Original Research Article

Soil Microbial Population As Influenced By Direct and Residual Effect of Organic and Inorganic Sources of Nutrients in Cowpea- Little Millet Cropping Sequence

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ABSTRACT

Field experiments were conducted during 2017-18 and 2018-19 in sandy loam soils of Tirupati (AP) to evaluate the direct and residual effect of organic and inorganic sources of nutrients on soil microbial population and yield of cowpea-little millet cropping sequence. Three levels of organic manures (no organic manure, FYM @ 5 tonnes ha\(^{-1}\) and poultry manure @ 2 tonnes ha\(^{-1}\)) and 3 phosphorus levels (0, 40 and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) applied to preceding cowpea and 3 graded levels of nitrogen viz., 0, 10 and 20 kg ha\(^{-1}\) applied to succeeding rabi little millet. Soil microbial population and yield of kharif, cowpea varied with manures and phosphorus levels. Poultry manure @ 2 tonnes ha\(^{-1}\) recorded higher soil microbial population and pod yield which was on par with application of FYM @ 5 tonnes ha\(^{-1}\). Among the phosphorus levels, application of 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) resulted higher soil microbial population and pod yield of cowpea. Soil microbial population and grain yield of little millet was influenced by the residual effect of organic manures and phosphorus applied to preceding cowpea, as well as direct nitrogen levels applied succeeding little millet, where 20 kg N ha\(^{-1}\) resulted higher values of microbial population and yield compared to 10 kg N ha\(^{-1}\) and control. This study concluded that the application of poultry manure @ 2 t ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) to preceding cowpea and 20 kg N ha\(^{-1}\) to succeeding little millet increased the soil microbial population and yield in main and residual cropping compared to respective control.

Keywords: Soil microbial population, Yield, Organic manures, Cowpea, Phosphorus, Residual effect, Direct effect, Little millet

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Introduction

Organic manures play a vital role in maintenance of physical, chemical and biological environment of soil and supply macro and micronutrients to crops, besides maintaining humic substances in soil (Sharma, 1992). The judicious combination of organic manures and fertilizers should be used for improving crop productivity and maintaining soil fertility (Dikshit and Khatik, 2002).

The soil is crowded with millions of living organisms which make it a living and a dynamic system. These organisms not only help in development of soils but also carry out a number of transformations and facilitating the availability of nutrient to the plants.
Cowpea [Vigna unguiculata (L.) Walp] is of immense importance, as it is a multipurpose grain legume extensively cultivated in arid and semiarid tropics. The cowpea is used as grain, green pods and fodder. Cowpea is grown as a catch crop, weed smothering crop, intercrop, mixed crop and green manure crop. It has ability to fix atmospheric nitrogen in soil in association with symbiotic bacteria under favourable conditions (Yadav, 1986).

The little millet is one among the six small millets grown in most of the regions of scanty and erratic rainfall on poor and marginal soils. Cultivation of this crop is mostly confined to hilly tract and poor tribal community of the country. The demand for little millet is increasing now-a-day due to its high nutritional profile with low glycemic index particularly by the people suffering from diabetes. It has good nutritive value as it is rich in carbohydrates (66.3%), protein (7.5 to 13.8%), fat (3.54%) crude fiber (5.73%), iron (1.38 mg 100 g⁻¹) and calcium (21.21 mg 100 g⁻¹) (Kulkarni et al., 1992).

Inclusion of legumes with the use of organic and inorganic sources of nutrients in cropping sequence results in improvement of base as well as succeeding crop to achieve food, nutritional security, increased productivity, profitability and sustainability. The present study was carried out to study the impact of different organic manures and inorganic fertilizers on yield and microbial population in post-harvest soil after main and residual crop.

