Original Research Article

EFFECT OF ENRICHED PHOSPHOCOMPOST ON SOIL BIOLOGICAL PROPERTIES OF PEARL MILLET IN VERTISOLS

Abstract

A field experiment was laid out with ten treatments replicated thrice in Randomized Block Design. Treatments comprised of T_1: control, T_2: 100% RDF, T_3: 100% RDF + 2.5 t bajra straw phosphocompost ha^{-1}, T_4: 100% RDF + 2.5 t cotton stalk phosphocompost ha^{-1}, T_5: 100% RDF + 2.5 t FYM ha^{-1}, T_6: 100% RDF + 5 t FYM ha^{-1}, T_7: 75% RDF + 2.5 t bajra straw phosphocompost ha^{-1}, T_8: 75% RDF + 2.5 t cotton stalk phosphocompost ha^{-1}, T_9: 75% RDF + 2.5 t FYM ha^{-1} and T_{10}: 75% RDF + 2.5 t FYM ha^{-1}. Soil biological properties were estimated at sowing, at flowering and harvesting of pearl millet. The experimental findings indicated that the soil microbial biomass were found to be increased at flowering than at sowing and further, gradually declined at harvest but higher than sowing stage. The significantly maximum Soil Microbial Biomass Carbon (SMBC) (212.42 µg C g^{-1} soil), Nitrogen(70.72 µg N g^{-1} soil) and Phosphorus (40.25 µg P g^{-1}) soil contents were recorded with 100% RDF + 2.5 t cotton stalks phosphocompost ha^{-1} (T_4) followed by 100% RDF + 2.5 t bajra straw phosphocompost ha^{-1} (T_3) at flowering. Among the FYM treatments, the higher SMBC, N and P were noted with 100% RDF + 5 t FYM ha^{-1} over 100% RDF alone. Further, it was noticed that C and N mineralization rate were increased at flowering stage and then declined at harvest as compare to sowing stage. However, at harvest, the highest C (9.12 µg C g^{-1} soil d^{-1}) and N (0.86 µg N g^{-1} soil d^{-1}) mineralization were recorded with 100% RDF + 2.5 t cotton stalks phosphocompost ha^{-1} (T_4) followed by 100% RDF + 2.5 t bajra straw phosphocompost ha^{-1} (T_3). Significantly maximum dehydrogenase activity (61.17 µg TPF g^{-1} soil 24 hr^{-1}), alkaline phosphatase activity (90.43µg*P*- Nitrophenol g^{-1} soil 24 hr^{-1}), fungal (23 × 10^{4}cfu g^{-1} soil), bacterial (43 × 10^{7}cfu g^{-1} soil) and actinomycetes (41 × 10^{6}cfu g^{-1} soil) population were noted in the treatment receiving 100% RDF + 2.5 t cotton stalks phosphocompost ha^{-1} (T_4).

Keywords: Phosphocompost, SMBC, SMBN, SMBP, Soil enzymatic activities, C and N mineralization.

1. Introduction

Phosphorus stimulates early root development and growth, thereby helping to establish seedlings quickly. It gives rapid and vigorous start to plants, strengthens straw, decreases lodging tendency and brings about early maturity of crops. Phosphorus in soils is immobilized or becomes less soluble either by absorption, chemical precipitation or by both processes [1]. Therefore, demand of phosphorus can be met through application of organic manure in the form of phosphocompost and microbial inoculants to the plant. Soil microorganism plays a key role in soil P dynamics and subsequent availability of phosphate to plant.

Composts produced from rice straw enriched with rock phosphate and inoculated with *Aspergillus niger, Trichoderma viride* and/or farmyard manure (FYM) showed maximum amount of soluble phosphorus [2]. Biswas and Narayanasamy [3] prepared rock phosphate enriched compost (RP-compost) by mixing four low grade Indian rock phosphates with rice straw with and without Aspergillus awamori. RP-compost had higher total P, citrate soluble P, organic P, acid and alkaline phosphatase activities, and lower water soluble P and microbial biomass C than normal compost. Thus, RP enriched compost could be an alternative and viable technology to utilize both low grade RPs and straw efficiently.

Cropping practices and fertilizer/manure application affects the soil microbial growth and activity. The decomposition of plant material and turnover of microbial biomass/organic carbon is comparatively faster in tropical conditions as compared to temperate conditions [4]. Soil organic carbon, microbial biomass carbon, urease and acid phosphatase activities increased with organic supplements like cowdung, Leuceana leaves, farm residues and Sesbania [5].The use of organic matter may help to improve soil organic carbon content, biological health of soil and crop production. Very little information is available on soil biological quality using different quality of organics

2. Material and Methods

A Field experiment was conducted at the farm of Bajra Research Scheme, College of Agriculture, Dhule. The experiment was laid out with ten treatments replicated thrice in Randomized Block Design. There were 10 treatments *viz.* T_1- Control, T_2- 100 % RDF, T_3- 100% RDF + 2.5 t Bajra straw phosphocompostha^{-1}, T_4- 100% RDF+ 2.5 t Cotton stalks phosphocompostha^{-1}, T_5- 100% RDF + 2.5 t FYM ha^{-1}, T_6- 100% RDF + 5 t FYM ha^{-1}, T_7- 75% RDF + 2.5 t Bajra straw phosphocompostha^{-1}, T_8- 75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1}, T_9- 75 % RDF + 2.5 t FYM ha^{-1}, T_{10}- 75% RDF + 5 t FYM ha^{-1}. The recommended dose of fertilizer for *kharif* pearl millet was 60:30:25 N: P_2O_5: K_2O kg ha^{-1}, respectively. The fertilizers, urea, single super phosphate and muriate of potash were used as a source of N, P and K, respectively. The half dose of N and full dose of P_2O_5 and K_2O were applied at the time of sowing, whereas remaining half dose of N was applied after the one month.

