



Effect of integrated nitrogen management on soil properties and enzymatic activities

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ABSTRACT

A field experiment was conducted at Agronomy farm, of S K N College of Agriculture, Jobner (Rajasthan) during *kharif* season 2017 in loamy sand soil with an objective “Effect of Integrated nitrogen management on soil properties in pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz]”. The experiment was laid out in factorial randomized block design with three replications, comprised eight treatments of sources of nitrogen (Control, 50% RDN through urea+ 50% RDN through vermicompost, 50% RDN through urea+ 50% RDN through FYM, 75% RDN through urea+ 25% RDN through vermicompost, 75% RDN through urea+ 25% RDN through FYM, 100% RDN through urea, 100% RDN through vermicompost and 100% RDN through FYM) and two treatments of biofertilizer (without inoculation and with *Azotobacter*) were applied to the pearl millet var. RHB-173. The application of sources of nitrogen, soil organic carbon, available nitrogen, phosphorus, potassium, dehydrogenase activity and alkaline phosphatase activity were increased significantly with the application of 75% RDN through urea+ 25% RDN through vermicompost at flowering and harvest stage. The soil organic carbon, available N, P_2O_5 , K_2O , dehydrogenase activity and alkaline phosphatase activities were also increased when inoculated with biofertilizer.

Key words: Alkaline phosphatase, *Azotobacter*, Dehydrogenase enzyme, FYM, Nitrogen, Organic carbon, Vermicompost

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is one of the important millet crop of arid and semi-arid climatic conditions. India is the largest producer of pearl millet having 9.1 m ha area with an annual production of 9.08 m tones and average productivity is 1156 kg/ha (Anonymous 2016-17). It is grown in poor sandy soil due to drought escaping character and also provides staple food in short period relatively in dry tracts of the country. It is nutritionally better than many cereals as good source of protein having higher digestibility (12.1%), fat (5%), carbohydrate (69.4%) and minerals (2.3%) (Ramdev *et*

al. 2017). Green fodder is either used as preserved hay or silage, which are extremely useful in dry regions. In the arid and semi-arid regions of the tropics and subtropics, soil organic carbon (SOC) is a limiting factor (< 5 g/kg), thus the retention capacity of nutrient is low, especially nitrogen. Therefore, the improvement of the soil carbon pool through different organic manures are helpful to improve soil fertility and sustained crop yields. Based on long-term field experiments, Srinivasarao *et al.* (1998) and Hemalatha and Chellamuthu (2013) found that application of FYM along with 100% NPK inorganic fertilizers increase the grain yield of finger millet as well as organic carbon level in soil. Sustainable yield indexes an approach to evaluate the sustainability of long-term cropping system, high lighting the importance of maintaining the soil carbon pool to attaining the sustainable crop yield.

Most of the Indian soils particularly the light textured are deficient in nitrogen which is one of the basic plant nutrients and plays an important role in various physiological processes. An adequate supply of nitrogen is associated with vigorous vegetative growth and dark green colour. Nitrogen compounds comprise of 40-50% of the dry matter of protoplast and nitrogen deficiency most often results in stunted growth, slow growth and chlorosis (Harper *et al.* 1994). Nitrogen uptake by plant from the soil in the forms

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of nitrate nitrogen and also the ammonium nitrogen is more likely to be the dominating source of nitrogen. In most of the agricultural systems, nitrogen is the major limiting nutrient for rapid growth development and metabolic activities in plants as well as in soil (Guohua *et al.* 2012). Nitrogen is vitally associated with activity of each living cell. It is essential constituent of compounds like amino acids, proteins, nucleic acids, porphyrin, flavin, purine, pyrimidine, nucleotides, enzymes and co-enzymes. Nitrogen is a constituent of chlorophyll. Both quantity and quality of pearl millet is improved with application of nitrogen (Upasani and Sharma 1980). Nitrogen to some extent, enhances the utilization of phosphorus and potassium and it is most commonly deficient nutrient in Indian soils and gives considerable response in pearl millet. Nitrogen fertilization increases the cation exchange capacity (CEC) of plant roots and make them more efficient to absorb the nutrients and exert favorable effects on growth and yield attributes, which results in higher grain and stover yield (Jadav *et al.* 2011).

