The Pharma Innovation Journal 2022; 11(12): 2182-2186

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 2182-2186

www.thepharmajournal.com
Received: 22-10-2022
Accepted: 25-11-2022

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Effect of organic farming on enzymatic activity and microbial populations of soybean

Gorde NB, Zade SP, Bodke VS and Nakhate PS

Abstract
The present study was carried out during *kharif* season 2021-22 at Organic Farming Research and Training Centre (OFRTC), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The field experiment was conducted with thirteen treatments and three replications in randomized block design. The result indicated that application of FYM along with vermicompost and neem cake i.e. 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake, improve the enzymatic and microbial activities of soil. Significant highest enzymatic activities like dehydrogenase, acid and alkaline phosphatase observed with the application of 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake, and helped in improving soil quality. Significantly higher microbial population was recorded with the application of 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake in treatment T_3. Lowest enzymatic and microbial population of soil was found in treatment T_{12} *i.e.*, absolute control. Based on present investigation, it can be concluded that soybean variety MAUS-612 with treatment T_3 (100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake) improved enzymatic and microbial activities of soybean grown Vertisol.

Keywords: Organics, FYM, vermicompost, neem cake, enzymes

Introduction
Microorganisms plays a key role in nutrient cycle to sustain the productivity of the soil. Because, they are the source and sink for mineral nutrition and bio-chemical transformations. Leguminous crop soybean (*Glycine max* (L.) Merril), commonly known as the "wonder bean" and "gold of the 21st century," belongs to the Fabaceae family with the subfamily Papiliionaceae. Although it is primarily a pulse crop, it has become more significant as an oilseed crop since it produces 20% cholesterol-free oil. Vitamins A, B, and D are all abundant in it. Soybean is an excellent source of protein from a nutritional perspective. It has a high protein content of 40 to 43%. Additionally, it has a mineral content of 38–43% and phospholipids of 2–2.5%. Apart from this soybean has a significant capacity to fix atmospheric nitrogen. Soybean promotes soil fertility through nitrogen fixation from the atmosphere (Kasasa *et al*., 2000; Sanginga, 2003) [5, 12]. Vermicomposting is a potential organic source containing beneficial microorganism, major nutrients (NPK) and micronutrients, enzymes and hormones. Use of FYM has been found to enhance the crop yields by improving physical and biological properties of soil and increasing water holding capacity of soil. Application of bio fertilizers *viz*., *Azotobactor* provides the nitrogen to the crops. Neem seedcake mixed with urea fertilizer significantly improves efficiency of fertilizer utilization in crop production by gradual release of nitrogen to crops thereby increasing the fertility of the soil (Ketkar, 1983) [6]. Organic farming is a holistic way of farming with a view of conservation of natural resources. Indian agriculture has a better chance to swithover to organic farming, because the per capita and per ha consumption of chemical fertilizers and pesticides in the country is much lower than the global estimates (Boraiah *et al.*, 2017) [1]. The continuous use of chemical fertilizers has resulted in to decrease in the crop yield and led to imbalance of nutrients in the soil, which has antagonistic effects on soil health. For the growth of microorganism's organic manures provide a good substrate and maintain a favourable nutritional balance for productive soil ecosystem.

Materials and Methods
Field experiment was conducted during *kharif* season 2021-22 at the Organic Farming Research and Training Centre (OFRTC) and Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

