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Studies on status of soil microbial population in foxtail millet – *Melia dubia* based agroforestry system under organic nutrient management practices

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Abstract
The experiment on "Studies on status of soil microbial population in foxtail millet – *Melia dubia* based agroforestry system under organic nutrient management practices" was conducted for two years on farmer's field at Santhekallur village of Raichur district. There were eleven treatments with three replications, laid out in completely randomized block design. The treatments consisted of application of no organic manure (control), FYM equivalent to 100 per cent RDN, FYM (50%) + Vermicompost (50%) and FYM (50%) + Poultry manure (50%) equivalent to 100 per cent RDN alone and in combination with foliar spray of 3.0 per cent panchagavya and 5.0 per cent vermiwash at 30 and 45 DAS and foliar spray of 3.0 per cent panchagavya at 30 DAS alternated with 5.0 per cent vermiwash at 45 DAS. Microbial population *viz*., bacteria, fungi and actinomycetes were assessed in soil under foxtail millet- *Melia dubia* based agroforestry system as influenced by organic nutrient management practices. At 60 DAS, in pooled data, FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher bacterial (47.11 10^6 CFU g^{-1} of soil), fungal (33.80 10^4 CFU g^{-1} of soil) and actinomycetes population (35.14 10^3 CFU g^{-1} of soil) when compared with no organic manurial treatment (28.45 10^6 CFU g^{-1} of soil, 20.64 10^4 CFU g^{-1} of soil and 22.64 10^3 CFU g^{-1} of soil, respectively). Similar trend was followed at harvest with decrease in population of all above microorganisms.

Keywords: Agroforestry, microbial population, organic manures, rhizosphere, FYM, poultry manure, vermicompost, panchagavya, vermiwash

Introduction
Use of organic manures is the object to accelerate microbial processes to enhance availability of nutrients in the assimiable form. Organics modify the micro-climate, alter the environment of soil microbes, enhance soil flora and fauna activity, modify soil moisture regimes and properties associated with it and soil temperature in the root zone. The microbial activities are enhanced as the fresh organic material acts as the nutrient source for the diverse soil flora and fauna. Microbial biomass is the total sum of all micro-organisms present in soil. Organic manures not only supply a higher amount of different nutrient elements but also contains beneficial microbes like nitrogen fixing bacteria, mycorrhizae and growth promoting substances for betterment of crops (Barik *et al*., 2006) [4]. With this back ground, an experiment on "Studies on status of soil microbial population in foxtail millet – *Melia dubia* based agroforestry system under organic nutrient management practices was conducted with objective is to assess the microbial in agroforestry system as influenced by organic manurial treatments.

Material and Methods
The experiment on "Studies on status of soil microbial population in foxtail millet – *Melia dubia* based agroforestry system under organic nutrient management practices" was conducted for two years on farmer's field at Santhekallur village of Raichur district which represents Northern Dry Zone of Karnataka (Zone 3). There were eleven treatments with three replications, laid out in completely randomized block design. The treatments consisted of application of no organic manure (control), FYM equivalent to 100 per cent RDN, FYM (50%) + Vermicompost (50%) and FYM (50%) + Poultry manure (50%) equivalent to 100 per cent RDN alone and in combination with foliar spray of 3.0 per cent panchagavya and 5.0 per cent vermiwash at 30 and 45 DAS and foliar spray of 3.0 per cent panchagavya at 30 DAS alternated with 5.0 per cent vermiwash at 45 DAS.

Microbial population *viz*., bacteria, fungi and actinomycetes were assessed in soil under foxtail millet- *Melia dubia* based agroforestry system as influenced by organic nutrient management practices. The soil samples were collected from the rhizosphere of the plants before sowing of crop, at 60 DAS and harvest during 2018 and 2019 from all the treatments and these soils were placed in a polyethylene bag and brought to laboratory and stored in refrigerator at 5° C until used for analysis. The rhizosphere soil samples collected from experimental site were analyzed for different soil microorganisms (Bacteria, Fungi and Actinomycetes) by serial dilution and plating techniques using specific media (Pramer and Schmidt, 1964) [13]. The observations recorded in this study was analyzed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by Cochran and Cox (1967) [5]. The level of significance on 'F' test was tested at 5 per cent. The results have been discussed based on critical difference at P = 0.05.

