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Effect of organic and inorganic nutrient sources on soil biological properties under wheat crop (*Triticum aestivum*)

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Abstract: A field experiment was conducted at the AICRP on the Integrated Farming System Field, Department of Soil Science and Agriculture Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *rabi* season 2019-20 to assess the effect of organic and inorganic nutrient sources on soil biological properties under wheat crop. The experiment was laid out in a randomized block design with seven treatments and three replications. The applied different level responses showed the highest grain and straw yield (2496.24 kg ha^{-1} and 4375.47 kg ha^{-1} respectively), the highest soil bacterial population, fungal population and actinomycetes (37.67 cfu x 10^7, 7.33 cfu x 10^4 and 34.66 cfu x 10^5 g^{-1} soil, respectively) were recorded in the treatment T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures. The soil dehydrogenase enzyme activity was highest in treatment T_1-100% RDF through organic manures (3.76 Dehydrogenase enzyme (µg TPF g^{-1} soil 24 hrs^1), acid and alkaline phosphatase enzyme activity was highest in the treatment T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures (49.67 µg pNP g^{-1}soil 24 hrs^{-1} and 19.97µg pNP g^{-1} soil 24 hrs^{-1}) respectively. Combine application of organic and inorganic nutrient sources along with RDF proved better for improving soil biological properties and enhancing crop productivity.

Keywords: *Productivity, enzymatic activities, soil microbial population, FYM, soil health.*

Introduction

Wheat (*Triticum aestivum* L.) is a king of cereal crop and origin of South West Asia. It is the second most staple crop in India after rice. India is the second largest wheat producing country in the world after China both in terms of area and production. It provides 20 percent of total food and it contains 12-15% percent protein, 3.2% fat and 67% carbohydrate, the major sources of dietary fiber in human nutrition for decades.

The application of organic and inorganic nutrient sources aims to improve and maintain soil fertility and productivity in a sustainably. The soil enzymes play a key role in organic matter decomposition in a soil environment. The soil enzymes catalyzed several vital reactions that are necessary for increasing the activity of soil microorganism and also marinating soil structure by acting as a cementing agent. They also help with nutrient cycling and maintain nutrient balance in the soil system. A number of enzymes like dehydrogenase, acid and alkaline phosphatase provide microbial activity. In general phosphatase group of enzymes that catalyze the hydrolysis of an ester of phosphoric acid to release phosphorus and dehydrogenase exist as an integral part of the intact cells, it also acts as a total oxidation potential of soil microbial community (Dick 1997).

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The application of soil amendment plays an important role in improving soil microbial activity with additional supplement food for soil microorganisms. Since the sole use of chemical fertilizers has reported in lack of production under continuous intensive cultivation and reduces the activity of microorganisms. Therefore the long term application of chemical fertilizer changed soil reaction, increased soil acidity and basicity caused a decrease in soil microbial population. Agricultural farm waste products *viz.* farm yard manure (FYM), vermicompost, neem cake and other organic sources play a dominant role in maintaining soil quality (Palm *et al.* 2001).

The organic matter in the soil is critical for better soil structure, nutrient cycling and maintaining the productivity of the crops. However, maintaining soil organic carbon is difficult in arid and semi-arid regions with rapid oxidation due to high temperatures. Combined application of organic manures and chemical fertilizers is the only way to increase organic matter content in the soil. The nutrient is assimilated by microorganisms and incorporated in microbial biomass soil bacteria, fungi and actinomycetes). Microorganisms regulate nutrients supplied in the soil system by assimilating and growing soil microbial biomass. The change of SOC is also associated with changes in soil microbial biomass carbon and soil microbial activities (Katkar *et al.* 2011)