Farmyard manure can be supplemented with NPK fertilizers. It not only provides most of the essential plant nutrients but also improves soil structure through binding effect on soil aggregates, cation exchange capacity, water holding capacity, fertilizer-use efficiency, microbial activity and nutrient availability in soils. Although, it is proved beneficial effects on soil as well as on plant growth and compensate the added cost. Vermicompost has also been advocated as good organic manure for use in integrated nutrient management practices in field crops (Shroff and Devesthali 1992).

Vermicompost are peatlike materials which increase high porosity, aeration, drainage, and waterholding capacity. They have a vast surface area, providing strong absorbability and retention of nutrients. Vermicompost contain nutrients in forms that are readily taken up by the plants such as nitrates, exchangeable phosphorus, and soluble potassium, calcium, and magnesium (Norman *et al.* 2005). Decomposition of various organic substrates (kitchen waste, agro-residues, institutional and industrial wastes including textile industry sludge and fibers) into valuable vermicompost has been extensively studied using an exotic earthworm species (epigeic-*Eisenia foetida*) (Garg *et al.* 1995). The effects of earthworm processed sheep-manure (vermicompost) on the growth, productivity and chemical characteristics of pearl millet by providing strong absorbability and retention of nutrients (Khaliq *et al.* 2006).

Biofertilizers are the preparations containing living cells or latent cells of efficient strains of microorganisms that help the crop plants in uptake of nutrients by their interaction in the rhizosphere when applied through seed or soil. There are various types of biofertilizers like *Rhizobium*, *Azotobacter*, *Azospirillum*, blue green algae and *Azolla*. Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances (Bahadur *et al.* 2014). Biofertilizers

can be expected to reduce the use of chemical fertilizers and pesticides. Biofertilizers restore the soil through natural nutrient cycle and build up soil organic matter. Biofertilizers play an important role in increasing the availability of native as well as applied nutrient and productivity in sustainable manner. *Azotobacter* is a free living nitrogen fixing bacteria. It has been reported to fix about 20 kg N/ha per year in a field of non legume crop and also secretes some growth promoting substances (Subba Rao 1982).

MATERIALS AND METHODS

The experiment was laid out according to factorial randomized block design with three replications. The experiment comprised eight treatments of sources of nitrogen (Control, 50% RDN through urea+ 50% RDN through vermicompost, 50% RDN through urea+ 50% RDN through FYM, 75% RDN through urea+ 25% RDN through vermicompost, 75% RDN through urea+ 25% RDN through FYM, 100% RDN through urea, 100% RDN through vermicompost and 100% RDN through FYM) and two treatments of biofertilizer (without inoculation and with *Azotobacter*) were applied to the pearl millet. The laboratory analysis of experimental soil evaluated that experimental soil was loamy sand in texture with high infiltration rate (22.46 cm/ hr) and saturated hydraulic conductivity 10.20 cm/hr. The soil was low in organic carbon (1.8 g/kg), low available nitrogen (128.34 kg N/ha), available phosphorus (15.23 kg P₂O₅/ha) and medium in available potassium (145.08 kg K₂O/ha). The soil was non saline with a reaction 8.2. In order to evaluate the fertility status and other physico-chemical properties, soil samples were taken from 0-15 cm depth from five random spots of the experimental field prior to layout and representative composite soil sample was prepared by quantity measure of sampling together. The homogeneous composite soil sample was subjected to physical, chemical and biological analysis.

Soil analysis

To assess the fertility status of soil, soil samples (0-15 cm depth) from each plot at harvest of crop were analyzed for physico-chemical and biological properties of soil. These were passed through 2.0 mm plastic sieve to avoid contamination. The sample were analyzed for EC, pH, SOC and total N, available NPK, dehydrogenase activity and alkaline phosphatase activity as per methods of subsequent analysis.