The phosphocompost prepared from bajra straw, cotton stalk and FYM were analyzed for their chemical composition and data placed in Table 1 and 2.

Table 1. Characterization of phosphocompost instead of this title

;kindly change the title like, (Characteristics of Phosphocompost)

Sr.No	Parameters	Bajra phosphocompost	Cotton phosphocompost

1	pH	7.3	7.4
2	EC (dSm^{-1})	0.63	0.43
3	Organic C (%)	24.88	26.60
4	Total N (%)	1.16	1.31
5	Total P (%)	1.68	1.85
6	Citrate soluble P (%)	0.81	0.88
7	Water Soluble P (%)	0.068	0.076
8	Total K (%)	0.85	0.75
9	C:N Ratio	21.44	20.31

Table 2. Characterization of FYM instead of this title

;kindly change the title like, (Characteristics of FYM)

Sr no	**Parameters**	**Contents**
1	pH	7.1
2	EC (dSm^{-1})	0.11
3	Organic C (%)	12
4	Total N (%)	0.61
5	Total P (%)	0.39
6	Total K(%)	0.79
7	C:N Ratio	19.67

In manure analysis, the organic carbon was determined by combustion method [6], the total N was analyzed by microkjeldahl method [7], the total P was analyzed by Vanadomolybdate blue colour colorimetric [8], the citrate and water soluble P was estimated by Colorimetric method [9] and the total K was determined by Flame photometry method [10]. In soil biological properties, the SMBC, SMBN and SMBP were determined by Chloroform fumigation extraction method [11], the CO_2 evolution by Alkali trap method [12], the NH_4 and NO_3 N by Distillation method [6], the soil microbial population were observed by Serial dilution plate method [13], the soil enzymatic activities DHA and alkaline phosphatase activities were determined by Spectrophotometric method [14] [15]. The data generated were statistically analysed in Randomized Block Design (RBD) as suggested by Panse and Sukhatme[16].

3. Result and Discussion

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3.1 Effect of enriched phosphocompostapplication on soil microbial biomass C, N and P

3.1.1 Effect on soil microbial biomass carbon

At sowing stage, SMBC ranged from 120.16 to 152.63 µg C g^{-1} soil, and the higher values were recorded where the phosphocomposts and FYM were incorporated before sowing of crop (Table 3). Further, at flowering stage, the SMBC ranged between 132.27 to 212.42 µg C g^{-1} soil. Significantly highest microbial biomass carbon (212.42 µg C g^{-1} soil) was noted in treatment T_4 (100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1}) which was more superior than other treatments and followed by T_3 i.e. application of 100% RDF + 2.5 t bajra straw phosphocompostha^{-1} (192.32 µg C g^{-1} soil). Application of these phosphocompost along with 75% RDF also recorded the higher values as compared to FYM. However, incorporation of 5 t FYM ha^{-1} significantly increased the SMBC over 2.5 t FYM ha^{-1}. The chemical fertilizer alone treatment (T_2) showed less SMBC (138.40 µg C g^{-1} soil) as compared to phosphocompost application. Similar trend was noticed at harvest of pearl millet and the microbial biomass C was ranged between 128.36 to 195.51 µg C g^{-1} soil. However, the magnitude of increase in SMBC at harvest with phosphocompost treatments i.e. T_3, T_4, T_7 and T_8 are of 38.12, 49.93, 22.85 and 32.12 per cent, respectively over 100% RDF alone. Further, it was noticed that SMBC increased from sowing to flowering stage and it gradually declined at harvest but values are quite higher than at sowing stage. The increase in soil microbial biomass carbon might be due to the higher microbial population and organic carbon as found in this study. This might create a calibrated soil quality indicator that only predicts whether soil is accumulating or losing soil carbon. Soil microbial biomass carbon was significantly increased by the application of phosphocompost and FYM over their initial values (control plot) but magnitude of increase was less in the plot where only chemical fertilizers applied. Similar increased in SMBC with phosphocompost application was noticed by Manna *et al*. [17] and with FYM application was showed by Mandal *et al*. [18].

