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Effect of Biomulches on Soil Health in Irrigated Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Present investigation of research was conducted during 2019 *rabi* season (September to January) at Tamil Nadu Agricultural University, Tamil Nadu, India in cv COSFV5 Sunflower to examine the impact of biomulches on soil properties such as chemical and biological properties of soil. Under different biomulches viz., live mulching with Sunhemp @ 40 kg ha^{-1}, Multi varietal crops (Navathaniyam) @ 50 kg ha^{-1}, *Terminalia chebula* powder @ 400 kg ha^{-1}, Mango leaves @ 4 t ha^{-1}, Tamarind leaf mulch @ 4 t ha^{-1}, Eucalyptus leaves @ 7 t ha^{-1}, Mustard seed powder @ 160 kg ha^{-1}, Neem leaves @ 2.5 t ha^{-1}, Two Hand weeding at 30 and 45 DAS and Weedy check @ Unmulched plot respectively. The field was laid out in Randomized Complete Block Design, treatments were randomized with the three replications. The nitrogen (33.8 kg ha^{-1}), phosphorous (14.9 kg ha^{-1}) and potassium (76 kg ha^{-1}) uptake was found maximum under Eucalyptus leaves @ 7 t ha^{-1}. The experimental results indicated that higher microbial count (Actinomycetes, Fungi and Bacteria) were found. Thus, biomulching revealed that it significantly improved the interaction of microbial flora and soil enzymatic activities in rhizospheric soil which in turn influenced the soil health. This was attributed to the slow decomposition of mulches that added nutrients to soil which in turn enhanced the sunflower yields.

Keywords Microbial load, Soil properties, Enzymatic activity.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a popular oilseed crop well known for its wide adaptability, Photoperiod insensitiveness, short duration, high quality edible oil (PUFA). It is fast growing high yielding thus requires more nutrients. It can be grown in wide range of soils with good drainage. Therefore, in present scenario, it is very much essential to adopt practices which retains the soil health, by keeping the production system a sustainable and productive one. Biomulchingis one such that reduces the deterioration of soil by preventing runoff and soil loss, minimizes weed infestation and decreases water evaporation. Thus, it expedites more retention of soil moisture and helps in regulating temperature fluctuations, improves physical, chemical and biological properties of soil and eventually enhances the growth and yield of crops (Naeem *et al.* 2015). In natural ecosystem, crop health often reveals the status of root zone

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microbial community. This community comprises bacteria, fungi, actinomycetes and algae, and all these can be used as biological indicators of soil quality. The addition of organic mulch with special concern to green leaves is another alternative for providing organic matter to the soil.

In agricultural soils, microorganisms are known to exert profound influences on the status of soil fertility, in particular on the availability of plant nutrients (Kennedy and Stubbs 2006) and play an important role in nitrogen cycling, nitrogen fixation and mineralization processes in all ecosystems. The soil microbial biomass is fundamental to maintaining soil functions because it represents the main source of soil enzymes that regulate transformation processes of elements in soils (Bohme and Bohme 2006). Among that Dehydrogenases play a significant role in the biological oxidation of soil organic matter (OM) by transferring hydrogen from organic substrates to inorganic acceptors (Zhang *et al.* 2010). This might be due to presence of sufficient soil available nutrients released upon decomposition from the mulches that favored alteration of soil pH and augmentation of microbial population according to Pal *et al*. (2013).

Green manuring alone manifested an increase of yield in Toria and the residual effect of green manuring on the following sunflower crop resulted in an additional yield of 317 kg ha^{-1}(Bahl and Pasricha 2001). The soil nutrients closely related to soil microbial population. *Sesbania aculeate* and *C. juncea* decomposed and released N at a faster rate and was significantly four times higher and supported more soil microbial biomass during early stages (within 10 days after incorporation) than other green manure crops (Inbushi *et al.* 1991). Keeping this view in consideration, the present investigation was carried out to study the effect of biomulches on interrelationship of microbial population, enzymatic activities and nutrient levels in soil of sunflower crop.