Dehydrogenase enzyme activity

Dehydrogenase activity was measured by the method given by Casida *et al.* (1964). In the method, the soil samples were incubated with 2, 3, 5- triphenyl tetrazolium chloride at 35⁰ C and the production of triphenyl formazan (TPF) was measured on a spectrophotometer at 485nm.

Alkaline phosphatase enzyme activity

The assay of alkaline phosphatase was carried out according to the method of Tabatabai and Bremner (1969)

Table 1 Effect of sources of nitrogen and biofertilizer on organic carbon and total nitrogen in soil at flowering and harvest

Treatment	Organic carbon (g kg ⁻¹)		Total nitrogen (kg ha ⁻¹)	
	Flowering stage	At harvest	Flowering stage	At harvest
<i>Source of nitrogen</i>				
S ₀ (Control)	2.641	2.00	373.80	298.38
S ₁ (50% RDN through urea + 50% RDN through vermicompost)	3.240	2.79	527.71	437.63
S ₂ (50% RDN through urea + 50% RDN through FYM)	3.190	2.71	505.73	417.74
S ₃ (75% RDN through urea + 25% RDN through vermicompost)	3.102	2.63	461.75	377.95
S ₄ (75% RDN through urea + 25% RDN through FYM)	2.866	2.49	417.77	358.06
S ₅ (100% RDN through urea)	2.729	2.28	395.78	318.28
S ₆ (100% RDN through vermicompost)	3.338	2.80	549.70	457.52
S ₇ (100% RDN through FYM)	3.534	2.97	593.68	497.31
SEm±	0.064	0.05	9.91	8.12
CD (P=0.05)	0.185	0.15	28.63	23.44
<i>Biofertilizer</i>				
A ₀ (Control)	2.960	2.37	423.36	336.00
A ₁ (<i>Azotobacter</i>)	3.200	2.80	533.12	454.72
SEm±	0.032	0.03	4.96	4.06
CD (P=0.05)	0.092	0.08	14.31	11.72

with borax-NaOH buffer (pH 9.4) using *p*-nitrophenyl phosphate disodium salt as substrate at 35°C.

RESULTS AND DISCUSSION

Soil organic carbon

Data pertaining to soil organic carbon (SOC) content in soil (Fig 1) as influenced by different sources of nitrogen and their effect are presented in Table 1. Significant highest SOC at flowering stage (3.53 g/kg) and at harvest (2.97 g/kg) was recorded in 100% RDN through FYM treatment among all the treatments. Treatment 100% RDN through vermicompost and 50% RDN through urea+ 50% RDN through vermicompost were statistically at par with each other.

A further study of results (Table 1 and Fig 1) revealed

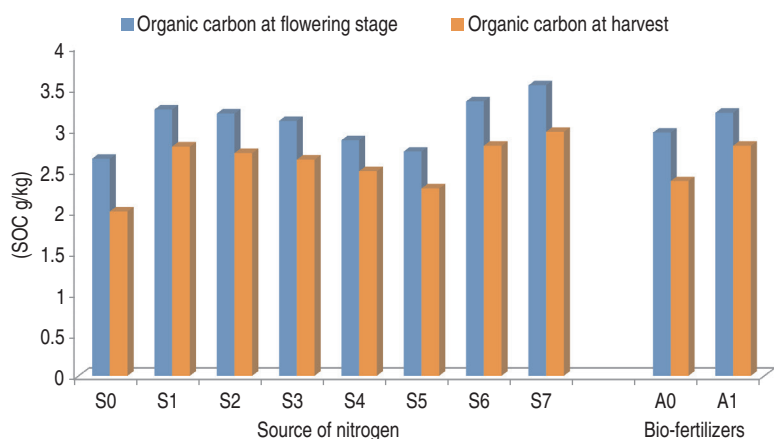


Fig 1 Effect of sources of nitrogen and biofertilizer on organic carbon in soil at flowering and harvest.

that seed inoculation with *Azotobacter* significantly increased the organic carbon content and proved its superiority over no inoculation, which showed an increase of 8.1% and 18.1% at flowering and harvesting stages, respectively. During the flowering stage organic matter is higher due to the higher rate of photosynthesis and nodulation. Similar results have been reported by Parham *et al.* (2002).