3.1.2 Effect on soil microbial biomass nitrogen

At sowing of crop the SMBN varied from 13.94 to 22.36 µg N g^{-1} soil (Table 3). Further, at flowering stage the content was found significantly increased and it ranged between 22.48 to 70.72 µg N g^{-1} soil. The lowest content was recorded under control and the highest under 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} followed by 100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (65.17 µg N g^{-1} soil). Application of these phosphocomposts along with 75% RDF also recorded the higher values as compared to FYM. However, incorporation of 5 t FYM ha^{-1} significantly increased the SMBC over 2.5 t FYM ha^{-1}. The chemical fertilizer alone treatment (T_2) showed less SMBN (28.32 µg N g^{-1} soil) as compared to INM. Similar trend was noticed at harvest of pearl millet and the microbial biomass N was ranged between 11.36 to 48.22 µg N g^{-1} soil. At this stage, application of bajra straw (T_3) and cotton stalks phosphocomposts (T_4) along with 100% RDF and their application with 75% RDF i.e. T_7 and T_8 treatments increases the SMBN by 119.36, 148.30, 96.91 and 114.01 per cent, respectively over 100%

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RDF alone (T_2) treatment. Further, it was noticed that SMBN increased from sowing to flowering stage and it gradually declined at harvest but values are quite higher than at sowing stage. The observations on the effect of different stages clearly indicated that microbial biomass C or N was subject to the time of sampling; highest values being associated with the tillering stage and the lowest at the dough stage. Microbial biomass was a small but very dynamic component of soil organic matter fluctuating with weather, crop, input and season by as much as 40% in native ecosystems and agricultural systems (Mandal *et al*.[18]). Significant increase in SMBN under different organic input was also reported by Tu *et al*. [19] and Thakare and Bhoyar [20].

3.1.3 Effect on soil microbial biomass phosphorous

Data inferred that at the time of sowing the SMBP was ranged from 9.48 to 20.17 µg P g^{-1} soil and the quite higher values of SMBP are noted in the plots where phosphocompost was applied before sowing (Table 3). Further, it was noticed that, at flowering stage, the SMBP found to be increased under all treatments as compared to at sowing stage. Significantly highest microbial biomass P was recorded in treatment T_4(100% RDF+ 2.5 t Cotton stalks phosphocompostha^{-1}) i.e. 40.25 µg P g^{-1} soil followed by the treatment T_3 i.e. 100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (35.14 µg P g^{-1} soil). Among the remaining phosphocompost treatments, the cotton stalks phosphocompost with 75% RDF (T_8) recorded the higher (32.13 µg P g^{-1} soil) values as compared to T_6 (100% RDF + 5 t FYM ha^{-1}) and T_5 (100% RDF + 2.5 t FYM ha^{-1})i.e. 25.70 and 23.62 µg P g^{-1} soil, respectively. The chemical fertilizer alone treatment (T_2) showed less (17.42 µg P g^{-1} soil) SMBP as compared to INM.

At the harvest of bajra, the SMBP was found to decline but was relatively higher over at sowing values. The lowest SMBP (10.17 µg C g^{-1} soil) was recorded under (T_1). Similarly,100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (T_4) and 100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (T_3) showed higher values of SMBP i.e. 25.20 and 23.09 µg P g^{-1} soil, respectively as compared to other treatments. Although, appraisal of the results point out that the phosphocompost application treatments i.e. T_3, T_4, T_7 and T_8 increases SMBP by 74.01, 89.90, 55.61 and 71.21 per cent, respectively over 100% RDF alone (T_2).

The application of organic fertilizers significantly increased soil microbial biomass C, N and P at all sampling days. In most cases, this increase was significantly higher in the compost than in the manure treatments. It may be due to the microbial biomass content in the compost itself (Jannoura*et al*. [21]). Different sources and rates of organic composts affected microbial biomass P and available P significantly. Vermicompost treatments showed a declining trend in both available and microbial biomass P with the reduction of doses. Microbial biomass P produced declining trend with the reduction in application rate of FYM was previously noticed by Saha *et al*. [22].

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Table 3.Effect of enriched phosphocompost application on soil microbial biomass carbon, nitrogen, phosphorous and mineralization of carbon and nitrogen (The tile was corrected) kindly align the table neatly please

Treatment	SMBC (μg C g^{-1} soil)			SMBN (μg N g^{-1} soil)			SMBP (μg P g^{-1} soil)			C mineralization (μg C g^{-1} soil d^{-1})			N mineralization (μg N g^{-1} soil d^{-1})		
	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest
T_1	120.16	132.27	128.36	13.94	22.48	11.36	9.48	12.36	10.17	5.28	7.35	3.16	0.45	0.54	0.30
T_2	125.47	138.40	130.40	14.78	28.32	19.42	11.23	17.42	13.27	6.30	8.17	5.20	0.49	0.61	0.36
T_3	149.41	192.32	180.12	21.95	65.17	42.60	18.20	35.14	23.09	10.24	17.50	8.75	0.87	1.96	0.71
T_4	152.63	212.42	195.51	22.36	70.72	48.22	20.17	40.25	25.20	10.72	19.36	9.12	0.91	2.12	0.86
T_5	132.48	155.17	141.37	16.92	40.38	24.32	13.55	23.62	18.12	7.75	10.22	6.21	0.62	0.92	0.49
T_6	139.37	172.76	155.62	18.31	49.14	32.48	14.70	25.70	20.43	8.82	12.36	7.12	0.70	1.32	0.52
T_7	142.26	178.25	160.20	19.44	52.15	38.24	16.12	30.21	20.65	9.17	13.27	7.88	0.78	1.65	0.57
T_8	146.23	184.36	172.28	21.42	57.72	41.56	17.23	32.13	22.72	9.72	15.47	8.12	0.82	1.80	0.63
T_9	129.36	147.63	136.73	16.62	35.12	21.36	12.26	19.51	14.22	7.18	9.23	6.97	0.52	0.74	0.38
T_{10}	137.16	167.38	148.92	17.35	47.36	30.43	12.84	21.36	16.51	8.27	10.75	7.00	0.56	0.86	0.43
SE (m)±	0.31	0.28	0.41	0.38	0.41	0.50	0.33	0.37	0.35	0.18	0.27	0.19	0.008	0.008	0.008
CD at 5%	0.92	0.84	1.22	1.14	1.21	1.50	0.97	1.08	1.05	0.53	0.81	0.56	0.024	0.025	0.022