MATERIALS AND METHODS

A field experiment with sunflower was conducted in sandy clay loam, *Typic ustropept* at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore to evaluate the effect of biomulches on soil microbiological properties on Sunflower during 2019. Composite soil samples were collected from 0–15 cm depth before and after harvest of the crop randomly in the experiment field for identifying soil texture using Robinson's International pipette method (Piper 1966), pH using 1:2 soil water suspension (Jackson 1973), soil organic carbon (%) using Wet chromic acid digestion method (Walkley and Black 1934), organic matter, available nutrients like Available N using Alkaline permanganate method (Subbaih and Asija 1956), P_2O_5 using Olsen's method and Available K_2O content using Neutral normal ammonium acetate method (Stanford and English 1949). The samples were further kept in refrigerator in plastic bag for analysis of microbiological properties and all the results were expressed on dry weight basis. Ten grams of soil was mixed in 90 ml of sterilized water blank. Shaken by whirling clock wise and anti-clock wise for nearly 5 min to suspend the soil uniformly and to dispense microbes to get dilution 10^{-1}. Serial dilutions were made by transferring one ml of each dilution to test tubes containing nine ml sterilized water blank. The microbial load of bacteria, fungi and actinomycetes in soil at initial and post-harvest soil were examined by serial dilution and standard plate count technique using Nutrient agar media at 10^{-6} dilution (Collings and Lyne 1968), Martin's Rose bengal agar at 10^{-4} dilution (Martin 1950) and Kenknights agar media at 10^{-3} dilution (Kenknight and Muncie 1939) respectively. The plates were inoculated and then kept for incubation under 30±1°C and emerged colonies were examined and counted under microscope. The incubation time varied according to the individual microbes. Microbial load was expressed as colony forming unit (CFU) g^{-1} of soil as suggested by Jensen (1968). Urease activity was measured as per the method proposed by Tabatabai and Bremner (1969). Alkaline phosphatase activity (APA) was measured by using the method described by Tabatabai and Bremner (1969) in spectrophotometer at 630 nm. Soil dehydrogenase activity (DHA) was determined by estimating the rate of production of tri-phenyl formazan (TPF) from tri-phenyl tetrazolium chloride (TTC) (Dhyan *et al.* 1999) in spectrophotometer at 485 nm.The plant samples were collected treatment wise then shade dried followed by oven drying and ground in a willey mill. The N, P and K content were estimated using Microkjeldahl method (Humphries

Table 1. Effect of biomulches on nutrient uptake in sunflower.

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1 : Live mulching with sunhemp @ 40 kg ha^{-1}	27.2	11.25	60.2	1900	5024
T_2 : Live mulching with multi-crops (Navathaniyam) @ 50 kg ha^{-1}	26.6	11	57.4	1893	5032
T_3 : *Terminalia chebula* powder @ 400 kg ha^{-1}	30.78	12.65	67.3	2087	5379
T_4 : Mango leaves @ 4 t ha^{-1}	31	13.5	69	2054	5437
T_5 : Tamarind leaf mulch @ 4 t ha^{-1}	26	10.7	55.2	1799	5001
T_6 : Eucalyptus leaves @ 7 t ha^{-1}	33.8	14.9	76	2297	5797
T_7 : Mustard seed powder @ 160 kg ha^{-1}	23.3	9.4	48.5	1669	4689
T_8 : Neem leaves @ 2.5 t ha^{-1}	22.79	9.2	48	1623	4541
T_9 : Two Hand weedings at 30 and 45 DAS	34.6	15.4	77.8	2400	5822
T_{10} : Weedy check @ Unmulched plot	19	7.9	42	1456	4023
SEm±	1.34	0.58	2.8	89.91	235.2
CD (P=0.05)	2.82	1.21	5.9	188.90	494.1

1956), Triple acid digestion with colorimetric estimation (Jackson 1973) and Triple acid digestion with flame photometric method (Stanford and English 1949) respectively. Furthermore, uptake of nutrients was calculated by multiplying the nutrient content and dry matter and expressed in kg ha^{-1}. The seed yield was computed when the seeds reached a moisture level of 13% and was expressed in kg ha^{-1}. Likewise, after harvesting the sunflower heads stalk were left in the field for sun drying for 3 days after that dry weight of stalk was computed and expressed in kg ha^{-1}. The experimental data was statistically analyzed by using Randomized Block Design for the various parameters and subjected to fischer's method of analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984) using AGRES software program. The treatment means were compared at a significance level of 0.05.

