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Effect of Agronomic Fortification through Enriched Organics and Foliar Nutrition in Foxtail Millet (*Setaria italica* L.) on Soil Biological Properties under Organic Condition

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A field experiment was conducted at Main Agricultural Research Station, Raichur, during *kharif*, 2018 to study the effect of agronomic fortification on through Zn and Fe enriched organics and foliar nutrition in foxtail millet (*Setaria italica* L.) cultivation. The experiment was laid out in randomized complete block design with three replications. Application of Zn and Fe enriched compost + foliar spray of panchagavya recorded significantly higher bacterial, fungal, actinomycetes, N_2-fixers and phosphorous solubising bacteria after harvest (61.33×10^6, 6.33×10^4, 30.50×10^3, 27.00×10^6 and 16.28×10^6 CFU g^{-1} of soil, respectively) and it was found on par with the treatment receiving Zn and Fe enriched vermicompost + foliar spray of $ZnSO_4$ and $FeSO_4$ and Zn and Fe enriched vermicompost + foliar spray of panchagavya. Microorganisms are indication of soil ability to store and recycle nutrients and energy this helps in stimulating and enhancing the millet yield. The lower microbial population (bacterial, fungal, actinomycetes, N_2-fixers and phosphorous solubising bacteria) was observed with compost application alone (25.00×10^6, 4.00×10^4, 15.00×10^3, 20.40×10^6 and 14.10×10^6 CFU g^{-1} of soil respectively).

Introduction

Organic farming system is based on the management of soil organic matter, which in turn maintains the physical, chemical, and biological properties of soil. It is now a well-established fact that organically managed soil exhibits greater soil organic carbon and total nitrogen, lower nitrate leaching and biological soil quality, so better soil health is inevitable for better growth and development of crop leading to higher production (Drinkwater *et al.*, 1998 and Glover *et al.*, 2002).

Soil micro-organisms are the living part of soil organic matter present in the soil. The microbial biomass and microbial activities in soil are crucial to sustain the productivity of soil. Organic farming is reported to have enhanced both microbial biomass and microbial activity by 20-30% and 30-100%, respectively (Stolze *et al.,* 2002).

The soil having high organic matter content ensures greater microbial activity and greater soil N supplying power than the soil having less organic matter. Soil organisms form a food web that decomposes organic matter and releases nutrients in the process. In food web bacteria and fungi, which obtain energy by decomposing soil organic matter directly. Protozoa and some nematodes are organisms that graze on bacteria and fungi, releasing nitrogen and phosphorous with prone to fixation in the soil (unavailable form for plant uptake) that can then be utilized by plants. In addition to helping break down organic matter, decomposers are often eaten by other arthropods (e.g., spiders) and can contribute to supporting populations of beneficial predatory arthropods. (Babalad *et al.*, 2011)

Foxtail millet (*Setaria italica* L.), is fairly drought tolerant. Due to its quick growth, it can be grown as a short-term catch crop either as sole crop or intercrop and Foxtail millet is a very rich source of various micro and macro nutrients, vitamins as well as minerals. The yield level of this crop is not stable under rainfed conditions due to its cultivation on marginal soils with less inputs use and potential yields are yet to be achieved (Hariprasanna., 2016).

The crop responds very well to organics due to its low nutrient requirement and the yield decline is mainly due to low soil fertility status and can be maintained on sustainable manner under organic system by increasing the soil microbial activity which are major component for nutrient recycling and making it available for plants uptake for growth and development of the crop. Hence micro organism plays a major in the organic production system. Resorting to enrichment with organic manures which acts as natural chelates seems to economically viable.

The enrichment of organic manures with micronutrients particularly Zn and Fe not only enhances the rate of decomposition but also improves the nutrient status (Prasenjit *et al.*, 2016). The present proposed investigation not only helps to maintain crop yields but also reduces the cost of production of foxtail millet cultivation since nutrients losses are reduced.

The present study was carried out to know the effect of enriched organics on soil microbial population in foxtail millet production under organic production system.

Materials and Methods

A field experiment was conducted during the *Kharif* 2018 at organic block of Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, which is situated between 16^{o} 12' North latitude and 77^{o} 20' East longitude with an altitude of 389 meters above the mean sea level and it falls within the North Eastern Dry Zone (Zone 2) of Karnataka.