Materials and Methods

The field experiments were conducted during two consecutive years (2017-18 and 2018-19) at S.V. Agricultural college farm, Tirupati of Andhra Pradesh. The soil of the experimental field was sandy loam in texture, low organic carbon (0.39 %) and available N (168.5 kg ha⁻¹) medium in P₂O₅ (18.8 kg ha⁻¹), available K₂O (161.3 kg ha⁻¹) and neutral in reaction (6.94). Initial bacteria (12.5 CFU x 10⁶ g⁻¹), fungi (7.8 CFU x 10⁴ g⁻¹) and actinomycetes (12.9 CFU x 10³ g⁻¹). The experiment was laid out in split-split design with three replications at same site during both the years. The treatments consisted of three organic manures, viz., control, (M₁) FYM @ 5 t ha⁻¹ (M₂) and poultry manure @ 2 t ha⁻¹ (M₃) as main plot treatments and three phosphorus levels, viz., 0 (P₁), 40 kg P₂O₅ ha⁻¹ (P₂) and 60 kg P₂O₅ ha⁻¹ as sub- plot treatments imposed to cowpea crop during kharif season. Three nitrogen levels 0 kg ha⁻¹ (S₁), 10 kg ha⁻¹ (S₂) and 20 kg ha⁻¹ (S₃) as sub- sub plot treatments imposed to little millet during rabi season. As per treatments, FYM and poultry manure were incorporated 15 days before sowing and phosphorus was applied at basal to cowpea during both the years. Cowpea variety “TPTC-29” was sown in rows 30 cm apart using a seed rate of 20 kg ha⁻¹. The green pods of cowpea were picked in three spells and haulms were incorporated into the soil thoroughly for full decomposition followed by sowing of little millet. As per treatment half of the nitrogen dose was applied as basal and remaining half was applied after 30 DAS. Little millet variety ‘OLM-203’ was raised in rows 20 cm apart using a seed rate of 10 kg ha⁻¹.

Results and Discussion

Soil microbial population after harvest of cowpea

Higher microbial population viz., bacteria, fungi and actinomycetes in soil was observed with application of poultry manure, which was comparable with that of farm yard manure applied soil. Lower microbial population was recorded with no manure application (Table 1). This might be due to relatively higher rate of multiplication of microbes associated with organic manures, which act as a substrate for
stimulation and rapid multiplication of microorganisms. Further, increase in microbial population could be the result of enhancement of soil organic matter in the soil as indicated by positive correlation of enzyme activities with soil organic carbon. This can be ascribed to the decomposed food material available from organic sources. The similar results were reported by Vineela et al., (2008), Nath et al., (2015). Poultry manure might have stimulated the microorganisms by serving of carbon, energy and other nutrients essential for their growth and multiplication, and thus increased the soil biotic activities in poultry manure applied soils. These results are in conformity with findings of Boomiraj (2003).

With regard to the phosphorus levels, application of 60 kg P₂O₅ ha⁻¹ recorded the higher microbial population in soil followed by 40 kg P₂O₅ ha⁻¹ addition and both were higher than no phosphorus application (Table 1). Phosphorus provided energy and constituents for new cell synthesis and favoured the multiplication of these microorganisms. This might be due to higher root activity in rhizosphere due to more availability of nutrients. These results are in conformity with findings of Babu et al., (2008). Residual effect of 60 kg P₂O₅ ha⁻¹ applied to preceding cowpea recorded the higher microbial population in soil followed by 40 kg P₂O₅ ha⁻¹ and both were superior over no phosphorus application (Table 2). This might be due to that as phosphorus is the key element which regulates the growth and activities of microorganisms and it's provide energy and constituents for new cell synthesis and favoured the multiplication of these microorganisms. This might be due to higher root activity in rhizosphere due to more availability of nutrients. These results are in conformity with findings of Babu et al., (2008). In addition to the residual effect of manures and phosphorus levels, the direct application of nitrogen also altered the microbial population in soil. With regard to nitrogen levels, application of 20 kg N ha⁻¹ (S₃) recorded the higher microbial population followed by application of 10 kg N ha⁻¹ (S₂) and was higher than no nitrogen application (S₁). The microbial population in rhizosphere of crop increased with increase of nitrogen from 0 to 20 kg N ha⁻¹. Singh et al., (1998) reported similar results of increased population of microbes due to nitrogen application.