RESULTS AND DISCUSSION

Nutrient uptake by sunflower

Nutrient uptake is the function of dry matter production. The aim of study clearly indicated that biomulching with Eucalyptus leaves at 7 t ha^{-1} had maximum nitrogen, phosphorous and phosphorous uptake (33.8, 14.9 and 76 kg ha^{-1}) at harvest followed by application of Mango leaves at 4 t ha^{-1} with a NPK uptake (31, 13.5 and 69 kg ha^{-1}) as shown in Table 1. Nutrient uptake of sunflower is affected by virtue of various bio-mulches. Increased nutrient uptake by crop could be correlated by addition of nutrients and increased microbial activity and increased dry matter at harvest. Unmulched control plot had reduced NPK uptake (19, 7.9 and 42 kg ha^{-1}). Similar results were published by Jat *et al.* (2011). Application of Eucalyptus leaves at 7 t ha^{-1} followed by Mango leaves at 4 t ha^{-1} was on par with *Terminalia chebula* powder at 400 kg ha^{-1} resulted in higher uptake of nutrients due to higher dry matter production and presence of higher nutrient content. Significantly higher utilization of nutrients resulted in higher nutrient uptake in affirmation with Lehoczky *et al.* (2006). Differential rate of photosynthesis, efficient translocation of assimilates to kernel (Iqbal *et al.* 2009).

Seed and stalk yield

Conducive conditions for crop growth and yield showed significantly higher variations through effective bio-mulches practices as indicated in Table 1. Application of Eucalyptus leaves at 7 t ha^{-1} resulted in superior seed yields as much as 2297 kg ha^{-1} followed by Mango leaves at 4 t ha^{-1} (2054 kg ha^{-1}) was comparable with *Terminalia chebula* powder at 400 kg ha^{-1} (2087 kg ha^{-1}). Perhaps, it also produced higher stalk yields (5797 kg ha^{-1}) under the application of Eucalyptus leaves at 7 t ha^{-1}followed by Mango leaves at 4 t ha^{-1} (5437 kg ha^{-1}) was comparable with *Terminalia chebula* powder at 400 kg ha^{-1} (5379 kg ha^{-1}). This could be substantiated with the fact that

Table 2. Effect in biomulches on total microbial count and enzymatic activity in sunflower.

Treatments	Total microbial count: Bacteria $\times 10^6$ CFU g^{-1}	Fungi $\times 10^4$ CFU g^{-1}	Actinomycetes $\times 10^3$ CFU g^{-1}	Dehydrogenase (µ g in TPF released g^{-1} in soil)	Urease (µ g in NH_4^+ released g^{-1} in soil)	Alkaline phosphatase (µ g in PO_4 released g^{-1} in soil)
T_1 : Live mulching with sunhemp @ 40 kg ha^{-1}	98.5	37.5	18.0	36.1	27.82	114.9
T_2 : Live mulching with multi-crops (Navathaniyam) @ 50 kg ha^{-1}	112.0	42.3	19.2	38	30	125
T_3 : *Terminalia chebula* powder @ 400 kg ha^{-1}	84.0	31.8	16.0	25	22.8	96.3
T_4 : Mango leaves @ 4 t ha^{-1}	88.7	32.4	16.5	30	24.7	94
T_5 : Tamarind leaf mulch @ 4 t ha^{-1}	75.0	30.0	15.4	22.6	20.2	100
T_6 : Eucalyptus leaves @ 7 t ha^{-1}	86.4	32.0	16.1	27.9	23.9	98
T_7 : Mustard seed powder @ 160 kg ha^{-1}	73.0	29.0	15.2	21.7	19.3	92
T_8 : Neem leaves @ 2.5 t ha^{-1}	97.0	37.0	17.9	35.2	27	112
T_9 : Two Hand weedings at 30 and 45 DAS	72.0	28.9	14.5	20.9	18	917
T_{10} : Weedy check @ Unmulched plot	53.0	25.0	12.9	12	15	75
SEm±	2.76	1.06	0.50	0.89	0.74	6.85
CD (P=0.05)	8.3	3.1	1.6	2.65	2.22	20.3