A variety, SiA-2644which is high in Fe and medium in Zn content was selected for study. The experiment was laid out in randomized complete block design with 10 treatments replicated thrice. The treatment consisted of application of Compost equivalent to 100% RDN (T_1), Enriched compost with $ZnSO_4$@ 15 kg ha^{-1}and $FeSO_4$ @ 10 kg ha^{-1}, equivalent to100% RDN(T_2), Enriched vermicompost with $ZnSO_4$@ 15 kg ha^{-1}and $FeSO_4$@ 10 kg ha^{-1}, equivalent to100% RDN(T_3), Compost equivalent to 100% RDN + Soil application of $ZnSO_4$@15 kg ha^{-1}and $FeSO_4$@ 10 kg ha^{-1}(T_4), Enriched compost with Zn and Fe, equivalent to100% RDN (T_2) + Foliar spray of 3% Panchagavya at 30 and 45 days after sowing (T_5), Enriched vermicompost with Zn and Fe, equivalent to100% RDN (T_3) + Foliar spray of3% Panchagavya at 30 and 45 days after sowing (T_6), Compost equivalent to 100% RDN + soil application of $ZnSO_4$@15 kg ha^{-1}and $FeSO_4$@ 10 kg ha^{-1}(T_4) + Foliar spray of 3% Panchagavya at 30 and 45 days after sowing (T_7), Enriched compost with Zn and Fe, equivalent to100% RDN (T_2) + Foliar spray of 0.5%$ZnSO_4$ and $FeSO_4$ each at 30 days after sowing (T_8), Enriched vermicompost with Zn and Fe, equivalent to100% RDN (T_3) + Foliar spray of 0.5%$ZnSO_4$ and $FeSO_4$ each at 30 days after sowing (T_9) and Compost equivalent to 100% RDN + soil application of $ZnSO_4$@15 kg $ha^{-1}$and $FeSO_4$@10 kg ha^{-1}(T_4) + Foliar spray of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 days after sowing (T_{10}).

Known quantity of organic manures as per the requirement of treatments (compost and vermicompost) are enriched with micronutrients like $ZnSO_4$ and $FeSO_4$ at the recommended dose $ZnSO_4$ @ 15 kg $ha^{-1}$and $FeSO_4$ @ 10 kg ha^{-1} and the manures were allowed to ferment for a month by frequently sprinkling of water and mixing the contents 2 to 3 times a day.

The enriched manures were applied at the time of sowing as per the treatments (Anilkumar and Kubsad, 2017, Patil *et al.*, 2017 and Nikhil and Salakinkop, 2017)

The soil of the experimental site was deep black, slightly alkaline with a pH of 7.71, EC 0.22 d Sm^{-1} and medium organic carbon (0.6 %) and had low nitrogen (137.2 kg ha^{-1}) and high phosphorus and potassium (74.70 and 752.5 kg ha^{-1}), low Zinc (0.58 ppm) and high iron (13.91) availability in soil. The initial soil microbial population like bacteria, fungal, actinomycetes, N_2-fixers and PSB (37.88× 10^6, 4.30 × 10^4, 16.66 × 10^3, 20.00 × 10^6 and 14.00 × 10^6 CFU g^{-1} of soil respectively) in experimental were analysed with the Serial dilution and agar plate method (Pramer and Schmidt, 1964).

The seeds were treated with *Azospirillium* @ 40g per kg of seed and they were dibbled at 4 cm apart in the shallow furrows opened at 30cm apart.

The crop was sown on 4th August, 2018. The soil sample are collected after harvesting of the crop and stored in the deep freezers to avoid contamination and reduction of microbial population and samples are analysed.

Results and Discussion

Soil micro-organisms play a very important role in soil fertility not only because of their ability to carry out bio-chemical transformation but also due to their importance as a source and sink for mineral nutrients. Use of organic manures is the object to accelerate microbial processes to enhance availability of nutrients in the as similar form.

The microbial activities are enhanced as the fresh organic material acts as the nutrient source for the diverse soil flora and fauna. 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.

Microbial biomass is the total sum of all micro-organisms present in soil. Addition of organic materials might have enhanced the microbial activity in the soil and the consequent release of complex organic substances which form ligands with iron and would have promoted iron from precipitation, and also direct addition of iron through inorganic sources (Sharma *et al.*, 2001)

Bacterial, fungal, actinomycetes, N_2-fixers and phosphorous solubilizers population differed significantly due to different agronomic fortification through enriched organics and foliar spray after harvest of the crop (Fig. 1 and 2).