Total nitrogen

Data depicted to total nitrogen content in soil (kg/ha) as influenced by different sources of nitrogen and manure were presented in Table 1. Treatment 100% RDN through FYM was recorded significantly highest total nitrogen in soil at flowering (593.7 kg/ha) and harvest (497.3 kg/ha). Application of treatment 100% RDN through vermicompost and 50% RDN through urea+ 50% RDN through vermicompost was statistically at par with each other.

Data (Table 1) further indicated that seed inoculation with *Azotobacter* in pearl millet seed recorded significantly higher total nitrogen in soil at flowering and after harvest of the crop and the magnitude of increase was 25.9% and 35.3% per cent over control, respectively. These microorganisms play a major regulatory role for organic carbon dynamics and increase in organic carbon ultimately increase total nitrogen.

Available nitrogen

Data presented in Table 2 and Fig 2 clearly indicated significant effect of different sources of nitrogen on the available nitrogen content of soil at flowering and after harvest

Table 2 Effect of sources of nitrogen and biofertilizer on available nitrogen, phosphorus and potassium in soil at flowering and harvest

Treatment	Available N (kg ha ⁻¹)		Available P ₂ O ₅ (kg ha ⁻¹)		Available K ₂ O (kg ha ⁻¹)	
	Flowering stage	At harvest	Flowering stage	At harvest	Flowering stage	At harvest
<i>Source of nitrogen</i>						
S ₀ (Control)	129.86	129.12	15.10	14.82	145.03	144.80
S ₁ (50% RDN through urea + 50% RDN through vermicompost)	143.82	142.91	20.30	19.13	151.84	151.47
S ₂ (50% RDN through urea + 50% RDN through FYM)	142.92	142.71	20.10	19.53	150.94	150.38
S ₃ (75% RDN through urea + 25% RDN through vermicompost)	139.93	139.12	19.10	18.73	149.32	147.68
S ₄ (75% RDN through urea + 25% RDN through FYM)	137.54	136.12	18.20	17.52	148.50	146.37
S ₅ (100% RDN through urea)	134.05	133.72	17.10	16.92	146.35	145.71
S ₆ (100% RDN through vermicompost)	146.71	144.81	21.20	20.63	157.13	155.88
S ₇ (100% RDN through FYM)	152.70	151.81	22.00	21.53	163.72	161.89
SEm±	1.98	1.95	0.26	0.25	2.12	2.11
CD (P=0.05)	5.71	5.64	0.76	0.73	6.13	6.09
<i>Biofertilizer</i>						
A ₀ (Control)	134.99	129.54	17.99	17.15	141.90	140.72
A ₁ (<i>Azotobacter</i>)	146.89	150.54	20.29	20.05	161.30	160.32
SEm±	0.99	0.98	0.13	0.13	1.06	1.06
CD (P=0.05)	2.86	2.82	0.38	0.37	3.06	3.05

of the pearl millet crop. An increase of 17.6% and 13.0% at flowering and after harvest of crop stages in available N content was recorded under 100% RDN through FYM treatment over control. While, treatment 100% RDN through vermicompost and 50% RDN through urea +50% RDN through vermicompost remained at par with each other.