which is situated within the Godavari drainage basin in the central part of India between 76^0 46'East longitude and 19^0 16'North latitude, having elevation of 408.46 above the mean sea level. The experiment was laid out in randomized block design with three replications and thirteen treatments viz. T_1 (100% RDN through FYM), T_2 (100% RDN through Vermicompost), T_3 (100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake), T_4 (100% RDN through FYM + Jeevamrut application at 30, 45 & 60 DAS), T_5 (75% RDN through FYM + Jeevamrut application at 30, 45 & 60 DAS), T_6 (50% RDN through FYM + Jeevamrut application at 30, 45 & 60 DAS), T_7 (100% RDN through FYM + Biofertilizer 2.5 lit/ha soil application (*Rhizobium* +PSB)), T_8 (75% through FYM +Biofertilizers2.5lit/ha Soil application (*Rhizobium* +PSB)), T_9 (50%RDN through FYM+ Biofertilizer 2.5lit/ha Soil application (*Rhizobium* +PSB)), T_{10} (Jeevamrut application at 30, 45, and 60 DAS), T_{11} (Jeevamruth application at 0, 15, 30, 45 and 60 DAS, T_{12} (Absolute Control), T_{13} (RDF+ 5 t FYM ha^{-1}). The RDF was 30:60:30 kg ha^{-1} for soybean. The seed of Soybean (MAUS-612) was sown in *kharif* season by dibbling one seed per hill at 45 x 5 cm^2 distance, gap filling was done 10 days after sowing to maintain plant population. Organic inputs i.e., FYM and Vermicompost were applied eight days before sowing. Jeevamrut was applied three times through soil @ 500 lit/hectare at 30, 45 and 60 DAS. Soil application Biofertilizer 2.5 lit/ha. The fertilizers used were urea, single super phosphate and muriate of potash. The initial soil properties showed that soils were slightly alkaline in reaction, normal in salt content, low in organic carbon content and slightly calcareous in nature. The available nitrogen and phosphorus were low and medium, respectively and high in potassium content. The soil deficit in zinc, marginal in iron and sufficient in Mn and Cu.

Results and Discussion

Enzymatic activities of soil

Dehydrogenase enzyme

Dehydrogenase is considered as an indicator of microbial activity because it occurs intracellularly in all living microbial cell. Dehydrogenase enzymes oxidize soil organic matter by transforming proton and electron from substrate to accepters. The data regarding dehydrogenase enzyme is presented in Table 1. Dehydrogenase activity ranged between 52.87 to 97.02 mgTPF24$hr^{-1}g^{-1}$ with mean value 67.86 mgTPF24$hr^{-1}g^{-1}$. Dehydrogenase activity was maximum in soybean grown soil when treated with different organic sources. Significantly higher Dehydrogenase activity 97.02 mgTPF24$hr^{-1}g^{-1}$ was found in treatment T_3 receiving 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake, followed by treatment T_2 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha *i.e.*, 90.69 mgTPF24$hr^{-1}g^{-1}$, 76.48 mgTPF24$hr^{-1}g^{-1}$. Whereas, significantly lowest dehydrogenase activity 52.87 mgTPF24$hr^{-1}g^{-1}$ was found in treatment T_{12} *i.e.*, absolute control.

The changed composition of the root exudates in the soybean rhizophore may be the cause of the dehydrogenase's increased activity. The rhizosphere microorganisms are greatly impacted both qualitatively and quantitatively by root exudates. According to Sridhar *et al.* (2014), the application of 120 kg N ha^{-1} of poultry manure, digested sludge, coir pith waste, press mud and FYM resulted in enhanced dehydrogenase and alkaline phosphatase activity.

Acid phosphatase enzyme

Acid phosphatase activity was maximum in soybean grown soil when treated with different organic sources. The data presented in Table 1. indicates that acid phosphatase activity in soil after the harvest of soybean. Acid phosphatase activity ranged between 16.05 to 36.01 ug $PNPg^{-1}$ hr^{-1} with mean value 29.48 ug $PNPg^{-1}$ hr^{-1}. Acid phosphatase activity was maximum in soybean grown soil when treated with different organic sources. Significantly higher the acid phosphatase activity 36.01 ug $PNPg^{-1}$ hr^{-1} was found in treatment T_3 receiving 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake, followed by treatment T_2 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha, T_7 100% RDN through FYM + Biofertilizers 2.5 lit/ha soil application (*Rhizobium*+ PSB), T_4:100% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS *i.e.*, 33.63 ug $PNPg^{-1}$ hr^{-1}, 33.01 ug $PNPg^{-1}$ hr^{-1}. 32.84 ug $PNPg^{-1}$ hr^{-1}, 32.49 ug $PNPg^{-1}$ hr^{-1}. Whereas, significantly lowest acid phosphatase activity 16.05 ug $PNPg^{-1}$ hr^{-1} was observed in treatment T_{12} *i.e.*, absolute control.

The organic acids released during the solubilization of nutrients have the tendency to somewhat decrease soil reaction, which enhances the enzymatic activity, which may be the cause of the rise in acid phosphatase activity in combinations of organic sources. According to Kamala and Singaram (1995) [4] the addition of organic manures has a significant impact on enzyme activities due to an increase in soil microbial activity. All of the enzyme activity was shown to be strongly positively correlated with the amounts of available NPK and organic carbon.