Soil microbial population after harvest of little millet

Among the organic manures, residual effect of poultry manure incorporation increased the soil microbial population followed by farm yard manure, during both the years of study (Table 2). This might be due to the addition of poultry manure or FYM in soil which leads to an increase in microbial population and activity due to more amounts of available carbon and nutrients like nitrogen and phosphorus to soil micro-organism which provide more energy. The addition of organic inputs enhanced the microbial counts in soil, which might be due to carbon addition and changes in physico-chemical properties of soil. Similar results were obtained by Meena et al., (2015). Higher population of microbes under organic manures acted as an index of soil fertility because it serves as temporary sink of nutrients flux as observed by Hassink et al., (1991).

Yield of cowpea

The green pod and haulm yield of cowpea was higher with incorporation of poultry manure, however, it was on par with those resulted due to FYM incorporation and both were significantly superior to no manure application during both the years of study (Table 3).
Table 1 Soil microbial population (CFU g\(^{-1}\) soil) at harvest of cowpea as influenced by organic manures and phosphorus levels

| Treatment                                      | Bacteria (x 10\(^6\)) | Fungi (x 10\(^4\)) | Actinomycetes (x 10\(^7\)) |
|------------------------------------------------|------------------------|---------------------|-----------------------------|
|                                                | Kharif, 2017 | Kharif, 2018 | Kharif, 2017 | Kharif, 2018 | Kharif, 2017 | Kharif, 2018 |
| Organic manures                                |            |            |            |            |            |            |
| M\(_1\): Control (No manures)                  | 32.0       | 30.4       | 21.4       | 18.7       | 48.9       | 39.9       |
| M\(_2\): FYM @ 5t ha\(^{-1}\)                 | 38.9       | 44.4       | 28.8       | 26.1       | 63.1       | 56.3       |
| M\(_3\): Poultry manure @ 2t ha\(^{-1}\)     | 39.8       | 45.4       | 30.3       | 27.2       | 64.0       | 56.9       |
| S Em ±                                         | 0.79       | 0.82       | 0.25       | 0.51       | 0.73       | 0.77       |
| CD (P=0.05)                                    | 3.1        | 3.3        | 1.0        | 2.0        | 2.9        | 3.1        |
| Phosphorus levels (kg P\(_2\)O\(_5\) ha\(^{-1}\)) |            |            |            |            |            |            |
| P\(_1\): Control                              | 30.7       | 27.9       | 21.2       | 15.2       | 46.5       | 40.4       |
| P\(_2\): 40                                   | 39.5       | 45.3       | 28.7       | 27.3       | 64.2       | 55.6       |
| P\(_3\): 60                                   | 40.5       | 47.1       | 30.5       | 29.5       | 65.4       | 57.1       |
| S Em ±                                         | 0.57       | 0.53       | 0.32       | 0.41       | 0.57       | 0.68       |
| CD (P=0.05)                                    | 1.7        | 1.6        | 1.0        | 1.2        | 1.8        | 2.1        |
| Interaction                                    |            |            |            |            |            |            |
| P at M                                         |            |            |            |            |            |            |
| S Em ±                                         | 1.37       | 1.43       | 0.43       | 0.88       | 1.26       | 1.34       |
| CD (P=0.05)                                    | NS         | NS         | NS         | NS         | NS         | NS         |
| M at P                                         |            |            |            |            |            |            |
| S Em ±                                         | 1.13       | 1.12       | 0.52       | 0.78       | 1.09       | 1.24       |
| CD (P=0.05)                                    | NS         | NS         | NS         | NS         | NS         | NS         |
| Pre experimental soil microbial population     | 12.5       | 13.7       | 7.8        | 8.3        | 12.9       | 14.2       |
**Table 2** Soil microbial population (CFU g⁻¹) at harvest of little millet as influenced by residual effect of manures and phosphorus applied to preceding cowpea and by direct application of nitrogen