It is further evident from data presented in Table 2 and Fig 2 revealed that seed inoculation with *Azotobacter* gave

significantly higher available nitrogen at flowering (146.89 kg N/ha) and after harvest of the crop (150.54 kg N/ha) with an increment of 8.8% and 16.2% over uninoculated, respectively. Nitrogen fertilizer in combination with FYM/green manure/vermicompost crop residue play an important role in improving the soil structure by reducing bulk density and increasing infiltration rate and the mean weight diameter of the aggregates was recorded with 100%

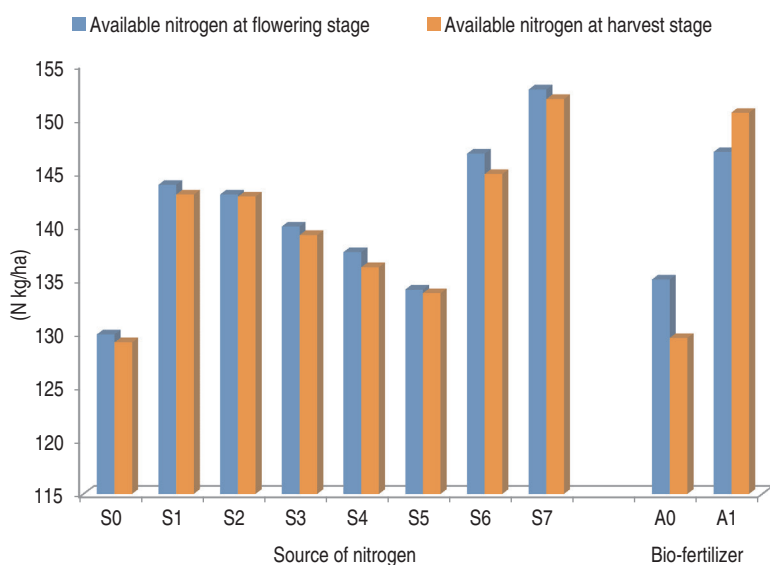


Fig 2 Effect of sources of nitrogen and biofertilizer on available nitrogen in soil at flowering and harvest.

RDN through FYM and organic carbon content registered an increase varying from 25.4% to 30.1% over control due to application of FYM. The findings of the present investigation are in agreement with those by Singh *et al.* (2007) in pearl millet, Kanzara *et al.* (2010) in castor and Dass *et al.* (2013). The data reported in Table 2 shows that effect of different integrated nitrogen management on soil organic carbon, total nitrogen, available phosphorus and available potassium was found to be significant. Treatment 100% RDN through FYM recorded significantly higher values of these parameters over the other treatments, which might be due to integrated nutrient supply system play an important role in maintaining the good soil condition. Incorporation of organic material in soil proliferates microorganism population and their activity. These microorganisms play a major regulatory role for organic carbon dynamics and increase in organic carbon

Table 3 Effect of sources of nitrogen and biofertilizer on dehydrogenase ($\mu\text{g TPF}^{-1} \text{g}^{-1} \text{soil h}^{-1}$) and alkaline phosphates ($\mu\text{g PNP produced g}^{-1} \text{soil h}^{-1}$) enzymatic activities in soil at flowering and harvest

Treatment	Dehydrogenase		Alkaline phosphates	
	Flowering stage	At harvest	Flowering stage	At harvest
<i>Source of nitrogen</i>				
S ₀ (Control)	8.90	7.80	7.70	7.10
S ₁ (50% RDN through urea + 50% RDN through vermicompost)	13.00	12.70	11.11	10.60
S ₂ (50% RDN through urea + 50% RDN through FYM)	9.82	11.50	9.80	9.10
S ₃ (75% RDN through urea + 25% RDN through vermicompost)	14.32	13.80	12.50	11.50
S ₄ (75% RDN through urea + 25% RDN through FYM)	12.11	12.60	10.80	10.30
S ₅ (100% RDN through urea)	11.50	11.10	8.30	7.80
S ₆ (100% RDN through vermicompost)	11.80	10.90	8.80	8.20
S ₇ (100% RDN through FYM)	9.80	9.50	8.00	7.80
SEm $\pm$	0.36	0.35	0.31	0.29
CD (P=0.05)	1.03	1.03	0.89	0.84
<i>Biofertilizer</i>				
A ₀ (Control)	10.51	10.29	8.88	8.25
A ₁ (<i>Azotobacter</i>)	12.31	12.19	10.38	9.85
SEm $\pm$	0.18	0.18	0.15	0.14
CD (P=0.05)	0.51	0.51	0.44	0.42

ultimately increase total nitrogen. In case of available phosphorus and potassium maximum values, might be due to combined use of organic and inorganic nutrient sources reduce the fixation of these nutrients and increase the efficiency of nutrients. The results are in close conformity with those of Anil Kumar *et al.* (2009) and Kanzaria *et al.* (2010).