Table.1 Population of bacteria, fungi and actinomycetes after harvest of foxtail millet as influenced by agronomic fortification through organic nutrient management practices

Treatments	Bacteria (No. × 10^6CFU g^{-1} of soil)	Fungi (No. × 10^4CFU g^{-1} of soil)	Actinomycetes (No. × 10^3CFU g^{-1} of soil)	N_2-fixers (No. × 10^6CFU g^{-1} of soil)	PSB (No. × 10^6CFU g^{-1} of soil)
Initial values	37.88	4.3	16.66	20.00	14.00
T_1: Compost*	25.00	4.00	15.00	20.40	14.10
T_2: Enriched compost with Zn and Fe**	32.00	4.33	15.83	22.30	14.72
T_3: Enriched vermicompost* with Zn and Fe**	45.00	5.00	20.00	24.67	15.29
T_4: Compost* + Soil application of $ZnSO_4$ and $FeSO_4$	38.33	4.67	17.00	23.00	14.83
T_5: Enriched compost with Zn and Fe + Foliar spray of Panchagavya**	61.33	6.33	30.50	27.00	16.28
T_6: Enriched vermicompost* with Zn and Fe + Foliar spray of Panchagavya**	54.00	5.67	23.67	26.11	15.72
T_7: Compost* + Soil application of $ZnSO_4$ and $FeSO_4$ + Foliar spray of Panchagavya	26.00	4.33	15.83	22.07	14.50
T_8: Enriched compost + Foliar spray of $ZnSO_4$ and $FeSO_4$**	53.00	5.33	23.40	25.00	15.43
T_9: Enriched vermicompost* + Foliar spray of $ZnSO_4$ and $FeSO_4$**	56.00	6.00	26.00	26.80	15.87
T_{10}: Compost* + Soil application of $ZnSO_4$ and $FeSO_4$ + Foliar spray of $ZnSO_4$ and $FeSO_4$	40.00	5.00	19.00	24.50	15.08
S. Em±	1.56	0.45	0.51	0.91	0.41
C. D. at 5%	4.63	1.32	1.52	2.70	1.23

*Compost equivalent to 100% RDN in T_1, T_4, T_7 and T_{10} DAS: Days after sowing
**Enriched compost equivalent to 100% RDN in T_2, T_5 andT_8
***Enriched vermicompost equivalent to 100% RDN in T_3, T_6 andT_9
Soil application: $ZnSO_4$ @ 15 kg $ha^{-1}$and $FeSO_4$ @ 10 kg ha^{-1}
Foliar spray: 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$ @ 30 DAS and 3.0 % of Panchagavya at 30 and 45 DAS

Fig.1 Population of bacteria, fungi and actinomycetes after harvest of foxtail millet as influenced by agronomic fortification through organic nutrient management practices

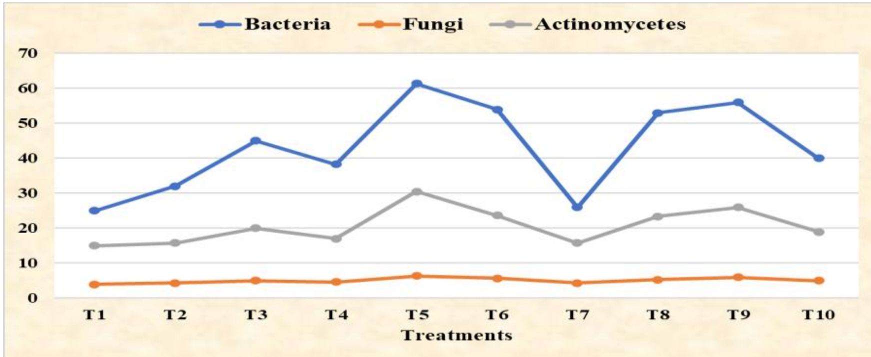
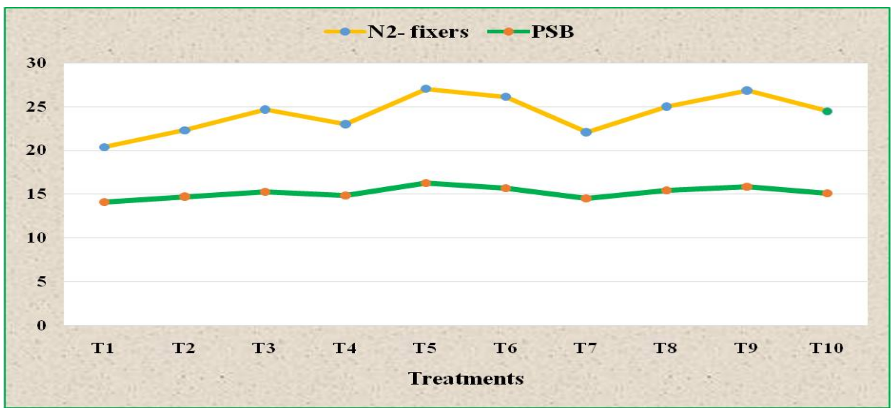


