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Short Note

Role of Organic Mulching on Soil Properties of Alfisol in Rainfed Maize

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Field experiment was conducted in Regional Research Station, Paiyur to asses the effect of organic mulching on soil physical properties, nutrient availability pattern and microbial population. The treatments included maize straw at 5 and10 t ha^{-1}, sugarcane trash at 5 and10 t ha^{-1}, raw coirpith at 5 and10 t ha^{-1} and dried weeds at 5 and10 t ha^{-1} and unmulched control, which were replicated thrice in Randomized Block Design. In maize, application of raw coir pith at 10 t ha^{-1} had reduced the bulk density and all the physical properties. Application of dried weed mulch at 10 t ha^{-1} (T_9) recorded highest water holding capacity. Dried weed mulch at 10 t ha^{-1} recorded higher available N, P and K while raw coirpith at 10 t ha^{-1} (T_7) increased the bacteria and fungal populations. Overall, mulches has great agro- ecological potential and they typically conserve the soil, improve the soil ecology, stabilize and improve soil properties.

Key words: Organic mulching; maize; soil physical properties; nutrient availability; microbial population

The rainfed agro ecosystem occupies a distinct place in Indian agriculture, as it constitutes nearly 67 per cent of the net sown area contributing 44 per cent of grain production and supporting 40 per cent population. Despite concerted efforts made in the past to improve the productivity of these areas by transferring improved technologies, gains in terms of higher yield and income are still not appreciable. Rainfall intensity is extremely variable even when the amount of rainfall received is relatively low, causing substantial runoff and soil erosion. Hence, the crop management system in rainfed farming must protect the soil resource. Temperature extremes in dryland areas limit the productivity and crops are either dried or permanently injured when critical temperatures exceeded (Balak Ram, 2003). Soils in the dryland regions of the world range from sandy, shallow, low-fertility to highly productive, medium to fine textured and deep, but the majority of dryland soils have serious problems. Restricted biological activity resulting from a suboptimal soil environment would greatly affect the cycling and transformation of nutrients present in the organic form. Biological activity of dryland soils is much lower than the humid zones because of low organic matter levels and periods of extreme dryness. There is also evidence that the organic matter present in dryland soils is chemically and biologically less stable, because there is less biological turnover of organic matter (Wani *et al.,* 2003).

Mulching is one of the promising technologies for dryland farming and is increasingly seen in the light of integrated soil management, an essential building stone for sustainable agriculture. The use of mulch has great agro- ecological potential and it typically conserves the soil, improves the soil ecology, stabilizes and enhances crop yield and provides various environmental services (Lampkin, 1990). Mulch helps in conserving soil moisture loss to the tune of 10 to 25 per cent through evaporation. Crop residues contain substantial quantities of plant nutrients and the concentration in oven-dry tissue ranges from 0.58 to 4.0 per cent for N, 0.1 to 1.1 per cent for P, and 0.2 to 3.4 per cent for K. However, the use of crop residues as fertilizers is especially important to resource-poor farmers. The use of crop residues varies from region to region and depends on their calorific values, lignin content, density, palatability and nutritive value. In addition to use of crop residues as fuel and fodder, the residue of some crops is used for thatching, composting, mulching, etc.

Materials and Methods

Experimental soil

Field experiment was taken up in a Regional Research Station, Paiyur, to study the role of organic mulching on soil properties under rainfed maize in an alfisol. The experimental soil analyzed for mechanical composition indicated that it belonged to sandy clay loam texture with 21.3 per cent clay, 14.7 per cent silt and 63.7 per cent sand. The per cent pore space was found to be 51.7. Bulk density and particle density of the soil were 1.32 and 2.81 Mg m^{-3} respectively.