Results and Discussion

The results of the experiment on effect of different organic manurial treatment influence on microbial population in soil under foxtail millet – *Melia dubia* based agroforestry was presented in Table from 1 to 3 and Fig. 1.

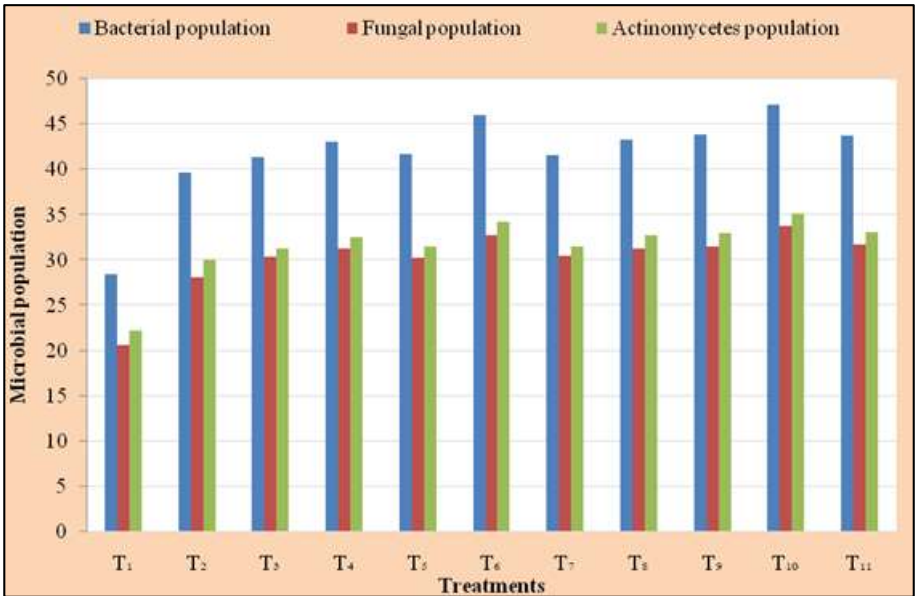

Fig 1: Microbial population in soil as influenced by organic nutrient management practices in foxtail millet- *Melia dubia* based agroforestry system

Effect on bacterial population (10^6 cfu g^{-1} soil)

Nutrient management practices through organics influenced soil bacterial population significantly at 60 DAS and at harvest in *Melia dubia* based agroforestry system. At 60 DAS, in pooled data, with tree association, FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher bacterial population (47.11) when compared with all the treatments except FYM + poultry manure + panchagavya spray (46.08), FYM + poultry manure + vermiwash spray (43.27), FYM + vermicompost + panchagavya alternated with vermiwash spray (43.90) and FYM + poultry manure (43.04) and also sole foxtail millet with recommended organic nutrient sources without tree component (43.80). Other treatments were intermediary in their effect. No organic manurial treatment recorded significantly lower bacterial population (28.45) over all the treatments. At harvest, there was gradual reduction in bacterial population from 60 DAS, however, effect was followed similar trend. In both stages of crop growth, higher bacterial population was observed with organic nutrient management practices in agroforestry system when compared to without tree association. These results are in line with findings of Rohini (2019) [14] in rice and Krupashree (2019) [9] in foxtail millet crops.

Effect on fungal population (10^4 cfu g^{-1} soil)

In pooled data, significant variation in fungal population in soil was exerted due to different organic nutrient management practices in foxtail millet cultivation with *Melia dubia* based agroforestry system. At 60 DAS, with tree association, application of FYM + poultry manure + panchagavya alternated with vermiwash spray resulted in significantly higher fungal population (33.80) and also sole foxtail millet with recommended organic nutrient sources without tree compenent (31.69) when compared with no organic manurial treatment (20.64), FYM (28.16), FYM + vermicompost + panchagavya spray (30.23). At harvest, with tree association, application of FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher fungal population (32.77) when compared with no organic manures treated plot (18.80) and FYM (26.91) and FYM + vermicompost + panchagavya (29.10). These results are in conformity with findings of Prabudoss *et al*. (2014) [12] in kodo millet and Uppendranaik *et al*. (2018) [15] in foxtail millet.