Alkaline phosphatase enzyme

The data narrated in Table 1. indicates that Alkaline phosphatase activity in soil after the harvest of soybean. Alkaline phosphatase activity was maximum in soybean grown soil when treated with different organic sources. The given data revealed that alkaline phosphatase activity ranged between 29.61 to 62.93 ug $PNPg^{-1}$ hr^{-1} with mean value (46.65 ug $PNPg^{-1}$ hr^{-1}). Significantly higher the Alkaline phosphatase activity (62.93 ug $PNPg^{-1}$ hr^{-1}) was found in treatment T_3 receiving 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake. Followed by treatments T_2 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha, T_7 100% RDN through FYM + Biofertilizers 2.5 lit/ha soil application (*Rhizobium*+ PSB), T_4 100% RDN through FYM + Jeevamrut application at 30, 45 & 60 DAS *i.e.*, 58.45 ug $PNPg^{-1}$ hr^{-1}, 55.81 ug $PNPg^{-1}$ hr^{-1}, 51.18 ug $PNPg^{-1}$ hr^{-1}, 47.14 ug $PNPg^{-1}$ hr^{-1}, respectively. Whereas, significantly lowest alkaline phosphatase activity (29.61 ug $PNPg^{-1}$ hr-1) was observed in treatment T_{12} *i.e.*, absolute control.

The enzyme alkaline phosphatase is related to microorganisms. Therefore, the highest alkaline phosphatase activity may have been caused by an increase in microbial biomass. These enzymes aid in the soluble mineralization of bound phosphorus, making it available to plants.

Table 1: Effect of organic farming on soil enzyme activity under soybean.

Treatments	Dehydrogenase mg TPF 24 $hr^{-1}g^{-1}$	Acid phosphatase ug $PNPg^{-1}$ hr^{-1}	Alkaline phosphatase ug $PNPg^{-1}$ hr^{-1}
T_1: 100% RDN through FYM	67.56	32.04	46.68
T_2:100% RDN through Vermicompost	90.69	33.63	58.45
T_3 :100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake	97.02	36.01	62.93
T_4:100% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	68.79	32.49	47.14
T_5:75% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	62.48	31.57	45.86
T_6:50% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	58.91	26.05	41.91
T_7:100% RDN through FYM + Biofertilizers 2.5 lit/ha soil application (*Rhizobium*+ PSB)	69.34	32.84	51.18
T_8:75% through FYM + Biofertilizers 2.5lit/ha soil application (*Rhizobium* +PSB)	63.44	31.90	46.31
T_9:50%RDN through FYM+ Biofertilizers 2.5lit/ha soil application (*Rhizobium* + PSB)	58.91	31.09	44.93
T_{10}: Jivamruth application at 30,45, and 60 DAS	56.852	20.68	34.17
T_{11}: Jivamruth application at 0,15, 30,45, and 60 DAS	58.91	25.95	41.46
T_{12}: Absolute control	52.87	16.05	29.61
T_{13}:RDF+ 5 t FYM/ha	76.48	33.01	55.81
Mean	67.86	29.48	46.65
S.Em. ±	2.63	1.31	8.54
C.D. at 5%	10.40	3.82	6.70
C.V.%	6.71	7.71	2.30

Microbial populations of soil

Soil Bacteria

Bacterial population differed significantly due to application of different organic sources after the harvest of soybean. The initial bacterial population was 45.00 CFU×$10^{-7}g^1$soil. The data presented in the Table 2. reported that bacterial populations in soil after the harvest of soybean. The bacterial population ranged between 29.33 to 88.83 CFU×$10^{-7}g^1$soil with mean value 56.30 CFU×$10^{-7}g^1$soil. Significantly highest bacterial population was recorded with the application 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake in treatment T_3. *i.e.*, 88.33 CFU×$10^{-7}g^1$soil. Followed by the treatment T_2 receiving 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha *i.e.*, 75.00 CFU×$10^{-7}g^1$soil, 68.66 CFU×$10^{-7}g^1$soil. Lowest the bacterial population 29.33 CFU×$10^{-7}g^1$soil was found in treatment T_{12} *i.e.*, absolute control.