| Treatment | Bacteria (x 10⁶) | Fungi (x 10⁴) | Actinomycetes (x 10³) |
|-----------|------------------|---------------|------------------------|
|           | rabi, 2017       | rabi, 2018    | rabi, 2017            | rabi, 2018 |
| Organic manures |                   |               |                        |            |
| M₁: Control (No manures) | 25.9            | 24.4          | 11.9                   | 10.7       | 34.6         | 29.3         |
| M₂: FYM @ 5t ha⁻¹ | 31.1            | 29.4          | 15.4                   | 13.0       | 39.0         | 39.5         |
| M₃: Poultry manure @ 2t ha⁻¹ | 34.4          | 33.7          | 17.7                   | 15.5       | 42.6         | 43.5         |
| SEm⁺       | 0.36             | 0.43          | 0.22                   | 0.16       | 0.63         | 0.47         |
| CD (P=0.05) | 1.4             | 1.7           | 0.8                    | 0.6        | 2.4          | 1.8          |
| Phosphorus levels (kg P₂O₅ ha⁻¹) |                   |               |                        |            |
| P₁: Control | 27.2            | 26.0          | 13.3                   | 11.7       | 35.2         | 34.4         |
| P₂: 40     | 30.9            | 29.5          | 15.0                   | 13.4       | 38.6         | 37.4         |
| P₃: 60     | 33.3            | 32.0          | 16.6                   | 14.1       | 42.4         | 40.3         |
| SEm⁺       | 0.33             | 0.23          | 0.21                   | 0.12       | 0.46         | 0.27         |
| CD (P=0.05) | 1.0             | 0.7           | 0.6                    | 0.3        | 1.4          | 0.8          |
| Nitrogen levels (kg ha⁻¹) |                   |               |                        |            |
| S₁: Control | 27.2            | 26.0          | 13.9                   | 11.9       | 32.5         | 34.8         |
| S₂: 10     | 30.9            | 29.5          | 15.0                   | 13.1       | 38.7         | 37.5         |
| S₃: 20     | 33.3            | 32.0          | 16.0                   | 14.2       | 45.1         | 39.8         |
| SEm⁺       | 0.23             | 0.24          | 0.20                   | 0.12       | 0.32         | 0.25         |
| CD (P=0.05) | 0.6             | 0.6           | 0.5                    | 0.3        | 0.9          | 0.7          |
| Interaction |                   |               |                        |            |
| Organic manures x Phosphorus levels |                     |               |                        |            |
| SEm⁺       | 0.57             | 0.40          | 0.37                   | 0.21       | 0.80         | 0.48         |
| CD (P=0.05) | NS              | NS            | NS                     | NS         | NS          | NS           |
| Organic manures x Nitrogen levels |                     |               |                        |            |
| SEm⁺       | 0.40             | 0.42          | 0.34                   | 0.21       | 0.57         | 0.44         |
| CD (P=0.05) | NS              | NS            | NS                     | NS         | NS          | NS           |
| Phosphorus levels x Nitrogen levels |                     |               |                        |            |
| SEm⁺       | 0.40             | 0.42          | 0.34                   | 0.21       | 0.57         | 0.44         |
| CD (P=0.05) | NS              | NS            | NS                     | NS         | NS          | NS           |
| Organic manures x Phosphorus levels x Nitrogen levels |                     |               |                        |            |
| SEm⁺       | 0.70             | 0.73          | 0.60                   | 0.37       | 0.98         | 0.77         |
| CD (P=0.05) | NS              | NS            | NS                     | NS         | NS          | NS           |
**Table 3** Green pod and haulm yield (kg ha\(^{-1}\)) of cowpea as influenced by organic manures and phosphorus levels

| Treatment                                      | Green pod yield  | Haulm yield     |
|------------------------------------------------|------------------|-----------------|
|                                                |      | kharif, 2017 | kharif, 2018 | kharif, 2017 | kharif, 2018 |
| **Organic manures**                            |      |              |              |              |              |
| M\(_1\): Control (No manures)                  | 1771 | 1916         | 9600         | 8414         |
| M\(_2\): FYM @ 5t ha\(^{-1}\)                  | 2607 | 2754         | 12703        | 10794        |
| M\(_3\): Poultry manure @ 2t ha\(^{-1}\)      | 2719 | 2872         | 13162        | 11137        |
| **SEm+**                                       | 50.3 | 66.3         | 118.9        | 110.0        |
| **CD (P=0.05)**                                | 203  | 267          | 479          | 443          |
| **Phosphorus levels (kg P\(_2\)O\(_5\) ha\(^{-1}\))** |      |              |              |              |              |
| P\(_1\): Control                              | 1964 | 2094         | 10061        | 8053         |
| P\(_2\): 40                                    | 2492 | 2650         | 12571        | 10954        |
| P\(_3\): 60                                    | 2641 | 2798         | 12833        | 11339        |
| **SEm+**                                       | 70.3 | 71.0         | 146.6        | 158.2        |
| **CD (P=0.05)**                                | 219  | 221          | 456          | 492          |
| **Interaction**                                |      |              |              |              |              |
| P at M                                         |      |              |              |              |              |
| **SEm+**                                       | 87.2 | 114.8        | 205.9        | 190.5        |
| **CD (P=0.05)**                                | NS   | NS           | NS           | NS           |
| M at P                                         |      |              |              |              |              |
| **SEm+**                                       | 111.4 | 120.3   | 239.0        | 249.3        |
| **CD (P=0.05)**                                | NS   | NS           | NS           | NS           |