Effect on actinomycetes population (10^3 cfu g^{-1} soil)

Actinomycetes population in soil was significantly influenced by different organic nutrient management practices in foxtail millet cultivation in *Melia dubia* based agroforestry system in both the years and pooled data. In pooled data, with tree association, FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher actinomycetes population (35.14) when compared with no organic manurial treatment (22.18) and application of FYM (30.01) and was on par with rest of the treatments. The no

organic manurial treatment resulted in significantly lower actinomycetes population (22.18). At harvest, in pooled data, with tree association, application of FYM + poultry manure + panchagavya alternated with vermiwash spray followed by FYM + poultry manure + panchagavya spray showed their significant superiority with respect to actinomycetes population (34.95 and 33.42, respectively) when compared with no organic manurial treatment (20.10) and application of FYM alone (29.24). The actinomycetes population recorded with no organic manurial treatment was significantly lower than all other treatments.

Organic manures not only help to supply the nutrients but also act as a food for microorganisms and encourage the multiplication of their population, which in turn improves the mineralization of nutrients in soil and thus, fertility and productivity of the soil will be improved. The enhancement of soil microbial biomass is known to influence crop productivity and nutrient cycling. In the present study, with tree association, significant improvement in the population of soil micro-organisms *viz*., bacteria, fungi and actinomycetes were with organic manurial treatments *i.e*., noticed at 60 DAS and harvest of foxtail millet. Marked effect was more in agroforestry system than open land. This might be due to the presence of easily metabolizable compounds at the beginning of the crop and also under active growth phase on account of releasing higher amounts of root exudates, supporting numerous and diverse micro flora. The significant increase in microbial population was observed with the addition of organic manures in combination with liquid organic manures *viz*., panchagavya and vermiwash in foxtail millet cultivation in *Melia dubia* based agroforestry system. Treatments which received FYM + poultry manure or FYM + vermicompost + panchagavya alternated with vermiwash recorded higher microbial population when compared with rest of the treatments. Lower microbial population was noticed in no organic manurial treatment and foxtail millet cultivation with recommended organic nutrient sources without tree association. They did not cause any significant variations in the soil microbial population, growth and functioning of soil microbial biomass as carbon substrate availability was limited. These results are in line with the findings of Meena *et al.* (2010) [11], Govindaraju and Reddy (2011) [7] and Alagappan *et al.* (2018) [1] who reported higher soil microbial population with addition of combined application of organics.

When comparison made between with and without tree component, microbial population were higher in tree association than in open condition. These results are in conformity with findings of Srinivasan and Mohan (2006), Yadav *et al*. (2011), Bainard *et al.* (2013) [2], Ramulu (2014), Balakrishna *et al*. (2016) [3], Doddabasava *et al.* (2018) [6], Indra *et al*. (2018) [8] and Yengwe *et al*. (2018) [16] in different agroforestry system than sole crops.

Table 1: Bacterial population in soil at 60 DAS and harvest in foxtail millet cultivation as influenced by organic nutrient management practices in *Melia dubia* based agroforestry system

Treatments	Bacteria (No. × 10^6 CFU g^{-1} of soil)					
	60 DAS			At harvest		
	2018	2019	Pooled	2018	2019	Pooled
T_1 : No organic manure (Control)	33.33	23.57	28.45	28.18	19.24	23.71
T_2 : FYM equivalent to 100% RDN	37.57	41.70	39.63	36.82	41.28	39.05
T_3 : FYM (50%) + Vermicompost (50%) equivalent to 100% RDN	39.18	43.49	41.33	38.39	43.05	40.72
T_4 : FYM (50%) + Poultry manure (50%) equivalent to 100% RDN	40.80	45.29	43.04	39.98	44.84	42.41
T_5 : T_3 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	39.50	43.85	41.67	38.71	43.41	41.06
T_6 : T_4 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	43.67	48.48	46.08	42.80	46.57	44.69
T_7 : T_3 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	39.47	43.82	41.64	38.68	43.38	41.03
T_8 : T_4 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	41.01	45.52	43.27	40.19	45.07	42.63
T_9 :T_3 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	41.61	46.19	43.90	40.78	45.73	43.25
T_{10} :T_4 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	45.46	48.77	47.11	44.55	48.28	46.41
T_{11} : Sole foxtail millet without tree component	41.52	46.08	43.80	41.02	45.62	43.32
S.Em ±	01.61	01.92	01.71	01.67	01.90	01.70
C.D. at 5%	04.76	05.67	05.04	04.92	05.61	05.03