Materials and methods

The experiment was conducted during the *rabi* season 2019-20 at the AICRP on Integrated Farming System Field, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experimental site lies between 19^0 46^0 North Latitude and 76^0 46^0 East longitude, having an elevation of 408.46 above the mean sea level. This region has a semi- arid tropical climate, where the annual average temperature varies from 33.50 ^{0}c in winter to 43.70^{0}c in summer which means the minimum temperature varies from 19.50- 27.70 ^{0}c. The soil of this region is medium to deep black. The experiment was laid out in Randomized Block design, with three replications and seven treatments *viz.,* T_1-100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.),T_2-100% RDF through chemical fertilizer,T_3-75% RDF through chemical fertilizer + 25% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.),T_4-50 % RDF through chemical fertilizer + 50 % RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.),T_5-25% RDF through chemical fertilizer + 75% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.),T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake) and T_7-Control (without any fertilizer).

After harvesting the crop, soil samples were collected from an experimental site at 0-15 cm soil depth. The biological properties were recorded with standard procedures (Jackson 1973). Soil enzymatic activities like dehydrogenase (2.33 µg TPF g^{-1} soil 24 hrs^{-1}), acid and alkaline enzyme (15.02 and 33.26 µg pNP g^{-1} soil 24 hrs^{-1}) were analyzed during initial soil condition. (Tabatabai and Bremner 1969). Initial soil bacteria, fungi and actinomycetes (24 .00 cfu x 10^7, 3.00 cfu x 10^4 and 22.00 cfu x 10^5 g^{-1}) were calculated respectively. The soil microbial population (bacteria, fungi and actinomycetes) count was carried out by standard serial dilution method for bacteria agar media, fungi; Bengal rose media and actinomycetes Ken knight agar media (Dhingra and Sinclair 1993). Statistical analysis was carried out as per the method given in "Statistical Method for Agricultural Workers" suggested by (Panse and Sukhatme 1985) using a computer program. Appropriate Standard errors (SE, critical) difference (C.D) at 5% and CV were calculated for further interpretation.

Results and discussion

Response of organic and inorganic nutrient sources on grain and straw yield of wheat crop

Grain and straw yield

The grain and straw yield was significantly increased with the application of different levels of nutrients in different treatments over control treatment. Data presented in table 1 showed that, the highest grain yield (2496.24 kg ha^{-1}) was observed in the treatment T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures, which was statistically at par with treatment T_{2}-100% RDF through chemical fertilizer (2414.12 kg ha^{-1}) and the lowest grain yield was observed in the control treatment (1979.87 kg ha^{-1}). The highest straw yield was recorded (4375.47 kg ha^{-1}) in the treatment T_{6}- 25% RDF through chemical fertilizer + 100% RDF through organic manures followed by T_2 treatment100% RDF through chemical fertilizer (4307.56 kg ha^{-1}) and T_5-25% RDF through chemical fertilizer + 75% RDF through organic manures (4113.47 kg ha^{-1}) and the lowest straw yield recorded in the control treatment (3824.34 kg ha^{-1}).

The enhancement in the grain yield might be due to an adequate and balanced proportion of plant nutrients supplied as per the requirement during the crop the growth period which was ultimately led to increased grain and straw yield of wheat. The similar results were found by (Devi *et al.*2011) under her study and reported that the application of (100% RDF+ vermicompost + PSB) recorded highest grain yield (4.74 t ha^{-1}). (Tiwari *et al.* 1998) reported that the addition of FYM showed a residual response in increasing the yield of wheat crop. The results of the current study confirms with the earlier results.

Table 1. Effect of organic and inorganic nutrient sources on Grain and Straw yield of wheat (kg/ ha)

Sr No	Treatments	Grain	Straw
T_1	100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	2106.41	3892.91
T_2	100% RDF through chemical fertilizer	2414.12	4307.56
T_3	75% RDF through chemical fertilizer + 25% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	2314.01	4045.35
T_4	50 % RDF through chemical fertilizer + 50 % RDForganic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	2232.15	4011.00
T_5	25% RDF through chemical fertilizer + 75% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	2206.66	4113.47
T_6	25% RDF through chemical fertilizer + 100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	2496.24	4375.47
T_7	Control (without any fertilizer)	1979.87	3824.34
	S.Em.±	84.78	98.67
	C.D. at 5 %	261.27	304.0
	C.V. %	6.53	4.19