The soil was slightly alkaline in reaction with a pH of 8.23 and electrical conductivity of 0.13 dSm^{-1} and moderate CEC (18.2 C mol (P^+) kg^{-1}). Chemical

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analysis for available major nutrients revealed that the soil was low in nitrogen (140.5 kg ha_{-1}), low in P (10.33 kg ha_{-1}) and high in K (385.5 kg ha_{-1}) with low organic carbon content (0.43 per cent). The soil belonged to the Vannapatti series (fine, mixed and isohypothermic moderately deep, well drained, red, fine loamy, moderately structured, non-calcareous with quartz gravels present in sub soil) and grouped under soil order Alfisol (*Typic Ustropept*)

Treatment Details

The field experiments were laid out in randomized block design with three replications. There were totally nine treatments and are detailed below. T_1- Control, T_2 - Maize straw mulch @ 5 t ha^{-1}, T_3 - Maize straw mulch @ 10 t ha^{-1}, T_4 -Sugarcane trash mulch @ 5 t ha_{-1}, T_5 - Sugarcane trash mulch @ 10 t ha^{-1}, T_6 - Raw coirpith mulch @ 5 t ha^{-1}, T_7 - Raw coirpith mulch @ 10 t ha_{-1}, T_8 - Dried weeds (before flowering) mulch @ 5 t $ha_{-1}$and T_9 - Dried weeds (before flowering) mulch @ 10 t ha_{-1}. The mulches selected for the study were spread at the calculated quantities on the 10_{th} day after sowing on the soil surface in between the rows of maize. The recommended doses of 60, 30, 30 kg of N, P_2O_5 and K_2O respectively were applied for maize. Half of the nitrogen in the form of urea, half of the potassium in the form of muriate of potash and full dose of phosphorus in the form of single super phosphate were applied basally. The remaining half of the nitrogen and half of the potassium were applied as top dressing on 45_{th} day after sowing.

Results and Discussion

Nutrient Content in Organic mulches

The dried weeds showed relatively higher nutrient contents (0.98, 0.31 and 0.88 per cent N, P and K) as compared to raw coirpith, maize stover and sugarcane trash (Table 1). The C: N ratio was found to be wider in coirpith (412:1) as compared to 45:1 in dried weeds.

Table 1. Nutrient content in organic mulches

Mulches	Total N(%)	Total P(%)	Total K(%)	O.C(%)	C:NRatio
Maize straw	0.85	0.25	0.65	58.6	69:1
Sugarcane trash	0.67	0.18	0.59	38.2	57:1
Raw coirpith	0.94	0.31	0.88	387.3	412:1
Dried weeds	0.98	0.40	0.93	44.1	45:1

Effect of organic mulches on soil physical properties

Application of organic mulches generally improves the soil physical conditions besides improving the nutrient availability and biological properties. Soil physical property improvement by addition of organic manure is mainly due aggregation of soil particle through which porosity, soil air, water holding capacity and bulk density are maintained at optimum level to maximize the crop yield.

Bulk density and porosity

Mulch application significantly improved the bulk density (Table 2) and porosity of soil. In maize, the bulk density of soil under raw coirpith mulch at 5 t ha_{-1} and 10 t ha_{-1} was 1.33 (0-15cm) and 1.42 (15-30 cm) Mg m_{-3} respectively and porosity was 44.9 per cent, when compared to its initial values of 1.40 and 1.47 Mg m_{-3} at 0-15 and 15-30 cm soil depth and 44.8 per cent of porosity. The decrease in bulk density and increased porosity was due to increased aggregation from increased soil organic carbon content under mulch. Similar findings were also expressed by Rajkannan *et al*. (2001) and Dahiya *et al*. (2003) who have reported that the presence of residues on the soil surface maintained the low bulk density. Ghosh *et al*. (2006) reported that the soil under wheat straw mulch generate more favorable habitats for soil and surface dwelling earthworms and microorganisms (Acharya *et al*., 2005) which might have contributed to low bulk density under straw mulch.

Water holding capacity and saturated hydraulic conductivity

The water holding capacity of soil conspicuously increased with various mulch treatments. Among the different mulches, application of dried weeds at 10 t ha_{-1} (T_9) recorded the highest water holding capacity (11.53 %) and it was superior to rest of treatments (Table 2). Water holding capacity of soil, which depends on micro porosity of soil varied significantly with different organic mulches application. The increased water holding capacity may be attributed to more micro pores, which are responsible for more water retention. Further, their higher humus content, higher surface area and favourable soil aggregates would have resulted in increased water holding capacity. These results are in confirmity with the findings of Venkatesh (1995).