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3.2 Effect of enriched phosphocompost application on carbon and nitrogen mineralization

The results on N mineralization were consistent with the differential effects of the plant residue treatments on C mineralization and microbial biomass. The results on N mineralization, C mineralization and microbial biomass were related to residue chemistry (Table 3). The study showed that phosphocompostand FYM in combination with chemical fertilizer had relatively high N concentration which accounted for the increased C and N mineralization and microbial biomass. The high C and N mineralization rate observed in the phosphocompost treatment in our study may also be partially due to enhanced activity of the soil fauna.

3.2.1 C Mineralization

At flowering stage of pearl millet, the C mineralization rate was slightly and significantly increased and it was varied from 7.35 to 19.36 µg C g^{-1} soil d^{-1}. The maximum C mineralization (19.36 µg C g^{-1} soil d^{-1}) was recorded with 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} followed by 100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (17.50 µg C g^{-1} soil d^{-1}). However, the increase in C mineralization was also noticed for T_8 (75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1}) and T_7 (75% RDF + 2.5 t Bajra straw phosphocompostha^{-1}) i.e. 15.47 and 13.27 µg C g^{-1} soil d^{-1}, respectively. The minimum rate of C mineralization (7.35 µg C g^{-1} soil d^{-1})was recorded under control. Application of FYM along with 100% and 75% RDF significantly increased the C mineralization over 100% RDF alone, but values are lower as compared to phosphocompost treatments.

The cumulative values of evolved CO_2–C increased rapidly from sowing to flowering, thereafter, it was decreased at harvest of crop. As the time progressed the differences between the treatments were more conspicuous. The treatment, 100% NPK + phosphocomposts showed greatest cumulative carbon mineralization throughout the period, while, the lowest mineralization was observed in control. The differences in the rates of C mineralization are indicative of the variable amounts of labile organic C accumulated in different fertilizer treatments (Rudrappa*et al*. [23]). Application of integrated nutrient supply increased C and N mineralization at grand growth stages of sorghum-wheat cropping system as compared to their individual application. Results showed that application of FYM + wheat straw + green manuring augmented C and N mineralization (Thakare, [24]).

3.2.2 N Mineralization

The rate of N mineralization at flowering stage was significantly increased and varied 0.54 to 2.12 µg N g^{-1} soil d^{-1}. 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (T_4) showed maximum N mineralization (2.12 µg N g^{-1} soil d^{-1})andwhich was followed by T_3 i.e. 100% RDF + 2.5 t Bajra straw phosphocompost ha^{-1} (1.96 µg N g^{-1} soil d^{-1}). The 75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} and 75% RDF + 2.5 t Bajra straw phosphocompostha^{-1} significantly increased the N mineralization rate

over sole chemical fertilizer and INM with FYM. Although, FYM treatments significantly increases the N mineralization over chemical fertilizer.

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Manure application created conditions that promoted an increase in the easily mineralizable inorganic-N pool, which was predominantly ammoniacal. The total inorganic N mineralized was 45–48 per cent higher in INM and organic nutrient management compared to chemical nutrient management due to greater organic matter levels because N mineralization is a microbial process that is influenced both by the quantity and quality of soil organic matter was previously reported by Dinesh *et al*. [25]. Similarly integrated nutrient supply increased C and N mineralization at grand growth stages of sorghum-wheat cropping system as compared to their early stage was noted by Thakare [24]. Our results showed that enhanced soil microbial biomass N and C were associated with high N and C mineralization. The higher C and N mineralization rate in this study might be due to enhanced microbial populations and their activities.

3.3 Effect of enriched phosphocompost application on enzyamatic activities

3.3.1 Dehydrogenase activity (DHA)

The dehydrogenase activity was found to be reduced at harvest of pearl millet although, it was higher than at sowing stage (Table 4). At the end of cropping, the highest activity (61.17 µg TPF g^{-1} soil 24 h^{-1}) was noted with 100% RDF+ 2.5 t Cotton stalks $phosphocompostha^{-1}$ (T_4) followed by T_3 i.e. 100% RDF + 2.5 t Bajra straw $phosphocompostha^{-1}$ (58.32 µg TPF g^{-1} soil 24 h^{-1}). The 75% RDF + 2.5 t Cotton stalks $phosphocompostha^{-1}$ also recorded the higher (52.60 µg TPF g^{-1} soil 24 h^{-1}) dehydrogenase activity than chemical fertilizer. The dehydrogenase activity under 100% RDF along with 2.5 t Bajra straw $phosphocompostha^{-1}$ (T_3) and 2.5 t Cotton stalks $phosphocompostha^{-1}$ (T_4) and their application with 75% RDF i.e. T_7 and T_8 were increased by 90.77, 100.10, 57.77 and 72.06 per cent, respectively over 100% RDF alone (T_2).