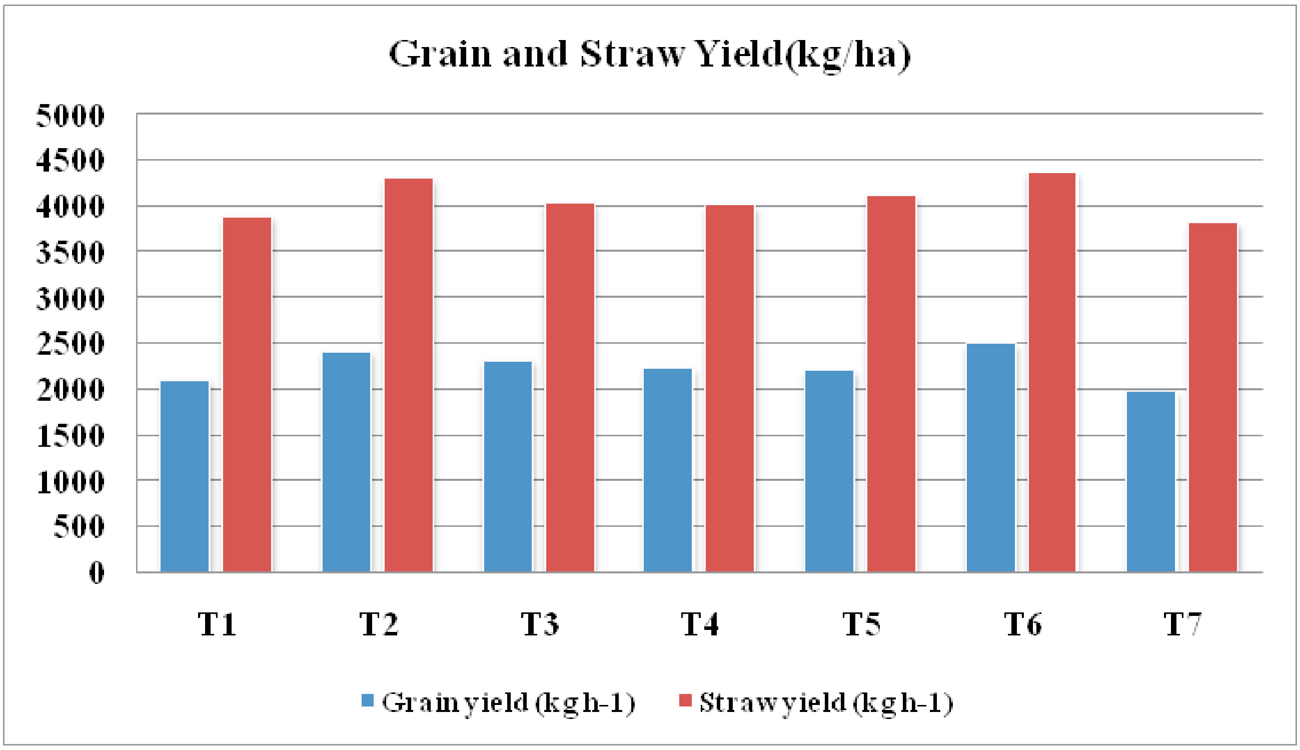

Fig.1. Effect of organic and inorganic nutrient sources on Grain and Straw yield of wheat (kg/ha).