Fig.2 Population of N_2-fixers and phosphorous solubilizing bacteria after harvest of foxtail millet as influenced by agronomic fortification through organic nutrient management practices



Application of Zn and Fe enriched compost equivalent to 100 % RDN+ foliar spray of 3 % panchagavya recorded significantly higher bacterial, fungal, actinomycetes, N_2-fixers and phosphorous solubising bacteria after harvest (61.33 × 10^6, 6.33 × 10^4, 30.50 × 10^3, 27.00 × 10^6 and 16.28 × 10^6 CFU g^{-1} of soil, respectively) and found on par with application of Zn and Fe enriched vermicompost equivalent to 100 % RDN + foliar spray of 0.5 % $ZnSO_4$ and $FeSO_4$ each at 30 DAS (56.00 × 10^6, 6.00 × 10^4, 26.00 × 10^3, 26.80× 10^6 and 15.87× 10^6 CFU g^{-1} of soil, respectively) and Zn and Fe enriched vermicompost equivalent to 100 % RDN + foliar spray of 3.0 % panchagavya at 30 and 45 DAS (54.00 × 10^6, 5.67 × 10^4, 23.67 × 10^3, 26.11× 10^6 and 15.72× 10^6 CFU g^{-1} of soil, respectively) and the lower microbial population (bacterial, fungal, actinomycetes, N_2-fixers and phosphorous solubising bacteria) was observed with compost application alone (25.00 × 10^6, 4.00 × 10^4, 15.00 × 10^3, 20.40 × 10^6 and 14.10 × 10^6 CFU g^{-1} of soil, respectively)could be due to application of organic manures which might have stimulated the growth and activities of soil microorganisms (Table 1).

Higher microbial population with application of Zn and Fe enriched compost, equivalent to 100 % RDN + foliar spray of 3 % panchagavya 30 and 45 DAS, Zn and Fe enriched vermicompost equivalent to 100 % RDN + foliar spray of 0.5 % $ZnSO_4$ and $FeSO_4$ each at 30 DAS and Zn and Fe enriched vermicompost equivalent to 100 % RDN + foliar spray of 3.0 % panchagavya at 30 and 45 DAS could be due to application of organic manures which might have stimulated the growth and activities of soil microorganisms. Cumulative effect of enriched organic manures with foliar spray of micronutrients/liquid organics in increased the organic carbon content of soil as which is the carbon and energy sources for microbes to multiply rapidly in the soil. Microorganisms are indication of soil ability to store and recycle nutrients and energy. Foliar spray of panchagavya was highly beneficial in improving bacteria, fungi, actinomycetes, N_2 fixing and phosphorous solubilizing bacteria. Increased activity of beneficial microorganism might also be due to fast decomposition organic matter fraction through enriched organics. These results are inconformity with the findings of Sharma *et al.*, (2001), Palekar (2006), Ramamoorthy *et al.*, (2009), Gore and Sreenivasa (2011) and Kiran *et al.*, (2015).

In conclusion the assessing soil quality, where soil quality depends on the flora and fauna present in the soil, soil biological properties are very important. Microbial biomass and soil microbial activity are vital for maintaining soil productivity. There is a need to provide a balanced proportion of microbial biomass and activity in the soil to ensure a consistent release of nutrients to plants. The study on the effect of agronomic fortification with enriched organics on the aspects of microbial biomass envisages the potentiality of organic farming for maintaining soil health and sustainable production.

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