Dehydrogenase activity

The data of Table 3 and Fig 3 indicated that the significantly highest value (14.32 and 13.80 $\mu\text{g TPF g}^{-1} \text{soil h}^{-1}$) of dehydrogenase activity was noted when 75% RDN through urea+ 25% RDN through vermicompost were applied at flowering and harvest. While, the lowest content of dehydrogenase activity was found in control (8.90 and 7.80 $\mu\text{g g}^{-1} \text{soil h}^{-1}$) at flowering and harvest stages, respectively. It was showed that treatments 50% RDN through urea + 50% RDN through vermicompost (13.00 and 12.70 $\mu\text{g TPF g}^{-1} \text{soil h}^{-1}$), and 75% RDN through urea +25% RDN through FYM (12.11 and 12.60 $\mu\text{g TPF g}^{-1} \text{soil h}^{-1}$) were at par with each other.

It was further observed that seed inoculation with *Azotobacter* in pearl millet significantly increased the dehydrogenase activity in soil at flowering and harvest stage and the magnitude of increase was 17.1% and 18.5% over no inoculation, respectively (Table 3). The measurement of dehydrogenase activity (DHA) in soil is utilized to obtain correlative information on the biological activity of microbial populations in soil rather than on the enzyme itself. As per the data illustrated in table 3 the DHA activity was found maximum at flowering stage and minimum after harvesting. Saviozzi *et al.* (1999) found that cattle manure

enriches some microbial communities that favour's higher soil productivity through maintenance of soil pH. Also, found that cattle manure increased microbial activity and stimulated the activity of several enzymes involved in N and P transformation. The activity of enzyme is generally when correlated with the size and activity of the microbial community and organic carbon content in the soil. At flowering stage organic matter is higher due to the higher rate of photosynthesis and nodulation. Similar results have been reported by Parham *et al.* (2002).

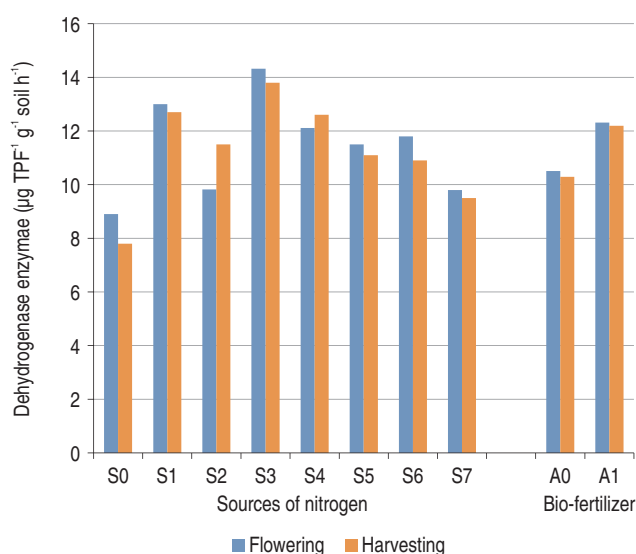


Fig 3 Effect of sources of nitrogen and biofertilizer on dehydrogenase enzymatic activities in soil at flowering and harvest.