Saturated hydraulic conductivity of soil insignificantly varied with different organic mulches application. Saturated hydraulic conductivity, a physical property indicates the condition of soil in terms of drainage. Different organic mulches application had significant effect on saturated hydraulic conductivity of soil. The highest saturated hydraulic conductivity was accounted (Table 2) in the treatment that has received raw coirpith at 10 t ha_{-1} (T_7) can be attributed to their higher pore space, low bulk density and favorable soil structure. These

Table 2. Effect of mulches treatments on bulk density (BD), saturated hydraulic conductivity (SHC), total porosity, water holding capacity and organic carbon of the soil at post harvest stage

Treatment	Bulk density ($Mg\ m^{-3}$)		SHC ($cm\ hr^{-1}$)	Total porosity (per cent)	WHC (mm)	O. C (per cent)
	0-15 cm	15-30 cm				
T1-Control (without mulch)	1.40	1.48	5.06	44.8	10.51	0.44
T2-Maize straw mulch @ 5 t ha^{-1}	1.38	1.47	5.08	44.8	10.19	0.44
T3-Maize straw mulch @ 10 t ha^{-1}	1.36	1.47	5.10	44.8	10.32	0.46
T4-Sugarcane trash mulch @ 5 t ha^{-1}	1.36	1.46	5.14	44.9	10.12	0.50
T5-Sugarcane trash mulch @ 10 t ha^{-1}	1.35	1.45	5.26	44.9	11.47	0.50
T6-Raw coirpith mulch @ 5 t ha^{-1}	1.33	1.42	5.30	44.9	11.51	0.48
T7-Raw coirpith mulch @ 10 t ha^{-1}	1.33	1.42	5.34	44.9	11.45	0.48
T8-Dried weeds (before flowering) mulch @ 5 t ha^{-1}	1.35	1.43	5.30	44.8	11.02	0.51
T9-Dried weeds (before flowering) mulch @ 10 t ha^{-1}	1.34	1.42	5.32	44.9	11.53	0.52
SEd	0.003	0.006	0.34	3.13	0.36	0.03
CD(P = 0.05)	0.008	0.012	NS	NS	0.77	NS

results are in accordance with the finding of Chan and Heena (1995).

Effect of different organic mulches on chemical properties

Organic carbon

Application of different organic mulches had favorably influenced the organic carbon content of soil. Among the different organic mulches, application of dried weeds at 10 t ha^{-1} (T_9) recorded higher organic carbon content followed by dried weeds at 5 t ha^{-1} (T_8), sugarcane trash at 5 t ha^{-1} and sugarcane trash at 10 t ha^{-1} than the control (Table 2). It might be due to higher humus content of dried weeds resulted from decomposition. The supply of nitrogen during initial period of decomposition avoided the immobilization caused by microbes in mulch treated plots. Similar results were observed by Balaji (1994) and Acharya *et al*. (1998). Tindall *et al*. (1991) also observed a buildup that in soil organic carbon of mulch applied plot due to their decomposition.

Table 3. Effect of treatments on Bacteria, Fungi and Actinomycetes population (CFU g^{-1}) of the soil at different stages of cropgrowth