Incorporation of crushed cotton compost influences soil enzymatic activities because the added material may contain intra- and extracellular enzymes and may also stimulate microbial activity in the soil, the organic amendment had a positive effect on the activity of these enzymes, particularly when the amendment was at the high dose, probably due to the higher microbial biomass produced in response recorded by Tejadaand Gonzalez [26]. Biological and biochemical properties of the soil have often been proposed as early and sensitive indicators of soil ecological stress or other environmental changes. Since, dehydrogenase activity is only present in viable cells, it is thought to reflect the total range of oxidative activity of soil microflora and consequently may be considered to be a good indicator of microbial activity. Generally, the enzyme activities in the soil are closely related to the organic matter content. The application of balanced amounts of nutrients and manures improved the organic matter and MBC status of soils, which corresponded with higher enzyme activity noted by Mandal *et al*. [18].

3.3.2 Alkaline phosphatase activity

Soil alkaline phosphatase activity indicated that at the start of experiment that is at sowing, the activity varied from 34.37 to 69.13 µg P- Nitrophenol g^{-1} soil 24 h^{-1}(Table 4). However, at flowering the activity was significantly increased and ranged from 50.17 to 145.53 µg P- Nitrophenol g^{-1} soil 24 h^{-1}. The maximum activity was recorded under 100% RDF + 2.5 t Cotton stalks $phosphocompostha^{-1}$ (T_4) followed by 100% RDF + 2.5 t Bajra straw $phosphocompostha^{-1}$ (T_3), 75% RDF + 2.5 t Cotton stalks

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phosphocompostha^{-1} (T_8) and 75% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (T_7) i.e. 145.43, 132.71, 127.30 and 110.29 µg *P*- Nitrophenol g^{-1} soil 24 h^{-1}. FYM application @ of 2.5 and 5 t ha^{-1} along with 75% and 100% RDF significantly increases the activity of this enzyme as compared to RDF alone. Minimum activity was recorded for the sample collected from control plot.

At the end of cropping or at the harvest of pearl millet, the activity of this enzyme was declined but higher than its sowing status, however, the highest activity (90.43 µg *P*- Nitrophenol g^{-1} soil 24 h^{-1}) was noted with 100% RDF + 2.5 t cotton stalk phosphocompostha^{-1} (T_4) followed by100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (T_3). Application of cotton salksphosphocompost and bajra straw phosphocompost along with 75% RDF significantly recorded higher alkaline phosphatase activity over FYM along with inorganic fertilizer treatments. However, FYM application (2.5 and 5 t ha^{-1}) along with RDF (75 and 100%) significantly enhanced the activity over 100% RDF alone. Further, it could be seen that the magnitude of increase of this enzyme activity is of 71.71 to 98.31 per cent for phosphocompost treated plots and 11.67 to 53.77 per cent for FYM over 100% RDF alone.

Alkaline phosphatase activitiy was higher under manure-amended plots and lower in the control. As with microbial biomass carbon, optimum and balanced application of fertilizers increased the phosphatase activity. There was a sharp increase in alkaline phosphatase activity due to wheat cultivation and afterwards it declined. That indicates the strong rhizospheric effect on phosphatase activity observed by Masto *et al.* [27]. Similarly, alkaline phosphatase activities of compost-treated soils were significantly higher than those in the CF treatment. Phosphatase activity increased when compost was added at rates up to 90 Mg ha^{-1}, and that the activity continued to show a linear increase with compost rates up to 270 Mg ha^{-1} in a field experiment observed by Chang *et al*. [28]. The signicantly greater activities of alkaline phosphatase activity in the FYM treated soils may be due to enhanced microbial activity and perhaps diversity of phosphate solubilizing bacteria due to manure input over the years. The phosphatase activity was also closely related to the microbial biomass C content, observed by Mandal *et al*. [18].

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Table 4. Effect of enriched phosphocompost application on dehydrogenase activity (DHA), alkaline phosphatase activity and microbial populations