**Table 4** Grain yield (kg ha\(^{-1}\)) of little millet as influenced by residual effect of manures and phosphorus applied to preceding cowpea and by direct application of nitrogen

|                  | **rabi, 2017** |      | **rabi, 2018** |      |
|------------------|----------------|------|----------------|------|
|                  | S\(_1\) | S\(_2\) | S\(_3\) | Mean for M | Mean for P | S\(_1\) | S\(_2\) | S\(_3\) | Mean for M | Mean for P |
| M\(_1\)          | P\(_1\) | 1036    | 1173    | 1460 | 1283 | 1002    | 1129    | 1412    | 1233 | 1317 |
|                  | P\(_2\) | 1096    | 1240    | 1536 | 1376 | 1046    | 1186    | 1476    | 1392 | 1364 |
|                  | P\(_3\) | 1116    | 1320    | 1574 |      | 1066    | 1266    | 1514    |      |      |
| M\(_2\)          | P\(_1\) | 1260    | 1444    | 1651 | 1474 | 1179    | 1363    | 1560    | 1392 | 1364 |
|                  | P\(_2\) | 1233    | 1471    | 1667 | 1426 | 1153    | 1391    | 1581    | 1392 | 1364 |
|                  | P\(_3\) | 1233    | 1558    | 1754 |      | 1153    | 1478    | 1667    |      |      |
| M\(_3\)          | P\(_1\) | 1164    | 1468    | 1729 | 1514 | 1123    | 1427    | 1659    | 1464 | 1408 |
|                  | P\(_2\) | 1269    | 1595    | 1725 | 1470 | 1219    | 1545    | 1675    | 1252 | 1567 |
|                  | P\(_3\) | 1302    | 1617    | 1757 |      | 1252    | 1567    | 1711    |      |      |
| **Mean for S**   | 1190    | 1432    | 1650    |   |   | 1133    | 1373    | 1584    |   |   |
### Table 5

Straw yield (kg ha⁻¹) of little millet as influenced by residual effect of manures and phosphorus applied to preceding cowpea and by direct application of nitrogen.

| Interaction between residual organic manures and nitrogen levels | rabi, 2017 | rabi, 2018 |
|---------------------------------------------------------------|------------|-------------|
|                   | S₁        | S₂        | S₃        | Mean of M | S₁        | S₂        | S₃        | Mean of M |
| M₁                 | 1083      | 1244      | 1523      | 1283      | M₁        | 1038      | 1194      | 1467      | 1233      |
| M₂                 | 1242      | 1491      | 1690      | 1474      | M₂        | 1161      | 1411      | 1603      | 1392      |
| M₃                 | 1245      | 1560      | 1737      | 1514      | M₃        | 1198      | 1513      | 1682      | 1464      |
| Mean of S          | 1190      | 1432      | 1650      | Mean of S | 1133      | 1373      | 1584      |