DAS: Days after sowing

Table 2: Fungal population in soil at 60 DAS and harvest in foxtail millet cultivation as influenced by organic nutrient management practices in *Melia dubia* based agroforestry system

Treatments	Fungi (No. × 10^4 CFU g^{-1} of soil)					
	60 DAS			At harvest		
	2018	2019	Pooled	2018	2019	Pooled
T_1 : No organic manure (Control)	23.04	18.24	20.64	21.89	15.71	18.80
T_2 : FYM equivalent to 100% RDN	26.57	29.76	28.16	25.24	28.57	26.91
T_3 : FYM (50%) + Vermicompost (50%) equivalent to 100% RDN	29.30	31.47	30.39	27.84	31.52	29.68
T_4 : FYM (50%) + Poultry manure (50%) equivalent to 100% RDN	29.38	33.24	31.31	27.91	31.59	29.75
T_5 : T_3 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	28.20	32.25	30.23	26.79	31.40	29.10
T_6 : T_4 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	30.91	34.62	32.77	29.37	33.28	31.33
T_7 : T_3 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	28.42	32.50	30.46	27.67	32.00	29.83
T_8 : T_4 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	29.52	33.06	31.29	28.04	32.08	30.06
T_9 :T_3 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	29.72	33.29	31.50	28.23	31.96	30.10
T_{10} :T_4 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	31.89	35.71	33.80	30.12	35.41	32.77
T_{11} : Sole foxtail millet without tree component	29.89	33.48	31.69	28.40	32.15	30.27
S.Em ±	01.16	01.28	01.19	01.01	01.38	01.12
C.D. at 5%	03.43	03.77	03.51	02.99	04.07	03.29

Table 3: Actinomyctes population in soil at 60 DAS and harvest in foxtail millet cultivation as influenced by organic nutrient management practices in *Melia dubia* based agroforestry system

Treatments	Actinomycetes (No. × 10^3 CFU g^{-1} of soil)					
	60 DAS			At harvest		
	2018	2019	Pooled	2018	2019	Pooled
T_1 : No organic manure (Control)	24.00	20.36	22.18	22.58	17.61	20.10
T_2 : FYM equivalent to 100% RDN	28.18	31.84	30.01	27.33	31.16	29.24
T_3 : FYM (50%) + Vermicompost (50%) equivalent to 100% RDN	29.38	33.20	31.29	28.50	32.49	30.50
T_4 : FYM (50%) + Poultry manure (50%) equivalent to 100% RDN	30.60	34.58	32.59	29.68	33.84	31.76
T_5 : T_3 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	29.63	33.48	31.55	28.74	32.76	30.75
T_6 : T_4 + Foliar spray of Panchagavya @ 3% at 30 and 45 DAS	32.20	36.39	34.29	31.24	35.61	33.42
T_7 : T_3 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	29.61	33.45	31.53	28.72	32.74	30.73
T_8 : T_4 + Foliar spray of Vermiwash @ 5% at 30 and 45 DAS	30.76	34.76	32.76	29.83	34.01	31.92
T_9 :T_3 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	30.96	34.98	32.97	30.03	34.23	32.13
T_{10} :T_4 + Foliar spray of Panchagavya @ 3% at 30 DAS and Vermiwash @ 5% at 45 DAS	33.19	37.09	35.14	32.66	36.23	34.95
T_{11} : Sole foxtail millet without tree component	31.14	34.95	33.05	30.20	34.43	32.32
S.Em ±	01.25	01.41	01.32	01.26	01.47	01.35
C.D. at 5%	03.70	04.15	03.91	03.71	04.33	03.99

Conclusion

From the foregoing discussion, it is clear that application of organic manures along with foliar sprays of panchagavya alternated with vermiwash significantly influenced the bacterial, fungal and actinomyctes population in soil when compared with control as well as in foxtail millet cultivated under open condition. Organic pools of carbon associated nutrients, particularly nitrogen, could be maintained in rhizosphere zone for maintaining soil organic matter there by sustaining soil quality.

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