Treatment	DHA (µg TPF g^{-1} soil 24 hr^{-1})			Alkaline P activity (µg PNP g^{-1} soil 24 hr^{-1})			Fungal count (x 10^4 cfu g^{-1} soil)			Bacterial count (x 10^7 cfu g^{-1} soil)			Actinomycetes count (x 10^6 cfu g^{-1} soil)		
	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest	At sowing	At flowering	At harvest
T_1	22.17	38.56	27.16	34.37	50.17	38.42	4	7	5	18	23	20	11	19	14
T_2	24.28	42.16	30.57	37.24	62.20	45.60	6	10	8	19	26	22	13	22	16
T_3	31.82	77.28	58.32	65.36	132.71	87.13	16	28	21	31	48	40	24	46	36
T_4	32.34	82.57	61.17	69.13	145.43	90.43	17	32	23	33	52	43	26	50	41
T_5	26.29	50.32	37.18	48.32	82.17	62.63	8	14	11	22	31	27	15	29	19
T_6	28.30	61.16	42.47	51.63	93.27	70.12	12	19	15	26	39	32	19	37	25
T_7	30.17	67.63	48.23	56.70	110.29	78.30	13	21	17	28	42	34	21	41	28
T_8	31.40	72.17	52.60	61.93	127.30	84.36	15	24	19	30	44	37	23	43	32
T_9	25.75	47.28	32.40	40.63	71.65	50.92	7	12	9	21	29	24	14	26	18
T_{10}	27.18	55.31	40.17	45.76	78.13	57.65	10	17	13	24	36	30	17	34	22
SE (m)±	0.43	0.58	0.47	0.42	0.48	0.34	0.70	0.48	0.59	0.54	0.48	0.50	0.38	0.55	0.52
CD at 5%	1.27	1.73	1.39	1.25	1.42	1.01	2.09	1.41	1.75	1.61	1.44	1.48	1.13	1.63	1.55

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3.4 Effect of enriched phosphocompost application on soil microbial population

3.4.1 Soil fungal population

The fungal population was varied from 4.00 to 17.00 x 10^4 cfu g^{-1} soil, further, itwasincreased at flowering and thandeclined at harvest of pearl millet but values are foundhigherthan at sowing stage (Table 4). At flowering stage of crop, significantly the maximum fungal population (32.00 x 10^4 cfu g^{-1} soil) wasrecordedwith100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (T_4) followed by 100% RDF+ 2.5 t Bajra stalks phosphocompostha^{-1} (T_3) i.e. 28 x10^4 cfu g^{-1} soil. Significantlyhigher population over chemicalfertilizerwasalsonotedwith 75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} and 75% RDF + 2.5 t Bajra straw phosphocompostha^{-1}. Although, the 5 t FYM ha^{-1}alongwith 100% RDF (T_6) and with 75% RDF (T_{10}) significantlyenhanced the fungal population i.e. 19 and 17 x10^4 cfu g^{-1} soil, respectively over 2.5 t FYM ha^{-1} withchemicalfertilizer.

At harvest of pearl millet, the maximum fungal population (23 x10^4 cfu g^{-1} soil) wasnoted in 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} followed by 100% RDF + 2.5 t bajra straw phosphocompostha^{-1} (21 x10^4 cfu g^{-1} soil). Higher population wasalsoobservedwith75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} and75% RDF + 2.5 t Bajra straw phosphocompostha^{-1} over 100% RDF alone. Further, FYM alongwithinorganicfertilizertreatmentsalsosignificantlyenhanced the fungal population as compared to inorganicfertilizeralone.

Regular addition of organic manures is the only way to increase soil organic matter status. Repeated application of farmyard manure for 10 years developed a different microbial community compared to that amended only with chemical fertilizers Vineela *et al*. [29]. Thakare and Gupta [30] also studied the effect of nutrient management on microbial population in vertisol. They noticed the higher microbial population under plot receiving treatment N through FYM, wheat straw and green manuring as compared to 100% NPK and control. Mahanta *et al*. [31] also concluded that the continuous application of FYM had beneficial effect on microbial population.

3.4.2 Soil bacterial population **Kindly align properly**

At sowing stage of crop, the bacterial populations were ranged between 18 to 33 x 10^7 cfu g^{-1} soil. Enhancement in bacterial population wasobserved at flowering stage and the rangedrecordedwas 23 to 52 x 10^7 cfu g^{-1} soil (Table 4). Significantly maximum population wasnotedwith100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (52 x 10^7 cfu g^{-1} soil), also100% RDF + 2.5 t Bajra straw phosphocompostha^{-1} showed second higherbacterial population (48 x 10^7 cfu g^{-1} soil). Whencomparingwith 100% RDF alone, significanthigher population wererecordedwith75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (44 x 10^7 cfu g^{-1} soil) and 75% RDF + 2.5 t Bajra straw (42 x 10^7 cfu g^{-1} soil). There was also increased in bacterial population in 100% RDF + 5 t FYM ha^{-1} (39 x 10^7 cfu g^{-1} soil) followed by 75% RDF + 5 t FYM ha^{-1} (36 x 10^7 cfu g^{-1} soil), 100% RDF + 2.5 t FYM ha^{-1} (31 x 10^7 cfu g^{-1} soil) and 75% RDF + 2.5 t FYM ha^{-1} (29 x 10^7 cfu g^{-1} soil) whichweresignificantlyhigher over chemicalfertilizeralonetreatment.

At harvest of pearl millet, the integrated management practices enhanced the bacterial population over 100% RDF alone and control. The bacterial population recorded at the end of crop in phosphocompoststreatmentsviz., 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1}, 100% RDF + 2.5

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t Bajra straw phosphocompostha^{-1},75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} and75% RDF + 2.5 t Bajra straw phosphocompostha^{-1}was 43, 40, 37 and 34 x 10^7 cfu g^{-1} soil, respectivelywhichwere 95.45, 81.82, 68.18 and 54.54 per cent, respectivelyincrease over 100% RDF alonetreatment.