biomulches addded nutrients to soil. This assisted in accumulation of photosynthates in sunflower kernals which produced higher dry matter production whereas unmulched control plot had resulted in lower yields (Reddy *et al.* 2008). This may be attributed owing to better utilization of the available resources that resulted due to better decomposition of biomulches to the maximum extent accounting for enhanced sunflower yields. Significantly reduced yields were recorded in unmulched control plot over the other treatments. About 63.38% increase in yield was noticed in Eucalyptus leaves treated plot compared to that of control plot. Congruent results were reported by Jaykumar *et al.* (1988). Mahmood *et al.* (2016) also showed an increase of 83, 67 and 9 % in TDM, LAD and CGR finally maximizing the grain yields of maize with the combined application of rice + sunflower + maize surface mulch.

Microbial population

The diverse mulching treatments positively influenced the soil microbial activity marked by higher organic carbon and soil nutrient concentrations as furnished in Table 2. Bacterial population was comparatively higher in number than fungi and actinomycetes. Bacterial, fungal and actinomycetes population noted in Live mulching with Multi varietal Crops (Navathaniyam) at 50 kg/ha (T_2) (112 CFU $\times 10^6$ g^{-1},42.3 CFU $\times 10^4$ g^{-1} and 18.0 $\times 10^3$ CFU g^{-1}) recorded higher at harvest. Unmulched control recorded lower Bacterial, fungal and actinomycetes population (53 CFU × 106 g^{-1}, 25 CFU $\times 10^4$ g^{-1} and 12.9 $\times 10^3$ CFU g^{-1}) at harvest respectively. The decomposition of mulch residues in soil released essential nutrients necessary for growth of both plant and microbes. Das *et al.* (2017) reported similar findings that soil available K was significantly influenced by residue mulching (Nakhro and Dkhar 2010). This had stimulatory effect on multiplication of soil microflora (Channappagoudar *et al.* 2013, Ping *et al.* 2015). Moderate soil nutrients were available in Eucalyptus leaves at 7 t ha^{-1}, Mango leaves at 4 t ha^{-1} this might be due to slow decomposition of the mulches. Availability of carbon was found higher at crop maturity stage which resulted in increased actinomycetes population in soil due to application of mulches (Pal *et al.* 2013).

Enzymatic activity

Soil enzymatic activity plays an important role in

Table 3. Effect of biomulches on post-harvest soil nutrients in sunflower.

Nitrogen Treatments	Post-harvest soil Phosphorus (kg ha^{-1})	nutrients Organic Potassium (kg ha^{-1})	carbon (kg ha^{-1})	(%)
T_1 : Live mulching with sunhemp @ 40 kg ha^{-1}	305	21.7 588	0.44	
T_2 : Live mulching with multi-crops (Navathaniyam) @ 50 kg ha^{-1}	309	23.5 638	0.47	
T_3 : *Terminalia chebula* powder @ 400 kg ha^{-1}	275	18.6 533	0.37	
T_4 : Mango leaves @ 4 t ha^{-1}	276	19.4 537	0.40	
T_5 : Tamarind leaf mulch @ 4 t ha^{-1}	249	16.6 482	0.35	
T_6 : Eucalyptus leaves @ 7 t ha^{-1}	276	19.0 535	0.39	
T_7 : Mustard seed powder @ 160 kg ha^{-1}	245	16.3 480	0.34	
T_8 : Neem leaves @ 2.5 t ha^{-1}	307	21.42	587	0.43
T_9 : Two Hand weedings at 30 and 45 DAS	244	16.12	479	0.32
T_{10} : Weedy check @ Unmulched plot	218	14.20	430	0.31
SEm± 8.70	0.64	17.110.01		
CD (P=0.05)	25.9	1.8 50.9	0.036	