In comparison to the control, the rhizosphere population was maximum when organic matter in the form of FYM and vermicompost was added. The positive association between enzyme activity and soil organic carbon suggests that an increase in soil organic matter may be the cause of the increased bacterial population. This is explained by the degraded food present in organic sources. Nagavani *et al.* (2015) [9] and Vineela *et al.* (2008) [16] both reported similar findings. Sharma *et al.* (1983) [13] reported the significance of organic matter in promoting bacterial growth, while Petrova (1965) [10] noted that cow dung was more effective than mineral fertilizer in boosting the microbial population in soil. Application of 50 t FYM ha^{-1} generated a two-fold rise in bacteria, actinomycetes, and fungi, as shown by (Suistova and Diuvelikawkh 1992) [15]. According to Manna and Ganguly (2001) [7], FYM inclusion enhanced soil microbial biomass more than chemical fertilizer did. The application of FYM @ 8 t ha^{-1} recorded the highest soil microbial count in the soybean-wheat-fallow cropping system compared to the recommended fertilizer dose and control.

Soil Fungi

Fungal population differed significantly due to application of different organic sources after the harvest of soybean. The initial fungal population was 10.00 CFU×$10^{-4}g^1$soil. The data presented in the Table 2. Indicates that fungal populations in soil after the harvest of soybean. The fungal population ranged between 6.00 to 17.33 CFU×$10^{-4}g^1$ soil with mean value (11.82 CFU×$10^{-4}g^{-1}$) soil. Significantly higher fungal population was recorded with the application 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake in treatment T_3. *i.e.*, (17.33 CFU×$10^{-4}g^{-1}$) soil followed by the treatment T_2 receiving 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha *i.e.*, 16.33 CFU×$10^{-4}g^1$soil, 13.00CFU×$10^{-4}g^1$soil. Lowest fungal population (6.00 CFU×$10^{-4}g^{-1}$) soil was found in treatment T_{12} *i.e.*, absolute control. The primary cause of this is the dead food material present in vermicompost and cow dung. According to Ramaswami and Raj (1973) [11] plots treated with manure had a greater fungus population. According to Yadav and Mowade (2004) [17] the best soil microclimate led to the highest documented fungus population. Vermicompost is a rich source of all nutrients additionally recognized for its valued for plant growth promoters, humus forming microbes and nitrogen fixers. (Kale *et al.*, 1994) [3].

Soil Actinomycetes

The population of actinomycetes as influenced by various organic sources presented in the Table 2. reported that populations of actinomycetes in soil after the harvest of soybean. Population of actinomycetes differed significantly due to application of different organic sources after the harvest of soybean. The initial population of actinomycetes was 17.00 CFU×$10^{-6}g^1$soil. The population of actinomycetes ranged between 11.00 to 30.33 CFU×$10^{-6}g^1$soil with mean value 22.07 CFU×$10^{-6}g^1$soil.Significantly higher the actinomycetes population was recorded with the application 100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake in treatment T_3. *i.e.*, 30.33 CFU×$10^{-6}g^1$soil. Followed by the treatment T_2 receiving 100% RDN through Vermicompost, T_{13} RDF+ 5 t FYM/ha *i.e.*, 25.66 CFU×$10^{-6}g^1$soil, 25.33 CFU×$10^{-6}g^1$soil. Lowest actinomycetes population 11.00 CFU×$10^{-6}g^1$soil was found in treatment T_{12}

i.e., absolute control.

The larger return of organic matter to the soil as a result of their breakdown was primarily responsible for the higher rate of actinomycetes population in this treatment. According to Sharma *et al.* (1983) [13] there is a correlation between organic matter and the number of actinomycetes. According to Munji *et al.* (2010) [8], organic manures considerably increased the population of actinomycetes. This increases the amount of biomass available to the microbes as food and boosts the number of bacteria in the soil. The majority of soil microorganisms are chemo-autotrophs, which means they need organic carbon sources as food. Because the oxidation of organic materials produces energy, this may be the reason why the microbial population in soils treated with organics is improving (Ingle *et al.*, 2014) [2].

Table 2: Effect of organic farming on microbial populations in soil under soybean.