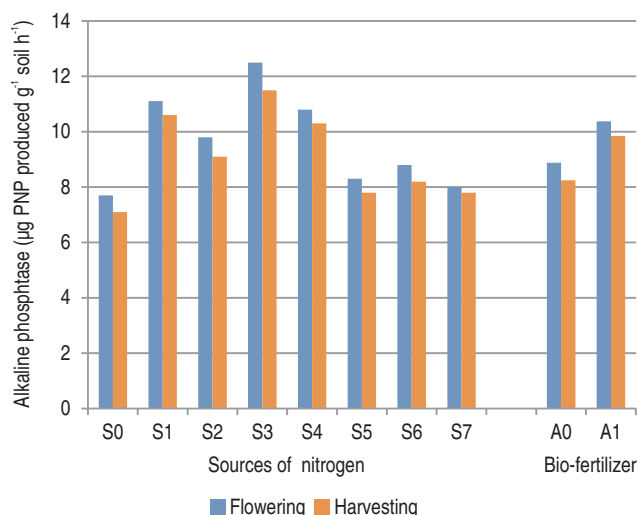


Fig 4 Effect of sources of nitrogen and biofertilizer on alkaline phosphates activity in soil at flowering and harvest.

Alkaline phosphatase activity

The data of Table 3 and Fig 4 indicate significantly highest value (12.50 and 11.50 $\mu\text{g PNP produced g}^{-1} \text{ soil h}^{-1}$) of alkaline phosphatase activity in soil in 75% RDN through urea+ 25% RDN through vermicompost treatment at flowering and after harvest, respectively, while, the lowest content of alkaline phosphatase activity was found in control (7.70 and 7.10 $\mu\text{g PNP produced g}^{-1} \text{ soil h}^{-1}$) at both the flowering and harvest stages, respectively. Treatments 50% RDN through urea + 50% RDN through vermicompost (11.11 and 10.60 $\mu\text{g PNP g}^{-1} \text{ soil h}^{-1}$), and 75% RDN through urea +25% RDN through FYM (10.80 and 10.30 $\mu\text{g PNP g}^{-1} \text{ soil h}^{-1}$) were found at par with each other. A further study of results (Table 3 and Fig 4) revealed that seed inoculation with *Azotobacter* significantly increased the alkaline phosphatase activity in soil and proved its superiority over no inoculation and showed an increment by 16.9% and 13.4% at flowering and harvesting stages, respectively. The phosphatases activity of soil at flowering stage was found highest with 75% RDN through urea+ 25% RDN through vermicompost. Phosphatases are extracellular enzymes that catalyze the hydrolysis of organic phosphates to inorganic orthophosphates thus, are an important link between biologically unavailable and available phosphorus, especially in aquatic soil systems. Thus, phosphatases activity at flowering increased as compared to after harvest of crop (Kumar *et al.* 2007). The activity of acid phosphatase in soil increased significantly after three years. In general, the enzyme activity was more when pearl millet was planted in rotation with legumes and crops grown under tilled condition (Kumar *et al.* 2007). Similar findings were found by Vandana *et al.* (2012) and Meena *et al.* (2014).

Conclusion

The Application of 100% RDN through FYM were significantly recorded higher organic carbon at flowering and after harvest in soil over control. Available nitrogen, phosphorus and potassium in soil increased due to

application of 100% RDN through FYM with the magnitude of 17.5%, 45.6% and 12.9% per cent over control at flowering stage. Maximum activity of Dehydrogenase and alkaline phosphates in soil at flowering and after harvest of the crop were recorded 60.8%, 76.1%, 62.3% and 61.9% with application of treatment 75% RDN through urea+25% RDN through vermicompost (S_3) over control. The treatment 50% RDN through urea+50% RDN through vermicompost (S_1) also remained statistically at par with the treatment 75% RDN through urea+25% RDN through FYM (S_4).