The population of soil bacteria, actinomycetes and fungi influenced by organic or inorganic nutrient management during crop growth stages. Fungal, bacterial and actinomycetes population was significantly affected due to application of organic manures and crop residue with phosphocompost recorded by Tamilselvi *et al*. [32]. Highest fungal, bacterial and actinomycetes population was recorded with FYM + phosphocompost and pigeonpea stalk + phosphocompost that was superior over chemical fertilizers. The higher microbial population might be due to the addition of organic manures and crop residue into the soil observed by Nagar *et al.*[33].

3.4.3 Soil actinomycetes population

Data inferred that at sowing stage the actinomycetes population ranged between 11 to 26 x 10^6 cfu g^{-1} soil (Table 4). Further, at flowering stage, itwasincreased and significantly maximum population wasnotedunder100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (50 x 10^6 cfu g^{-1} soil) followed by 100% RDF + 2.5 t bajra stalks phosphocompostha^{-1} (46 x 10^6 cfu g^{-1} soil). Followed by thesetreatments, the significantlyhigheractinomycetes population was observed under 75% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} (43 x 10^6 cfu g^{-1} soil) and 75% RDF + 2.5 t Bajra straw phosphocompostha^{-1} (41 x 10^6 cfu g^{-1} soil) as compared to chemical fertilizer alone treatment (22.00 x 10^6 cfu g^{-1} soil). The 100% RDF + 5 t FYM ha^{-1} and 75% RDF + 5 t FYM ha^{-1} significantly enhanced the actinomycetes population over their reduced rate.

At the end i.e. at the harvest of pearl millet, the maximum actinomycetes population (41 x 10^6 cfu g^{-1} soil) was recorded with 100% RDF + 2.5 t Cotton stalks phosphocompostha^{-1} followed by 100% RDF + 2.5 t bajra stalks phosphocompostha^{-1} (36 x 10^6 cfu g^{-1} soil) which were found to be 156.25 and 125.00 per cent, respectively increased over 100% RDF alone. Rest of the treatments significantly increases the actinomycetes population over control.

The soil microbial biomass, populations of bacteria, fungi and actinomycetes increased significantly in the compost-treated soils compared with the CF-treated soil. The populations of bacteria, actinomycetes and fungi in the soil amended with compost were significantly higher than the populations in the no fertilizer and CF treatments. On average, the populations of microorganism in the soil amended with compost were 1.68-fold higher than those in the chemical fertilizer treatment and increased with increases in the compost application ratesnoted by Chang *et al*. [28]. Thakare and Bhoyar[20] found that bacterial and actinomycetes population were maximum in organic and inorganic inputs under soybean in vertisol. The continuous application of FYM had beneficial effect on microbial population observed by Mahanta *et al*. [31].

4. CONCLUSION: Based on the experimental findings, the application of 100 % RDF+ 2.5 t Cotton stalks phosphocompostha^{-1} and 100% RDF+ 2.5 t bajra straw phosphocompostha^{-1} were enhanced soil biological activities in terms of SMBC, SMBN, SMBP, carbon and nitrogen mineralization. Also they

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stimulate the soil microbial population and enzymatic activities such as DHA and alkaline phosphatase in pearl millet.***(Kindly check grammar they stimulate or It Stimulates)***

Disclaimer: Authors hereby declare that NO generative AI technologies such as Large Language Models and text-to-image generators have been used during the writing or editing of manuscripts.

REFERENCES

1. Tilak, K.V., Ranganayaki, K.K., Pal, K.K., Saxena, A.K., Nautiyal, C.S., Tripathi, A.K. and Johri, B.N. Diversity of plant growth and soil health supporting bacteria. Current Science. 2005; 89(1):136-150.

2.Gaber., Zayed and Heba, A. Bioactive compost from rice straw enriched with rock phosphate and their effect on the phosphorus nutrition and microbial community in rhizosphere of cowpea. Bioresource Technology. 2005;96:929-935.

3.Biswas, D.R. and Narayanasamy, G. Rock phosphate enriched compost: an approach to improve low grade Indian rock phosphate. Bioresource Technology. 2006;97:2243-2254.

4. Kaur, G. and Reddy, M. S. Effects of phosphate-solubilizing bacteria, rock phosphate and chemical fertilizers on maize-wheat cropping cycle and economics. Pedosphere.2015; 25(3):428-437.

5. Chakrabarti, K., Sarkar, B., Chakraborty, A., Banik, P. and Bagchi, D. K. Organic recycling for soil quality conservation in a sub-tropical plateau region. Journal of Agronomy and Crop Science. 2000;184:137-142.

6. Black, C.A. *Methods of Soil Analysis*, Part-II. American Society of Agronomy, inc., Madison, Wisconsin, USA.1982.

7. Parkinson, J.A. and Allen, S.E. A wet oxidation procedure suitable for the determination of nitrogen and mineral nutrients in biological materials. Communication in Soil Science and Plant Analysis.1975;**6**:1-11.