catalyzing reactions indispensable in life processes of soil microorganisms, decomposition of organic residues, circulation of nutrients, as well as forming organic matter and soil structure. Significantly higher enzymatic activity was noticed in Live mulching with Multi varietal Crops (Navathaniyam) at 50 kg/ha (T_2) 38 µ g of TPF released g^{-1} of soil, 30 µ g of NH_4^+ released g^{-1} of soil and 125µ g of PO_4 released g^{-1} of soil recorded higher at harvest as furnished in Table 2. This was comparable with Live mulching with sunhemp at 40 kg/ha (T_1) 36.1 µ g of TPF released g^{-1} of soil, 27.8 µ g of NH_4^+ released g^{-1} of soil and 114.9 µg of PO_4 released g^{-1}. Unmulched control recorded lower fungal population (12 µ g of TPF released g^{-1} of soil, 15 µ g of NH_4^+ released g^{-1} of soil and 75µg of PO_4 released g^{-1}) at harvest respectively. Soil enzymatic activity was significantly higher in Live mulching with Multi varietal crops (Navathaniyam) at 50 kg ha^{-1}, Live mulching with sunhemp at 40 kg ha^{-1}, Neem leaves at 2.5 t ha^{-1}. This might be due to soil microbial activity were positively associated with soil as represented in Table 3 (Dinesh *et al.* 2010). Soil enzymes like dehydrogenase, urease and phosphatase are the bio-indicators of soil quality. Control recorded the least enzymatic activity. Higher enzymatic activity was observed due

Table 4. Correlation analysis of microbial population, enzymatic activities and available nutrient of soil.

	Bacteria	Fungi	Actinomycetes	Dehydrogenase	Urease	Alkaline phosphatase	Nitrogen	Phosphorus	Potassium	Organic carbon
Bacteria	1									
Fungi	0.98	1								
Actinomycetes	0.99	0.98	1							
Dehydrogenase	0.99	0.96	0.99	1						
Urease	0.99	0.96	0.98	0.99	1					
Alkaline phosphatase	-0.18	-0.19	-0.25	-0.19	-0.30	1				
Nitrogen	0.27	0.25	0.21	0.16	0.15	0.45	1			
Phosphorous	0.26	0.24	0.21	0.14	0.16	0.34	0.98	1		
Potassium	0.24	0.21	0.19	0.12	0.14	0.33	0.97	1.00	1	
Organic carbon	0.32	0.29	0.28	0.20	0.21	0.32	0.97	0.99	0.98	1

to higher organic matter added upon decomposition (Abd El-Maksoud *et al.* 1997). A significant positive correlation of Dehydrogenase, urease activity was established with fungal, bacterial and actinomycetes population, whereas, phosphatase activity showed a negative correlation with microbial population. This could be justified with similar results presented with the incorporation of daincha (*Sesbania aculeate*), there was rise in microbial activity of the soil which in turn amplified dehydrogenase activity as furnished in Table 3 (Inbushi *et al.* 1991). This was in line with the findings which stated that there was an increase in DHA and SMBC was due to a reduction in pH and ESP of soil on account of addition of organic matter as result of decomposition from green gram residues (Shirale *et al.* 2018).

Post-harvest soil nutrients

Post-harvest nutrient status of soil influenced by different biomulches are presented in Table 3. Live mulching with Multi varietal Crops (Navathaniyam) at 50 kg/ha (T_2) (308.9, 23.5 and 638 kg ha^{-1}) recorded higher N, P and K post-harvest availability respectively. These biomulches significantly added soil nutrients upon decomposition. Unmulched control revealed that lesser amount of N, P and K post-harvest availability (218, 14.2 and 430 kg ha^{-1}). Bio-mulching modified soil environment and had hysterically significant effect on soil quality. Soil nutrients were proportionate to soil microbial activity and thus stimulated the soil enzymatic activity. Eventually bio-mulching increased the post-harvest soil nutrients such as soil available N, soil available P and available K. Dinesh *et al.* (2000) opined that soil organic carbon, microbial biomass carbon and total Nitrogen were positively correlated with the enzyme activities as represented in Table 4. Congruent results were given by Somasundaram (2012) and Maheswari and Arthanari (2017).

CONCLUSION

It could be concluded from the study that biomulching significantly increased soil fertility in sunflower. Soil biological health was also favored due to enzymatic activity which resulted in enhanced microbial growth. Henceforth, the biomulching added additional nutrients to soil which in turn stimulated the nutrient uptake of the sunflower crop accounting for enhanced yields.

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