Treatment	Bacteria x 10^6			Fungi x 10^4			Actinomycetes x 10^3		
	Knee high	Tasseling	Post harvest	Knee high	Tasseling	Post harvest	Knee high	Tasseling	Post harvest
T1-Control (without mulch)	35.7	47.7	34.0	20.0	22.3	17.7	4.12	5.56	6.46
	(1.55)	(1.67)	(1.52)	(1.30)	(1.33)	(1.24)	(0.61)	(0.74)	(0.81)
T2-Maize straw mulch @ 5 t ha^{-1}	39.0	47.0	36.7	21.7	24.7	21.3	5.15	6.44	7.12
	(1.59)	(1.67)	(1.56)	(1.33)	(1.39)	(1.33)	(0.71)	(0.80)	(0.85)
T3-Maize straw mulch @ 10 t ha^{-1}	42.7	47.3	40.0	23.3	24.0	22.0	6.24	6.98	7.86
	(1.63)	(1.68)	(1.60)	(1.36)	(1.37)	(1.34)	(0.79)	(0.84)	(0.89)
T4-Sugarcane trash mulch @ 5 t ha^{-1}	46.0	49.7	44.7	23.7	26.0	23.3	6.56	7.46	8.36
	(1.66)	(1.69)	(1.65)	(1.37)	(1.41)	(1.36)	(0.81)	(0.87)	(0.92)
T5-Sugarcane trash mulch @ 10 t ha^{-1}	47.7	54.0	48.3	22.7	25.3	24.0	7.34	8.24	8.98
	(1.68)	(1.72)	(1.68)	(1.35)	(1.40)	(1.37)	(0.86)	(0.91)	(0.95)
T6-Raw coirpith mulch @ 5 t ha^{-1}	49.7	56.7	45.0	24.7	29.0	24.3	7.84	8.86	9.34
	(1.71)	(1.75)	(1.65)	(1.39)	(1.46)	(1.38)	(0.89)	(0.94)	(0.96)
T7-Raw coirpith mulch @ 10 t ha^{-1}	55.0	60.3	48.3	24.7	29.3	25.3	8.88	9.12	10.46
	(1.73)	(1.77)	(1.68)	(1.39)	(1.46)	(1.40)	(0.94)	(0.95)	(1.02)
T8-Dried weeds (before flowering) mulch @ 5 t ha^{-1}	47.3	56.0	42.7	23.7	27.0	22.3	9.26	9.84	10.84
	(1.66)	(1.74)	(1.63)	(1.37)	(1.43)	(1.34)	(0.96)	(0.99)	(1.03)
T9-Dried weeds (before flowering) mulch @ 10 t ha^{-1}	48.3	57.0	44.3	21.7	26.7	22.0	10.12	10.68	11.12
	(1.71)	(1.75)	(1.64)	(1.33)	(1.42)	(1.33)	(0.99)	(1.02)	(1.04)
SEd	0.017	0.034	0.018	0.027	0.034	0.028	0.010	0.011	0.012
CD(P = 0.05)	0.036	0.073	0.038	NS	0.072	0.060	0.022	0.023	0.025

* Values in the parenthesis are log transformed

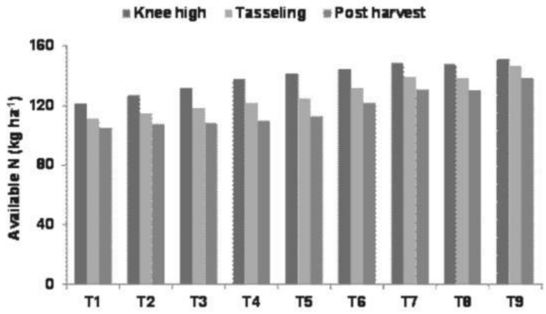
Available nitrogen

The available nutrient contents of the soil varied significantly with various organic mulches application. The highest available N was recorded in dried weeds mulch at 10 t ha^{-1} (T_9) which showed 31 per cent higher available N over the control (Fig. 1a). This could be attributed to the lower C: N ratio of dried weeds which resulted in fast decomposition and release of nutrients as compared to maize stover, sugarcane trash and raw coirpith. Balaji (1994) and Venkatesh (1995) also reported similar increase in available nitrogen content of the soil due to mulch application. The high available nitrogen in surface mulch treatment is due to higher microbial biomass and activity often lead to high nitrogen mineralization and soil ammoniacal nitrogen and nitrate nitrogen concentration.

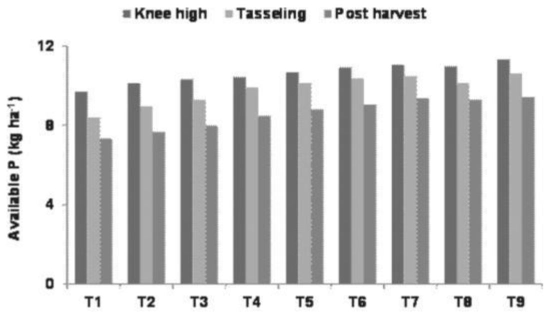
Available phosphorous

Application of different organic mulches significantly influenced the available phosphorus

1a. Available Nitrogen



1b. Available Phosphorous



1c. Available Potassium

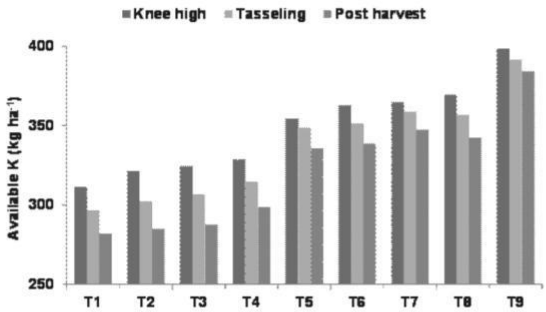


Fig. 1a-1c. Effect of mulches treatments on soil available macronutrients

T1- Control, T2 - Maize straw mulch @ 5 t ha-1, T3 - Maize straw mulch @ 10 t ha-1, T4 -Sugarcane trash mulch @ 5 t ha-1, T5 - Sugarcane trash mulch @ 10 t ha-1, T6 - Raw coirpith mulch @ 5 t ha-1, T7 - Raw coirpith mulch @ 10 t ha-1, T8 - Dried weeds (before flowering) mulch @ 5 t ha-1and T9 - Dried weeds (before flowering) mulch @ 10 t ha-1.