Effect of organic and inorganic nutrient sources on enzyme activity of soil

Activity of dehydrogenase enzyme

The data presented in table 2 revealed that the dehydrogenase enzyme activity ranges in the tune of 1.78-3.76 µg TPF g^{-1} soil 24 hrs^{-1}. A significantly higher soil dehydrogenase was recorded (3.76 µg TPF g^{-1} soil) in the treatment T_1-100% RDF through organic manures, which was statistically at par with treatment T_5-25% RDF through chemical fertilizer + 75% RDF through organic manures (3.58 µg TPF g^{-1} soil 24 hrs^{-1}) and T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures (3.64 µg TPF g^{-1} soil 24 hrs^{-1}). The lowest dehydrogenase was recorded (1.78 µg TPF g^{-1} soil 24 hrs^{-1}) in the control treatment.

The application of organic nutrient sources as well as inorganic sources alone recorded highest dehydrogenase activity and a combination of organic and inorganic sources increased dehydrogenase activity as compared to initial dehydrogenase activity (2.33 µg TPF g^{-1} soil 24 hrs^{-1}) and found decreased in control plot (Fig. 2). The increased dehydrogenase enzyme activity is associated with organic sources acting as sole sources of carbon and energy for heterotrophs. The similar results were reported by (Ingle *et al.*2012) and reported that the highest dehydrogenase activity was recorded (55.01 µg TPF g^{-1} soil 24 hrs^{-1}) in application of 100% RDF+10 t FYM and lowest was recorded (34.75 µg TPF g^{-1} soil 24 hrs^{-1}) in the control plot.

Activity of soil alkaline Phosphatase enzyme

The data presented in Table 2 revealed that, alkaline phosphatase enzyme ranged in the tune of 31.60-49.67 µg pNP g^{-1} soil 24 hrs^{-1}. The treatment T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures, was recorded highest alkaline phosphatase enzyme activity (49.67 µg pNP g^{-1} soil 24 hrs^{-1}) which was significantly superior over all other treatments. The highest alkaline phosphatase enzyme was found to be released where application of organic and inorganic nutrient combinations as compared to initial alkaline phosphatase enzyme activity (33.26 µg pNP g^{-1} soil 24 hrs^{-1}) and others treatments may be due to added material on decomposition may provide intra and extra enzymes and may also stimulate microbial activity in the soil. Similar results were reported by (Shrinivasan *et al.*2016) where in reported that the highest alkaline phosphatase enzyme activity was higher (85.8 pNP g^{-1} soil 24 hrs^{-1}) in the treatment of RDF+ FYM.

Activity of soil acid phosphatase enzyme

The data presented in Table 2 indicated that the application of inorganic and organic nutrient sources alone and in combination with organic and inorganic nutrient sources in different levels showed the activity of soil acid phosphatase enzyme range (16.08- 19.97 µg pNP g^{-1} soil 24 hrs^{-1}). The significant highest acid phosphatase released was recorded (19.97 µg pNP g^{-1} soil 24 hrs^{-1}) in the treatment T_6- 25% RDF through chemical fertilizer + 100% RDF through organic manures, which was statistically at par with T_1-100% RDF through organic manures (19.54 µg pNP g^{-1} soil 24 hrs^{-1}) and T_5-25% RDF through chemical fertilizer + 75% RDF through organic manures (19.29 µg pNP g^{-1} soil 24 hrs^{-1}). The significantly increased activity of acid phosphatase enzyme in the application of organic and inorganic nutrient sources combination and alone organic nutrient sources as compared to initial soil acid phosphatase enzyme activity (15.02 µg pNP g^{-1} soil 24 hrs^{-1}) may be due to the addition of organic substance to soil served as carbon sources that enhance the activity of microbes. Similar results were reported by (Jannavi *et al.*2018) and stated that the highest acid phosphatase enzyme activity was recorded (32.2 µg pNP g^{-1} soil 24 hrs^{-1}) in the treatment of application of 100% RDF+ FYM and lowest was recorded (10.7 µg pNP g^{-1} soil 24 hrs^{-1}) in the control plot.

