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Short communication

Influence of mulches on rhizosphere microflora, yield and weed competition in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
A field experiment was conducted during the summer season of 2014 to study the effect of various mulching materials on rhizosphere microflora, yield and weed competition in okra. Mulching with black polythene sheet recorded the highest yield (15.63 Mg ha^{-1}) of okra. Among organic mulches used, mango leaves and newspaper recorded higher yield of 10.06 and 9.37 Mg ha^{-1}respectively, along with higher microbial population in okra rhizosphere. Mulching had great influence on the population of bacteria, fungi and actinomycetes as compared to unmulched plots. All the treatments with mulches favoured the population of fungi and actinomycetes and crop yield. Pre emergence spraying of pendimethalin @ 1.0 kg ha^{-1} gave the lowest weed count and weed dry weight. The least weed index was recorded in hand weeding (23.1) followed by mango leaves, pendimethalin and mulching with paper.

Key words: Rhizosphere, Bacteria, Fungi, Actinomycetes, Mulching, Okra

Mulching is a cultural practice widely adopted in vegetables such as okra to suppress weed growth and to conserve soil moisture. Mulches provide different kinds of ecological niches in the subsystem of crop environment. They encourage the proliferation of micro-arthropods, earthworms and other beneficial microorganisms in the rhizosphere that bring about changes in the status of soil fertility (Yadav et al., 2008). Rhizosphere is the narrow zone of soil around roots and a specialized ecological niche for fungi, bacteria, actinomycetes and other microbes, and is influenced by root exudates, soil factors, age and type of host plant and molecular signals. Organic compounds released by the roots and microbes dominate the rhizosphere. Mulching in widely spaced crops like okra can be practiced as an alternative method to reduce the herbicide load in soil and to improve the activity of soil microflora towards sustainable crop production. Several studies showed that crop residues like paddy straw, wheat straw, banana leaf and even weeds like dry water hyacinth performed well when they were used as surface mulch (Goswami and Saha, 2006). An experiment was conducted to assess the population and response of rhizosphere microflora and weeds to different mulches in okra, an important vegetable in India, grown in summer.

A field experiment was conducted at the Agronomy Farm, College of Horticulture, Vellanikkara, Thrissur, Kerala during the summer season (March - May) of 2014. The

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experimental site, which enjoys typical humid tropical climate, lies between $13^0 32'$ N latitude and $78^0 26'$ E longitude, with an elevation of about 40 m from mean sea level. The soil is sandy loam with low pH of 4.8, high organic carbon (1.5 %), low available N (195.3 kg ha^{-1}), medium available P (15.17 kg ha^{-1}) and medium available K (232.7 kg ha^{-1}). The experiment was conducted in randomized block design with nine treatments and three replications. The treatments comprised of mulching with mango leaves (5 Mg ha^{-1}), mulching with coconut leaves (5 Mg ha^{-1}), mulching with fresh weeds (5 Mg ha^{-1}), mulching with paddy straw (5 Mg ha^{-1}), mulching with paper, mulching with black polythene sheet, hand weeding, pre emergence spraying of pendimethalin (1.0 kg ha^{-1}) and unweeded control. Seeds of the cultivar "Arka Anamika" (@ 8.5 kg ha^{-1}) were dibbled at a spacing of 60 cm x 30 cm. Mulching was done at the time of sowing as per the treatments.

The effect of mulching on bacteria, fungi and actinomycetes population were studied at different growth stages viz., at sowing, 60 DAS (fruiting) and at final harvest (maturity). Composite soil samples were collected from each treatment and serial dilution technique and pour plate method (Agarwal and Hasija, 1986) were followed to assess the population. The population of bacteria, fungi and actinomycetes was enumerated on nutrient agar, Martin's Rose Bengal agar and Kenknight's agar media respectively. The plates were incubated at 30 ± 2^0C and the populations of bacteria, fungi and actinomycetes were observed at 2, 5 and 7 days after inoculation, respectively. The results were recorded and expressed as cfu g^{-1}. The sampling at the time of sowing represented the initial population of soil microorganisms. Observations on weed count, weed dry weight at 30 DAS and yield of okra were recorded and the data were subjected to analysis of variance using the statistical package 'MSTAT - C' (Freed, 2006). Weed index was worked out as per the formula suggested by Gill and Vijaykumar (1969).

