reason for lower bulk density compared to initial bulk density might be due to addition of organic matter through incorporation of sun hemp as *insitu* and glyricidia leaves and horse gram intercropping. In these treatments, addition of organic matter caused for more porosity because of more micro pores in soil may the reason for lower bulk density. Similar results were also noticed by Sharma *et al*. (2010).

Table 1: Infiltration rate, bulk density and water holding capacity of soil as influenced by different organic mulches and green manuring

Treatments	Infiltration rate (cm hr-1)	Bulk density (g cc-1)	Water Holding Capacity (%)
T1:Mulching with paddy straw	5.27	1.45	45.45
T2:Mulching with dry leaves	4.92	1.47	44.95
T3:Mulching with coconut fronds	4.63	1.48	43.89
T4:Mulching with saw dust	4.60	1.46	43.50
T5:Horse gram (*insitu* green manuring)	5.67	1.44	46.25
T6:Sunhemp (*insitu* green manuring)	5.80	1.42	47.51
T7:Glyricidia (*exsitu* green manuring)	5.73	1.43	46.58
T8:Pongemia (*exsitu* green manuring)	5.43	1.45	46.08
T9: Control.	4.56	1.49	40.55
S.Em ±	0.31	0.02	1.30
CD (P =0.05)	NS	NS	3.89

NS – Non significant

The data present in Table 1 shows that water holding capacity of soil vary significantly among all the treatments. The numerically higher water holding capacity of 47.51 per cent recorded by sunhemp *insitu* green manuring incorporation followed by glyricidia and intercropping with horse gram 46.58 and 46.25 per cent respectively. The lowest water holding capacity is found in control treatment (40.55 %).

The higher water holding capacity observed may be due to addition of organic matter through incorporation of sunhemp as *insitu* and glyricidia leaves and horse gram intercropping. In these treatments, addition of organic matter caused more water holding capacity of soil. Similar results were also reported by Singh *et al.* (2015) [5].

Chemical Properties of soil: Data in the (Table 2.) indicated that there was slight increase in soil pH value in all the treatments as compared to initial (5.80) pH value. However, there is no significant differences were observed after the harvest of crop among the treatments. Numerically higher pH value of 6.42 was recorded in sunhemp *insitu* green manuring and lower pH of 6.29 was recorded in control treatment.

Organic mulches and green manuring incorporation in soil might have helped in the maintaining soil organic matter which leads to increase in the pH of soil. The organic matter added in these treatments upon decomposition releases weak acids and might diluted acidity causing for increasing pH under acidic soils. These results are in consonance with the findings of Kumar *et al.* (2014) [6] and Yaseen *et al.* (2014) [7]

Table 2: Soil fertility status as influenced by different organic mulches and green manuring in maize

Treatments	pH	Organic carbon (%)	Available nutrients (kg ha-1)		
			N	P2O5	K2O
T1 :Mulching with paddy straw	6.35	0.41	204.08	24.05	125.01
T2 :Mulching with dry leaves	6.33	0.41	202.33	23.33	124.85
T3:Mulching with coconut fronds	6.32	0.42	201.33	23.17	117.41
T4:Mulching with saw dust	6.28	0.40	197.12	22.81	115.02
T5:Horse gram (*insitu* green manuring)	6.40	0.43	210.00	25.00	128.08
T6:Sunhemp (*insitu* green manuring)	6.42	0.46	227.00	28.67	133.78
T7:Glyricidia (*exsitu* green manuring)	6.38	0.45	217.17	27.11	130.86
T8:Pongemia (*exsitu* green manuring)	6.37	0.42	204.44	24.29	126.66
T9: Control.	6.29	0.39	192.67	20.67	113.11
S.Em ±	0.33	0.02	6.39	1.38	3.70
CD (P =0.05)	NS	NS	19.15	4.14	11.10
Initial value	5.80	0.39	159.00	17.6	109.00

Available nitrogen: The data pertaining to available soil nutrients is presented in (Table 2.) Data on available nitrogen status after the harvest of the crop indicated the superiority of sunhemp *insitu* green manuring on available soil nitrogen (227.00 kg ha-1) over other treatments. But, it was on par with green leaf manuring of glyricidia (217.17 kg ha-1), intercropping of horse gram (210.00 kg ha-1). The lower available nitrogen of 192.67 kg ha-1 was noticed in control plots.

The increased nitrogen with sunhemp, glyricidia and horse gram is associated with addition of N upon decomposition besides atmospheric N fixation in the legumes. The similar results may also reported by Padhi and Panigrahi (2006) [8]. Were also reported similar results.