status of soil. Among the different organic mulches, application of dried weeds mulch at 10 t ha^{-1} (T_9) recorded higher available phosphorus (Fig. 1b). The reason attributed to the increased available phosphorus in soil might be due to higher phosphorus content of dried weeds. Further, decomposition of dried weeds leads to increase in the available nitrogen which in turn increased the phosphorus status due to its synergetic effect. The organic acids released from decomposition of dried weeds could have released fixed phosphorus into the available pool. Kale *et al.* (1992) also reported an increase in soil available phosphorus with mulch application. Similar findings were also expressed by Duraisami and Mani (2000), who have reported that, irrespective of the cropping and nitrogen levels and available phosphorus decreased considerably with advancement of maize growth which might be due to crop removal.

Available potassium

Different organic mulches application had its own influence on availability of K in soil. Among the different organic mulch combinations, application of dried weeds at 10 t ha^{-1} (T_9) registered the highest available K, which was higher than other mulches and control (Fig. 1c). The reason attributed could be the organic and inorganic acids produced during decomposition of dried weeds might have helped in the release of mineral bound insoluble potassium. The increased N could have also increased the K availability through its synergistic effect. Similar results were obtained by Srinivasan Rao *et al.* (1997). Lal *et al*. (2000) reported that the microorganisms and organic decomposition products affect the availability of potassium through liberation of organically bound potassium by decomposition process as well as by solubilization of insoluble forms present in soil and minerals.

Effect of different organic mulches on soil biological properties

Microbial population

Generally, the organic mulch application had conspicuously increased the microbial population. Application of different organic mulches had significantly increased the bacterial build up of soil. The highest bacterial population was associated with the application of raw coirpith at 10 t ha^{-1}(T_7) under maize crop (Table 3). This observation may be attributed to the coirpith containing higher amount of growth promoting substances, vitamins and enzymes, which in turn increased the bacterial population. In addition to that the cooler soil temperature and enhanced soil moisture would have increased the root biomass production, which resulted in higher production of root exudates increasing bacterial population in rhizosphere region. These results are in confirmity with the findings of Gunadi *et al.* (1999) and Suresh *et al.* (1995).

Application of different organic mulches conspicuously increased the fungal population. Among the different organic sources, raw coirpith mulch at 10 t ha^{-1}(T_7) under maize recorded maximum fungal population over the control (Table 3). The reason attributed again to the favourable environment facilitated by organics. The fungal population gradually increased from vegetative to harvesting stage. The increased microbial population in mulch applied soil might be due to the presence of high organic carbon content in soil. Significant increase in microbial biomass and activity under crop residue mulch was reported by Karlen *et al*. (1994) and Dominy and Haynes (2002).

Application of dried weeds at 10 t ha^{-1} (T_9)

accounted for the highest population of actinomycetes while the lowest population noticed in control (Table 3). The reasoning discussed under bacteria and fungi also holds good for actinomycetes. Tu *et al*. (2006) reported that the organic mulching had beneficial effects on soil microbes likely through buffering the extreme fluctuations in soil moisture and temperature. Organic mulching also improves soil moisture through reducing evaporation from soil (Franzluebbers *et al*., 1995), thus mitigating the disruptive effect of soil drying on microbes especially in dry season.

Conclusion

Overall, the results of the experiment conducted to study the effect of organic mulching on soil physical properties and nutrient availability pattern under rainfed condition at Regional Research Station, Paiyur, Krishnagiri district, Tamil Nadu with maize hybrid that the raw coirpith and dried weeds mulches at 10 t ha-1 along with application of N, P and K fertilizer could improve the soil fertility status besides improving the soil physical and, microbial population pattern in the rainfed Alfisols.

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