Treatments	Soil Microbial population		
	Soil Bacteria CFU× $10^{-7}g^{1}$soil	Soil Fungi CFU× $10^{-4}g^{1}$soil	Soil Actinomycetes CFU×$10^{-6}g^{-1}$soil
T_1: 100% RDN through FYM	59.66	12.00	22.33
T_2:100% RDN through Vermicompost	75.00	16.33	25.66
T_3 :100% RDN through 33% FYM + 33% Vermicompost + 33% Neem cake	88.33	17.33	30.33
T_4:100% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	63.33	12.33	25.33
T_5:75% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	49.66	11.33	21.33
T_6:50% RDN through FYM + Jivamrut application at 30, 45 & 60 DAS	47.00	10.66	20.00
T_7:100% RDN through FYM + Biofertilizers 2.5 lit/ha soil application (*Rhizobium*+ PSB)	65.00	12.66	25.33
T_8:75% through FYM + Biofertilizers 2.5lit/ha soil application (*Rhizobium*+ PSB)	56.00	11.66	24.00
T_9:50%RDN through FYM+ Biofertilizers 2.5lit/ha soil application (*Rhizobium*+ PSB)	48.00	11.00	20.00
T_{10}: Jivamruth application at 30,45, and 60 DAS	38.33	9.33	16.00
T_{11}: Jivamruth application at 0,15, 30,45, and 60 DAS	43.66	10.00	19.33
T_{12}: Absolute control	29.33	6.00	11.00
T_{13}:RDF+ 5 t FYM/ha	68.66	13.00	25.33
Mean	56.30	11.82	22.07
S.Em. ±	2.22	0.59	1.15
C.D. at 5%	6.49	1.72	3.36
C.V.%	6.85	8.68	9.04

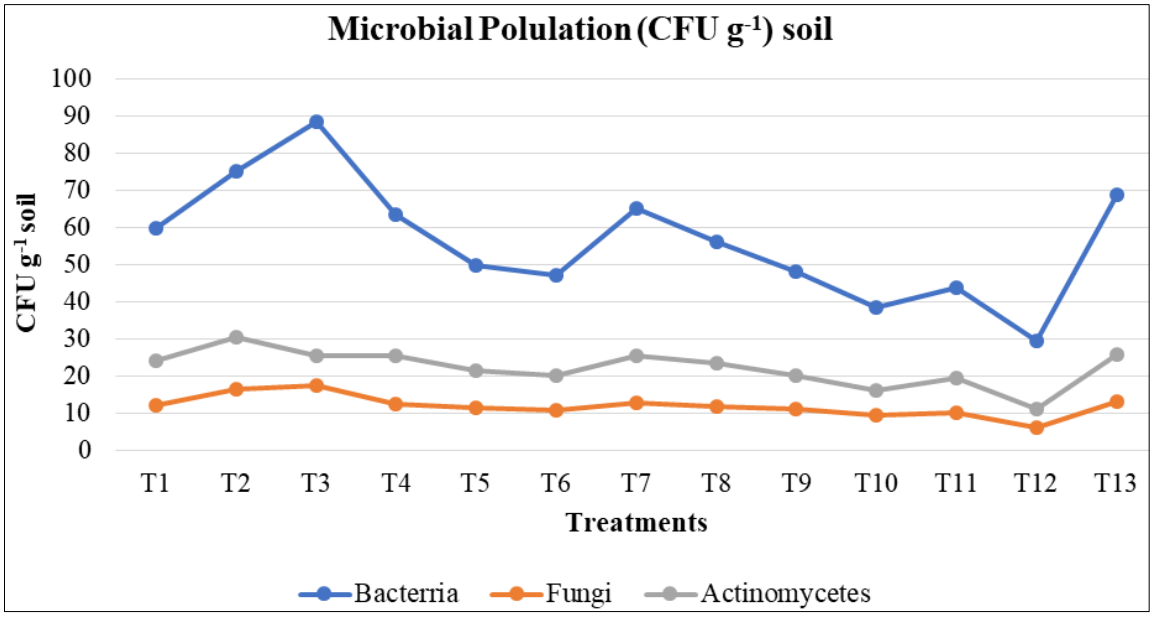

Fig 1: Effect of organic farming on microbial populations in soil under soybean.

4. Conclusion

From the above study, we concluded that application of 33% FYM + 33% Vermicompost + 33% Neem cake or FYM in combination of different organic manures enhanced the microbial activity (bacteria, fungi and actinomycetes) which inturn improves the soil fertility. Application of FYM in combination with Vermicompost and Neem cake also increased enzymatic activity (Dehydrogenase, Acid and Alkaline phosphatase enzyme).

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