Available phosphorus: The data on available phosphorus as influenced by different organic mulches was found to be significant. The higher available soil phosphorus was registered in plots received sunhemp green manuring (28.67 kg ha-1) which was on par with other treatments except, Mulching with sawdust, not mulched (control). Sunhemp *insitu* green manuring, *Exsitu* green leaf manuring with glyricidia and intercropping of horse gram and *exsitu* green leaf manuring with pongemia are in order of merit

The cause for increased phosphorous with these treatments might be associated with addition of organic matter which add 'P' upon decomposition besides solubilizire the non-available soil 'p' reserve due to release of weak organic acids which is also supported by soil Ph observations. Increased biological and chemical activity in rhizosphere might have resulted in higher available nutrients under sole crop of pulses and intercropping systems (Inal *et al*., 2007) [9]. More available nutrients in above said treatments may be due to dense canopy and mulching created an environment of low temperature (Table 2.), poor light and high humidity which is not favorable for weeds growth.

Available Potassium: Significant differences were observed among different treatments with regard to available soil potassium as influenced by different mulching treatments. The higher available soil potassium was observed with sunhemp *insitu* green manuring incorporation (133.78 kg ha-1), green leaf manuring with glyricidia (130.86 kg ha-1), intercropping of horse gram (128.08 kg ha-1), *exsitu* green leaf manuring with pongamia (126.66 kg ha-1), mulching with paddy straw (125.01 kg ha-1), and mulching with dry leaves which were on par and significantly superior to control plot.

In this investigation, significant differences were found among the various treatments, with regard to soil potassium at the end of experimentation at harvest, the data on available potassium as influenced by different mulching treatments indicated the superiority of sunhemp *insitu* green manuring. This may be due to mineralization of K from organic matter and non-labile pool through improved beneficial microbial population in green manuring incorporated 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. Inal, *et al*. (2007) [9] reported significantly higher acid phosphatase activity in rhizosphere of intercropped maize than sole cropping with maize.

Effect of organic mulches and green manuring on microbial activity: The population of soil microorganisms obtained in the rhizosphere of maize at harvest has been presented in the Table 3.The microbial population was estimated before sowing and after harvest of the crop in the experimental site by using serial dilution and plate count method. The population of total bacteria, total fungi, 'P' solubilizers, *Rhizobia* and *Azotobacter spp*. Were found increased at the time of harvesting compared to their initial observation before sowing.

Maximum total bacterial population (101×105 CFU) was observed in the treatment receiving green manuring with sunhemp followed by the treatment of intercropping with gliricidia (94.33×105 CFU). The control plots was recorded the lower number of total bacteria (63×105 CFU). The highest number of total fungi (54.67×104 CFU) was recorded in the treatment receiving sunhemp *insitu* green manuring followed by glyricidia crop as an *exsitu* green manuring of (53.33×104 CFU). The least number of total fungi was recorded in control (31.67×104 CFU). Symbiotic and asymbiotic nitrogen fixing bacteria, *Rhizobium* and *Azotobacter* (18.67 and 22.43 CFU×103 respectively), were found higher in the treatments receiving sunhemp *insitu* green manuring followed by glyricidia *exsitu* green leaf manuring and the third higher population was obtained in the treatment intercropped with horse gram. However, lower number of *Rhizobia* and *Azotobacter* population were recorded in control plot.

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 system treatments.

Table 3: Microbial population in the maize rhizosphere at harvest of crop as influenced by different organic mulches and green manuring

Treatments	Total bacteria CFU×105	Total fungi CFU×104	Total 'P' solubilizers CFU×103	*Rhizobium* CFU×103	*Azotobacter* CFU×103
T1:Mulching with paddy straw	83.33	45.67	18.33	17.00	17.67
T2:Mulching with dry leaves	68.33	43.00	17.33	16.00	17.00
T3:Mulching with coconut fronds	67.33	38.67	14.67	10.67	14.33
T4:Mulching with saw dust	57.00	34.67	14.33	11.33	16.00
T5:Horse gram (*insitu* green manuring)	93.00	53.00	22.33	16.00	20.17
T6:Sunhemp (*insitu* green manuring)	101.00	54.67	28.67	18.67	22.43
T7:Glyricidia (*exsitu* green manuring)	94.33	53.33	23.33	16.33	20.33
T8:Pongemia (*exsitu* green manuring)	84.67	46.33	21.33	17.33	19.33
T9: Control.	63.00	31.67	13.00	15.00	12.00
Initial value	45.23	23.70	9.51	11.15	7.23

The higher 'P' solubilizer population of 28.67 CFU x 104 and 23.33 CFU x 104 was noticed, respectively, in sunhemp *insitu* green manured and glyricidia leaf manured plots. The increased beneficial microbial population with sunhemp, glyricidia and horsergram is associated with supplementation of organic materials which are the food reserves for them, besides these organic matter also conserved moisture and maintained micro climate of lower soil temperature facilitating their rapid multiplication and resulted in increased population. further, the legumes *viz.*, sunhemp and horsegram also hosted rhizobium in their root nodules similar findings were also reported by Elfstrand *et al*. (2007) [10].

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