The initial bacterial population ranged from 150.6×10^6 to 203.3×10^6 cfu g^{-1} (Table 1). The bacterial population was reduced drastically from sowing to 60 DAS and then to harvest. The highest count was observed for the treatment mulched with paddy straw at 60 DAS and at harvest (Table 1). Mulching with mango leaves, newspaper and coconut leaves also recorded better activity of bacteria at 60 DAS and at harvest compared to others. The least count of bacteria was recorded for pendimethalin, hand weeding and polythene sheet. Subrahmaniyan et al. (2008) reported that plastic film mulch significantly increased soil temperature by 1-1.9^0C at different phenophases of crop growth from sowing to harvest. The data in Table 1 also showed the decreasing population of bacteria from sowing to harvest. However, the population of actinomycetes and fungi increased. The inhibitory effect of root exudates of grasses on bacteria was reported by Gopalakrishnan et al. (2009). Similarly, herbicidal application has detrimental effects on bacterial activity after its application (Ramesh and Nadanassababady, 2005). The decrease in bacterial population may also be due to the competitive influence and the toxic effect of herbicides in soil (Ghosh et al., 2012). It is also reported that microbial population is dependent on soil temperature, air temperature, moisture and relative humidity and the lowest bacterial population was observed during summer season (Yadav and Yadav, 2013).

Soil moisture content is an important factor, which influences the activity of micro organisms in soil. Higher population of bacteria in mulched soil may be due to favourable moisture. Aswathi et al. (2006)

Table 1. Effect of different mulches on the population of bacteria, fungi and actinomycetes.

Treatments	Population (cfu g^{-1})								
	Bacteria (×10^6)			Fungi (×10^3)			Actinomycetes(×10^4)		
	At sowing	At 60 DAS	At harvest	At sowing	At 60 DAS	At harvest	At sowing	At 60 DAS	At harvest
T_1- Mulching with mango leaves @ 5 Mg ha^{-1}	160.6	23.6^{ab}	15.6^{b}	50.6	60.3^{bc}	51.6	93.3	75.3^{cd}	160.3
T_2- Mulching with coconut leaves @ 5 Mg ha^{-1}	193.3	20.3^{ab}	12.6^{b}	31.6	57.6^{c}	56.6	95.0	87.6^{abc}	175.3
T_3- Mulching with fresh weeds @ 5 Mg ha^{-1}	161.0	19.3^{b}	12.6^{b}	37.6	81.0^{ab}	49.3	96.6	73.0^{cd}	178.6
T_4- Mulching with paddy straw @ 5 Mg ha^{-1}	150.6	27.3^{a}	24.0^{a}	33.3	56.6^{c}	61.0	87.0	76.0^{cd}	147.6
T_5- Mulching with paper	161.6	20.6^{ab}	15.0^{b}	31.6	73.3^{abc}	52.0	96.0	94.3^{ab}	169.0
T_6- Mulching with black polythene sheet	203.3	10.6^{c}	9.0^{b}	41.3	60.3^{bc}	41.0	87.3	82.6^{bcd}	175.3
T_7- Hand weeding	180.6	8.6^{c}	9.3^{b}	35.3	55.3^{c}	49.0	84.0	102.6^{a}	159.0
T_8- Pendimethalin 1.0 kg ai ha^{-1} (Pre emergence)	196.6	6.3^{c}	8.6^{b}	38.3	74.0^{abc}	54.6	83.3	88.6^{abc}	162.6
T_9- Unweeded control	171.6	18.6^{b}	14.0^{b}	54.6	88.0^{a}	67.3	83.6	65.3^{d}	135.6
CD (0.05)	NS	7.3	7.4	NS	22.4	NS	NS	18.1	NS

* In column, mean followed by common letters do not differ significantly at 5 % level by DMRT.

reported that local grass straws and leaf mulches in brinjal under hot arid conditions recorded higher moisture content in the range of 33-100 per cent compared to unmulched plots.

