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 pearlmillet [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 pearlmillet 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, P2O5, K2O, dehydrogenase activity and alkaline phosphates 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 light 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
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 water holding 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 fetida) (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 35°C and the production of triphenyl formazan (TPF) was measured on a spectrophotometer at 485 nm.

Alkaline phosphatase enzyme activity

The assay of alkaline phosphatase was carried out according to the method of Tabatabai and Bremner (1969)
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 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 (593.7 kg/ha) and harvest (497.3 kg/ha). Application of treatment 100% RDN through FYM, vermicompost and 50% RDN through urea+ 50% RDN through vermicompost was statistically at par with each other.

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.
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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% 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 pearlmillet, 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 improving 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 2 Effect of sources of nitrogen and biofertilizer on available nitrogen, phosphorus and potassium in soil at flowering and harvest

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Available N (kg ha⁻¹) Flowering stage</th>
<th>At harvest</th>
<th>Available P₂O₅ (kg ha⁻¹) Flowering stage</th>
<th>At harvest</th>
<th>Available K₂O (kg ha⁻¹) Flowering stage</th>
<th>At harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₀ (Control)</td>
<td>129.86</td>
<td>129.12</td>
<td>15.10</td>
<td>14.82</td>
<td>145.03</td>
<td>144.80</td>
</tr>
<tr>
<td>S₁ (50% RDN through urea + 50% RDN through vermicompost)</td>
<td>143.82</td>
<td>142.91</td>
<td>20.30</td>
<td>19.13</td>
<td>151.84</td>
<td>151.47</td>
</tr>
<tr>
<td>S₂ (50% RDN through urea + 50% RDN through FYM)</td>
<td>142.92</td>
<td>142.71</td>
<td>20.10</td>
<td>19.53</td>
<td>150.94</td>
<td>150.38</td>
</tr>
<tr>
<td>S₃ (75% RDN through urea + 25% RDN through vermicompost)</td>
<td>139.93</td>
<td>139.12</td>
<td>19.10</td>
<td>18.73</td>
<td>149.32</td>
<td>147.68</td>
</tr>
<tr>
<td>S₄ (75% RDN through urea + 25% RDN through FYM)</td>
<td>137.54</td>
<td>136.12</td>
<td>18.20</td>
<td>17.52</td>
<td>148.50</td>
<td>146.37</td>
</tr>
<tr>
<td>S₅ (100% RDN through urea)</td>
<td>134.05</td>
<td>133.72</td>
<td>17.10</td>
<td>16.92</td>
<td>146.35</td>
<td>145.71</td>
</tr>
<tr>
<td>S₆ (100% RDN through vermicompost)</td>
<td>146.71</td>
<td>144.81</td>
<td>21.20</td>
<td>20.63</td>
<td>157.13</td>
<td>155.88</td>
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<tr>
<td>S₇ (100% RDN through FYM)</td>
<td>152.70</td>
<td>151.81</td>
<td>22.00</td>
<td>21.53</td>
<td>163.72</td>
<td>161.89</td>
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<tr>
<td><strong>SEm</strong></td>
<td>1.98</td>
<td>1.95</td>
<td>0.26</td>
<td>0.25</td>
<td>2.12</td>
<td>2.11</td>
</tr>
<tr>
<td><strong>CD (P=0.05)</strong></td>
<td>5.17</td>
<td>5.64</td>
<td>0.76</td>
<td>0.73</td>
<td>6.13</td>
<td>6.09</td>
</tr>
<tr>
<td>Biofertilizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A₀ (Control)</td>
<td>134.99</td>
<td>129.54</td>
<td>17.99</td>
<td>17.15</td>
<td>141.90</td>
<td>140.72</td>
</tr>
<tr>
<td>A₁ (Azotobacter)</td>
<td>146.89</td>
<td>150.54</td>
<td>20.29</td>
<td>20.05</td>
<td>161.30</td>
<td>160.32</td>
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<tr>
<td><strong>SEm</strong></td>
<td>0.99</td>
<td>0.98</td>
<td>0.13</td>
<td>0.13</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td><strong>CD (P=0.05)</strong></td>
<td>2.86</td>
<td>2.82</td>
<td>0.38</td>
<td>0.37</td>
<td>3.06</td>
<td>3.05</td>
</tr>
</tbody>
</table>

![Fig 2 Effect of sources of nitrogen and biofertilizer on available nitrogen in soil at flowering and harvest.](image-url)
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 µg TPF g⁻¹ 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 µg g⁻¹ 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 µg TPF g⁻¹ soil h⁻¹), and 75% RDN through urea +25% RDN through FYM (12.11 and 12.60 µg TPF g⁻¹ 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.](image-url)
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The data of Table 3 and Fig 4 indicate significantly highest value (12.50 and 11.50 µg PNP produced g⁻¹ 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 µg PNP produced g⁻¹ 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 µg PNP g⁻¹ soilh⁻¹), and 75% RDN through urea +25% RDN through FYM (10.80 and 10.30 µg PNP g⁻¹ 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, 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 (S₃) over control. The treatment 50% RDN through urea+50% RDN through vermicompost (S₄) also remained statistically at par with the treatment 75% RDN through urea+25% RDN through FYM (S₅).

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