Table 2. Effect of organic and inorganic nutrient sources on soil dehydrogenase, alkaline phosphatase and soil acid phosphatase activity

Sr No	Treatments	Dehydrogenase enzyme (µg TPF g^{-1} soil 24 hrs^{-1})	Alkaline phosphatase (µg pNP g^{-1} soil 24 hrs^{-1})	Acid phosphatase (µg pNP g^{-1} soil 24 hrs^{-1})
T_1	100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.)	3.76	41.30	19.54
T_2	100% RDF through chemical fertilizer.	2.62	33.51	14.79
T_3	75% RDF through chemical fertilizer + 25% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.)	2.86	36.01	14.48
T_4	50 % RDF through chemical fertilizer + 50 % RDF organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.)	3.31	40.97	16.91
T_5	25% RDF through chemical fertilizer + 75% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.)	3.58	44.96	19.29
T_6	25% RDF through chemical fertilizer + 100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	3.64	49.67	19.97
T_7	Control (without any fertilizer)	1.78	31.60	16.08
	Initial	2.33	33.26	15.02
	S.Em.±	0.1313	0.89	0.55
	C.D. at 5 %	0.40	2.74	1.71
	C.V. %	7.39	3.89	5.56

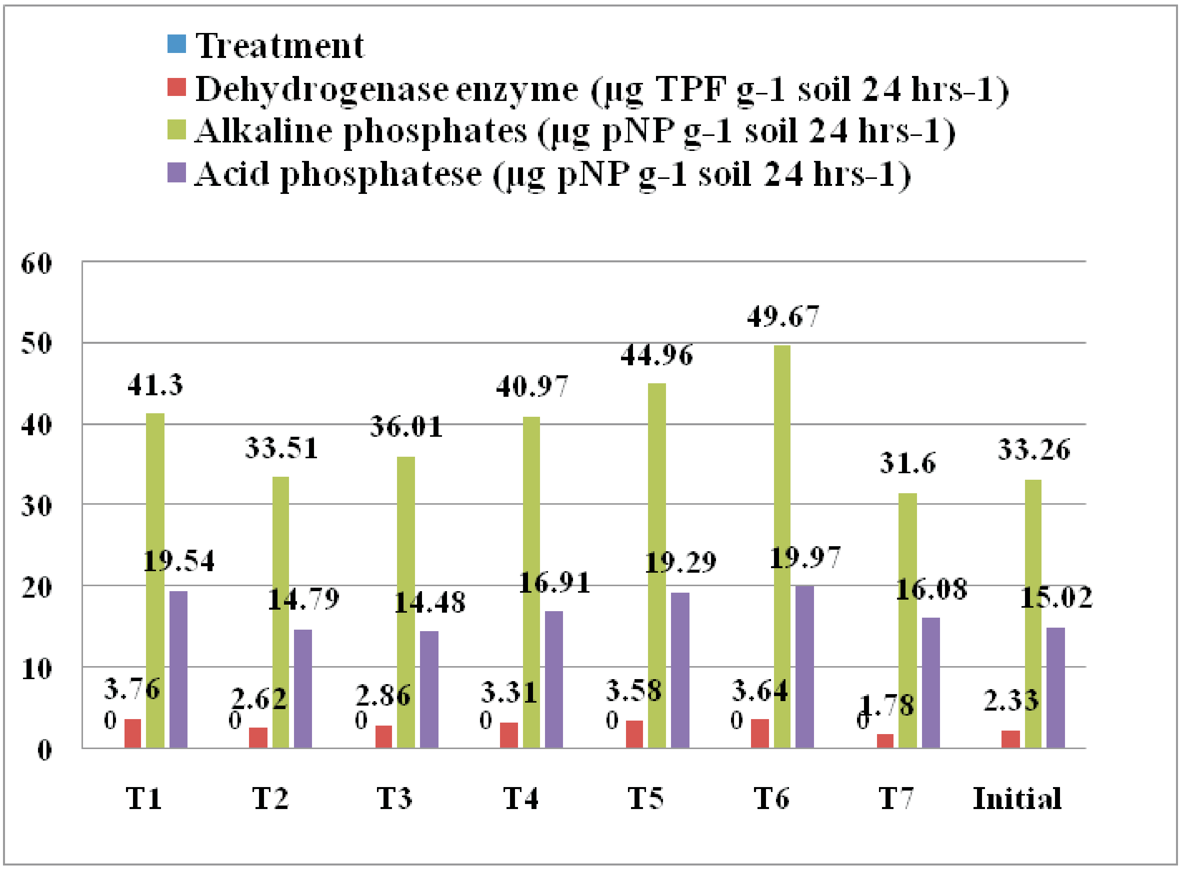

Fig. 2. Effect of organic and inorganic nutrient sources on soil dehydrogenase, alkaline phosphatase and soil acid phosphatase activity

Bacteria population in soil

The data is presented in Table 3indicated the soil bacterial population was observed the highest (37.67 cfu x 10^7 g^{-1} soil) in the treatment of T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures, which was statistically at par with treatment T_1-100% RDF through organic manures (34.67 