The initial population of fungi ranged from 31.6×10^3 to 54.6×10^3 (Table 1). The fungal population in the soil increased from sowing to 60 DAS and then reduced at harvest stage (Table 1). Higher count was observed in unweeded control, mulching with fresh weeds and pendimethalin. The least count was recorded for hand weeding, paddy straw and mango leaves at 60 DAS. After harvest, higher counts were observed in unweeded control, paddy straw and pendimethalin. From the results, it is clear that fungi population was less affected by herbicidal application and could also tolerate less moisture condition of soil as fungi proliferated under unweeded control. The fungi was greatly influenced by rhizodeposits of okra as its population was higher during the crop reproductive stage, it may also be due to the higher root exudates found in crops at this stage (Yu et al., 2005). Mulching with paddy straw and mango leaves maintained almost consistent population till harvest and even a little higher population from 60 DAS to harvest. Beneficial effects of mulching and root exudates of wheat on fungal population were reported by Yanbing et al. (2008).

The initial actinomycete population ranged from 83.3×10^4 to 96.6×10^4 cfu g^{-1} (Table 1).

Mulching greatly influenced actinomycetes in rhizosphere of okra as population appeared to increase from sowing to harvest. Among the different treatments, hand weeding, newspaper, pendimethalin and coconut leaves recorded higher colony count (Table 1) at 60 DAS and the lowest was recorded in the case of unweeded control. The population increased tremendously from sowing to harvest, among which unweeded control recorded the lowest count (135.6×10^4 cfu g^{-1}) compared to others. Herbicidal application had no effect on its population. Decomposition of organic materials may influence the population of actinomycetes as higher population was recorded at the end of growth stage. According to Pal et al. (2013), population of actinomycetes in soil increased towards soyabean crop maturity because of higher availability of carbon at that stage due to litterfall.

Among the different treatments, pre emergence spraying of pendimethalin @ 1.0 kg ha^{-1} gave the lowest weed count (34 no. m^{-2}) and weed dry weight (2.33 g m^{-2}). Among various organic mulches, newspaper and mango leaves were better alternatives with lower weed count and weed dry weight (Table 2). As hand weeding was done on 30th day, weed count and dry weights were higher in hand weeded plots at this stage. All the mulched plots recorded lower weed count and weed dry weight compared to unweeded plots. The least weed index was recorded in hand weeding (23.1) followed by mango leaves, pendimethalin and mulching with paper. From the data, it is clear that mulches can prevent the germination and establishment of weeds.

Mulching influenced the yield of okra greatly. Higher yield was recorded for mulching with polythene sheet (15.63 Mg ha^{-1}) followed by hand weeding (12.02 Mg ha^{-1}). Polyethylene mulch had pronounced positive effect on yield of okra (Mahadeen, 2014). Unweeded control recorded the lowest yield of 1.05 Mg ha^{-1}. Compared to unweeded control plots, plants with black polythene mulch recorded 93 percent higher yield. On mulching with mango leaves and newspaper, the yield increases were 90 and 89 percent respectively. However, mulching with paddy straw, coconut leaves and fresh weeds recorded lower yield compared with other mulches, where higher microbial counts were recorded.

It could be concluded that better weed management is possible through the use of organic mulches. Mulching with crop residues, leaves, grasses or paper nourishes the crop rhizosphere and positively influences the yield. Hence, mulching can be recommended as a

Table 2. Effect of mulches on weed count, dry weight, weed index and crop yield

Treatments	Weed count (No. m^{-2})	Weed dry weight (g m^{-2})	Weed index (%)	Yield (Mg ha^{-1})
T_1- Mulching with mango leaves @ 5 Mg ha^{-1}	15.16	2.82	35.60	10.06
T_2- Mulching with coconut leaves @ 5 Mg ha^{-1}	21.73	6.43	70.88	4.55
T_3- Mulching with fresh weeds @ 5 Mg ha^{-1}	27.04	6.09	73.02	4.22
T_4- Mulching with paddy straw @ 5 Mg ha^{-1}	18.73	4.13	67.96	5.01
T_5- Mulching with paper	15.77	2.28	40.06	9.37
T_6- Mulching with black polythene sheet	9.47	2.05	-	15.63
T_7- Hand weeding	27.70	7.10	23.10	12.02
T_8- Pendimethalin 1.0 kg ai ha^{-1} (Pre emergence)	5.83	1.67	38.80	9.56
T_9- Unweeded control	28.41	9.01	93.28	1.05
CD(0.05)	1.61	1.71	-	1.71

crop management technique for higher yield and better activity of rhizosphere microorganisms.

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