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REFERENCES

- Anonymous. 2016-17. Economic Survey. Government of India, Ministry of Finance and Company Affairs, Economic Division, New Delhi
- Bahadur I, Meena V S and Kumar S. 2014. Importance and application of potassic biofertilizer in Indian agriculture. *International Research Journal of Biological Science* 12: 80-85.
- Casdia L, Klein D and Santoro T. 1964. Soil dehydrogenase activity. *Soil Science* 98: 371-176.
- Dass A, Sudhishri S and Lenka N K. 2013. Integrated nutrient management to improve finger millet productivity and soil conditions in hilly region of eastern India. *Journal of Crop Improvement*: 528-546.
- Guohua X, Xiaorong F and Anthony J M. 2012. Plant nitrogen assimilation and use efficiency. *Annual Review of Plant Biology* 63:153-182.
- Harper J E. 1994. Nitrogen metabolism. (In) *Physiology and Determination of Crop Yield*, pp 285-302. ASA,CSSA, and SSSA, Madison, WI.
- Fageria N K and Baligar V C. 2005. Enhancing nitrogen use efficiency in crop plants. *Adv. Agron.* 88, 97-185.
- Jackson M L. 1973. *Soil Chemical Analysis*, pp. 239-241. Prentice Hall, Pvt. Ltd. New Delhi,
- Jadav R P, Khafi H R and Raj A D. 2011. Effect of nitrogen and vermicompost on protein content and nutrients uptake in pearl millet [*Pennisetum glaucum*(L.) R. Br.]. *Agricultural Science Digest*. 31: 319- 321.
- Johnson C M and Ulrich A. 1959. Analytical methods of use in plant analysis. *Cali. Exp. Station Bull.* 766: 26-78.
- Kanazara K K, Sutaria S G, Akbari N K, Vara D A and Padmani R D. 2010. Effect of integrated nutrient management on productivity of pearl millet and soil fertility of sandy loam soils under rainfed conditions. *An Asian Journal of Soil Science*: 154-156.
- Khaliq I N, Zahid M A, Chowdhry and Kashif M. 2006. Combining ability studies in yield related attributes in spring wheat. International Symposium on Sustainable Crop Improvement and Integrated Management. September 14-16, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan.
- Kumar P, Kathju S, Panwar J, Saini V K and Tarafdar J C. 2007. Dehydrogenase and phosphatase activities in soils under arid ecosystems as influenced by tillage, soil depth and crop rotation. *Journal of the Indian Society of Soil Science* 55: 488-492.
- Norman Q A, Clive A E, Peter B, James D M and Lucht M C. 2005. Effects of vermicompost's produced from cattle

- manure, food waste and paper waste on the growth and yield of peppers in the field. *Pedobiologia*. **49**: 297 – 306.
- Parham J A, Deng S P, Raun W R and Johanson G V. 2002. Long term cattle manure application in soil, Effect on soil Phosphorus levels, microbial biomass C, and dehydrogenase and phosphatase activity. *Biology Fertilizer Soil* **35**: 328-337.
- Ramdev T, Yadav L R, Choudhary S L and Shisuvinahalli G V. 2017. Effect of integrated use of fertilizer and manures on growth, yield and quality of pearl millet. *International Journal of Current Microbiology and Applied Sciences* **6**: 2510-2516.
- Saviozzi A, Biasci A, Riffaldi R, Levi-Minzi R. 1999. Long-term effects of farmyard manure and sewage sludge on some soil biochemical characteristics, *Biol. Fert. Soils* **30**: 100–106.
- Shroff V N and Devasthali S. 1992. Earthworm farming-scope and limitations. (In) *Proceedings of National Seminar on Natural Farming*. Somani L L, Totawat K L and Baser B L (Eds.) pp 126-142.
- Singh A K, Tripathi P N and Singh R. 2007. Effect of *Rhizobium* inoculation, nitrogen and phosphorus levels on growth, yield and quality of *kharif* cowpea. *Crop Research* **33**: 71-73.
- Tabatabai MA and Bremner JM. 1989. Use of nitrophenylphosphatase of soil phosphatase activity. *Soil Biology and Biochemistry*, **1**: 301-307.
- Vandana L J, Rao P C and Padmaja G. 2012. Effect of crop cover on soil enzyme activity. *Journal of Research, ANGRAU* **40**: 1-5.