cfu x 10^7 g^{-1} soil). The significant increase in the availability of bacterial population with the application of organic, inorganic nutrient sources alone or in combination organic and inorganic nutrient sources as compared to the initial soil available bacterial population (24 cfu x 10^7 g^{-1} soil) may be due to the addition of organic matter. Similar results found by (Meshram *et al*. 2016) and reported that the maximum bacterial population (229.42 cfu x 10^7 g^{-1} soil) in the treatment of application of NPK+5t FYM and minimum (95.60 cfu x 10^7 g^{-1} soil) in the control plot.

Table 3. Effect of organic and inorganic nutrient sources on microbial population

Sr No	Treatments	Bacteria (cfu x 10^7) g^{-1} soil	Fungi (cfu x 10^4) g^{-1} soil	Actinomycetes (cfu x 10^5) g^{-1} soil
T_1	100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	34.67	6.00	32.00
T_2	100% RDF through chemical fertilizer	25.00	3.33	24.33
T_3	75% RDF through chemical fertilizer + 25% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	27.00	3.66	25.66
T_4	50 % RDF through chemical fertilizer + 50 % RDF organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	27.33	4.00	27.00
T_5	25% RDF through chemical fertilizer + 75% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake.)	28.33	5.00	28.33
T_6	25% RDF through chemical fertilizer + 100% RDF through organic manures (1/3 FYM+1/3 Vermi compost+ 1/3 Neem cake)	37.67	7.33	34.66
T_7	Control (without any fertilizer)	26.67	3.66	24.66
	Initial	24.00	3.00	22.00
	S.Em.±	1.03	0.32	1.40
	C.D. at 5 %	3.19	1.00	4.34
	C.V. %	6.08	11.95	8.69