8. Piper, C. S. Soil and Plant Analysis. Hans Publ., Bombay, Asian Ed.1966.

9. Jackson, M.L. *Soil Chemical Analysis*. Prentice Hall Pub, Pvt. Ltd. New Delhi.1973.

10. Chapman, H.D. and Pratt, P.F.Methods of Analysis for Soil Plant and Water. Division of Agrilculture Science. California University., U.S.A. Agronomy. 1961;9: pp 363-382.

UNDER PEER REVIEW

11.Brookes, P.C., Kragt, J.P., Powlson, D.S. and Jenkinson, D.S. Chloroform fumigation and release of soil nitrogen: a rapid direct extraction method to measure microbial biomass nitrogen in soil. Soil Biology and Biochemistry. 1985;17:837-842.

12.Pramar D and E.L. Schimidt. Experimental soil microbiology. Burgers publication Com Minnesota. U.S.A.1965.

13.Dhingra, O.D and Sinclair, J.B. Basic Plant Pathology Methods, CBS Publication, New Delhi.1993.

14.Casida, L., Klein, D. and Santoro, T. Soil dehydrogenase activity. Soil Science. 1964;98:371-376.

15.Tabatabai, M.A. and Bremner, J.M. Use of p-nitrophynyl phosphatase for assey of soil phosphatase activity. Soil Biology and Biochemistry. 1969;1:301-307.

16. Panse, V.G. and Sukhatme, P.V.Statistical Method Agricultural Workers, Revised Edn. ICAR, New Delhi.1995.

17.Manna, M.C., Ghosh, P.K. and Ganguly, T. K. Comparative performance of four sources of enriched phosphocompost and inorganic fertilizer application on yield, uptake of nutrients and biological activity of soil under soybean-wheat rotation. Food, Agriculture & Environment. 2003;1(2):203-208.

18. Mandal, A., Patra, A. K.,Singh, D., Swarup, A. and Masto, R. E. Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages.Bioresource Technology. 2007;98:3585-3592.

19.Tu, C., Ristaino, J. B. and Hu, S. Soil microbial biomass and activity in organic tomato farming systems: Effects of organic inputs and straw mulching. Soil Biology and Biochemistry. 2006;38:247-255.

20. Thakare, Ritu and Bhoyar, S. Dynamics of soil biological fertility as influenced by organic and inorganic inputs under soybean in vertisol. An Asian Journal of Soil science. 2012;7:18-22.

21.Jannoura, A.,Brunsb, C. and Joergensena, R. G. Organic fertilizer effects on pea yield, nutrient uptake, microbial root colonization and soil microbial biomass indices in organic farming systems.European Journal of Agronomy. 2014;49:32-41.

22. Saha, S., Mina, B. L., Gopinath, K. A., Kundu, S. and Gupta, H. S. Relative changes in phosphatase activities as influenced by source and application rate of organic composts in field Crops. Bioresource Technology. 2008;99:1750-1757.

UNDER PEER REVIEW

23.Rudrappa, L.,Purakayastha, T. J., Singh, D. and Bhadraray, S. Long-term manuring and fertilization effects on soil organic carbon pools in a typic haplustept of semi-arid sub-tropical India. Soil and Tillage Research. 2005;88:180-192.

24. Thakare, Ritu. Effect of cropping system and nutrient management on C and N mineralization. Panjabrao Krishi Vidyapeeth Research Journal. 2009;33(2):202-205.

25.Dinesh, R., Srinivasan, V., Hamza, S. and Manjusha A. Short term incorporation of organic manures and biofertilizers influences biochemical characteristics of soil under an annual crop [Turmeric (curcuma longa L.)] Bioresource Technology. 2010;101:4697-4702.

26. Tejada, M. and Gonzalez, J. L. Crushed cotton gin compost on soil biological properties and rice yield. European Journal of Agronomy. 2006;25:22-29.

27.Masto, R. E.,Chhonkar, P. K., Dhyan Singh and Patra, A. K. Changes in soil biological and biochemical characteristics in a long-term field trial on a sub-tropical inceptisol. Soil Biology and Biochemistry. 2006;38:1577-1582.

28. Chang, E., Chung, R. and Tsai, Y. Effect of different application rates of organic fertilizer on soil enzyme activity and microbial population. Soil Science and Plant Nutrition.2007;53(2):132-140.

29.Vineela,C., Wani, S. P., Srinivasarao, Ch., Padmaja, B. and Vittal, K.P.R. Microbial properties of soils as affected by cropping and nutrient management practices in several long-term manurial experiments in the semi-arid tropics of India. applied soil ecology. 2008;40:165-173.

30. Thakare, Ritu and Gupta, V. R. Effect of cropping systems and nutrient management on microbial population in vertisol. Panjabrao Krishi Vidyapeeth Research Journal. 2003;27(2):145-150.

31.Mahanta, D., Bhattacharyya, R., Gopinath, K.A., Tuti, M.D.,Jeevanandan, K., Chandrashekara, C., Arunkumar, R., Mina, B.L., Pandey, B.M., Mishra, P.K., Bisht, J.K.,Srivastv, A.K. and Bhatt, J. C. Influence of farmyard manure application and mineral fertilization on yield sustainability, carbon sequestration potential and soil property of gardenpea–french bean cropping system in the Indian Himalayas. Scientia Horticulturae. 2013;164:414-427.

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