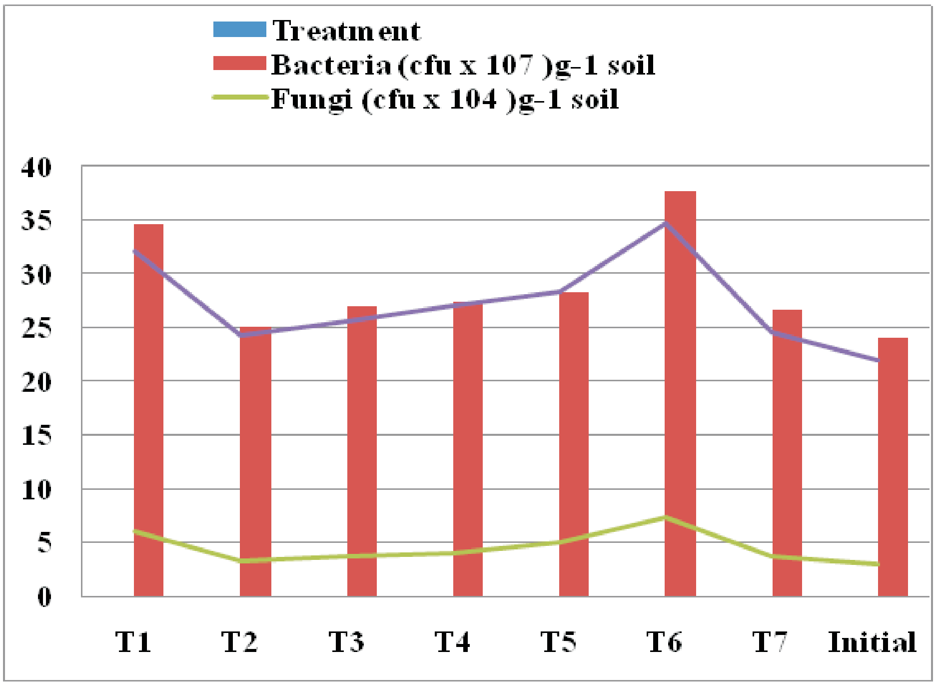

Fig 3. Effect of organic and inorganic nutrient sources on soil microbial population.

Fungi population in soil

The data presented in Table 3 indicated that the application of inorganic, organic nutrients alone or in combination with organic and inorganic nutrients at different levels showed the available soil fungi population maximum (7.33 cfu x 10^4 g^{-1} soil) in the treatment of T_6 -25% RDF through chemical fertilizer + 100% RDF through organic manures, which was significantly superior over all other treatments. Among the different nutrient applications treatments, inorganic, organic nutrients alone or in combination with organic and inorganic nutrient increase the soil available fungi as compared to initial fungal population in soil (3.00 cfu x 10^4 g^{-1} soil) might be ascribed to the decomposed food material available from organic sources. Similar results were reported by (Arabad *et al* .2014) that the maximum fungal population (29 cfu X 10^5 g^{-1}soil) in treatment received only FYM and was found at par with treatment received 100% NPK + FYM (28 cfu x10^5 g^{-1} soil)

Actinomycetes population in soil

The data presented in Table 3 indicated that the maximum actinomycetes population was found (34 .66 cfu x 10^5 g^{-1} soil) in the treatment of T_6 -25% RDF through chemical fertilizer + 100% RDF through organic manures, which was statistically at par with treatment T_1-100% RDF through organic manures (32.00 cfu x 10^7 g^{-1} soil). Actinomycetes population were found increased significantly by the application of organic, inorganic alone and organic along with inorganic nutrient sources applied as compared to initial actinomycetes population in soil (22.00 cfu x 10^5 g^{-1} soil) which might be due to organic matter supplied food for microbes. Similar results also reported by (Mali *et al*.2015) and reported that the maximum actinomycetes population (16.25 cfu x10^4 g^{-1} soil) was recorded in the treatment of application of 50% N through FYM and 50% through RDF.

Conclusion

It can be concluded from the above experiment that the application of different level responses showed the highest grain and straw yield (**(**2496.24 kg ha^{-1} and 4375.47 kg ha^{-1} respectively), the highest soil bacterial population, fungal population and actinomycetes (37.67 cfu x 10^7, 7.33 cfu x $10^4$and 34 .66 cfu x 10^5 g^{-1} soil, respectively) were recorded in the treatment of T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures. The soil dehydrogenase enzyme activity was found highest in treatment T_1-100% RDF through organic manures (3.76 Dehydrogenase enzyme (µg TPF g^{-1} soil 24 hrs^{-1}**)**, acid and alkaline phosphatase enzyme activity was highest in the treatment of T_6-25% RDF through chemical fertilizer + 100% RDF through organic manures (49.67 µg pNP g^{-1}soil 24 hrs^{-1} and 19.97 µg pNP g^{-1} soil 24 hrs^{-1}) respectively**.** Combined application of organic and inorganic nutrient sources along with RDF proved better for improving soil biological properties and enhancing crop productivity.

Competing Interest: The authors have declared that no competing interest exists.

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