| Interaction between residual organic manures and nitrogen levels | rabi, 2017 | rabi, 2018 |
|---------------------------------------------------------------|------------|-------------|
|                   | S₁        | S₂        | S₃        | Mean of M | S₁        | S₂        | S₃        | Mean of M |
| M                  | 23.21     | 90.6      | NS        | 23.45     | 91.5      | NS        | 12.79     | 36.7      |
| P                  | 16.05     | 49.4      | NS        | 14.96     | 46.1      | NS        | 25.91     | NS        |
| S                  | 13.47     | 38.6      | NS        | 12.79     | 36.7      | NS        | 22.16     | 63.5      |
| MxP                | 27.81     | NS        | NS        | 25.91     | NS        | NS        | 22.16     | NS        |
| MxS                | 23.34     | 66.9      | NS        | 22.16     | NS        | NS        | 38.39     | NS        |
| PxS                | 23.34     | 66.9      | NS        | 22.16     | NS        | NS        | 38.39     | NS        |
| MxPxS              | 40.43     | NS        | NS        | 38.39     | NS        | NS        |

| Interaction between residual organic manures and nitrogen levels | rabi, 2017 | rabi, 2018 |
|---------------------------------------------------------------|------------|-------------|
|                   | S₁        | S₂        | S₃        | Mean of M | S₁        | S₂        | S₃        | Mean of M |
| M₁                 | 1370      | 1526      | 1806      | 1568      | M₁        | 1337      | 1492      | 1766      | 1532      |
| M₂                 | 1479      | 1729      | 1928      | 1712      | M₂        | 1432      | 1681      | 1873      | 1662      |
| M₃                 | 1544      | 1859      | 2040      | 1815      | M₃        | 1497      | 1812      | 1980      | 1763      |
| Mean for S         | 1465      | 1705      | 1925      | Mean for S| 1422      | 1662      | 1873      |

| Interaction between residual organic manures and nitrogen levels | rabi, 2017 | rabi, 2018 |
|---------------------------------------------------------------|------------|-------------|
|                   | S₁        | S₂        | S₃        | Mean of M | S₁        | S₂        | S₃        | Mean of M |
| M                  | 26.75     | 104.4     | NS        | 27.04     | 105.5     | NS        | 16.87     | 51.9      |
| P                  | 16.43     | 50.63     | NS        | 14.62     | 41.9      | NS        | 29.22     | NS        |
| S                  | 13.87     | 39.80     | NS        | 14.62     | 41.9      | NS        | 29.22     | NS        |
| MxP                | 23.93     | 68.93     | NS        | 25.32     | 72.6      | NS        | 25.32     | NS        |
| MxS                | 24.02     | NS        | NS        | 25.32     | NS        | NS        | 43.86     | NS        |
| PxS                | 24.02     | NS        | NS        | 25.32     | NS        | NS        | 43.86     | NS        |
| MxPxS              | 41.61     | NS        | NS        | 43.86     | NS        | NS        | 43.86     | NS        |
Bacterial population

Pre experimental  
After harvest of cowpea (M3P3)  
(Poultry manure @2 t ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\))

After harvest of little millet (M3P3S3)  
(Residual Poultry manure @ 2 t ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\) and direct effect of 20 kg N ha\(^{-1}\))
Fungal population

Pre experimental

After harvest of cowpea (M₃P₃) (Poultry manure @ 2 t ha⁻¹ and 60 kg P₂O₅)

After harvest of little millet (M₃P₃S₃) (Residual Poultry manure @ 2 t ha⁻¹ and 60 kg P₂O₅ and direct effect of 20 kg N ha⁻¹)
Actinomycetes population

Pre experimental

After harvest of cowpea (M₃P₃)
(Poultry manure @ 2 t ha⁻¹ and 60 kg P₂O₅)

After harvest of little millet (M₃P₃S₃)
(Residual Poultry manure @ 2 t ha⁻¹ and 60 kg P₂O₅ and direct effect of 20 kg N ha⁻¹)
Fig. 1 Soil microbial population (CFU g⁻¹) as influenced by organic manures and phosphorus levels applied to preceding cowpea and nitrogen applied to succeeding little millet during 2017-18.
Fig. 2 Soil microbial population (CFU g⁻¹) as influenced by organic manures and phosphorus levels applied to preceding cowpea and nitrogen applied to succeeding little millet during 2018-19.
This might be due to the fact that organic manures supplied balanced nutrition to the crop, improved soil condition and thereby resulting in better growth and development leading to higher yield attributes and yield. The same was obvious through the findings of Yadav et al., (2007), Rao et al., (2013) and Singh et al., (2015).

Successive increase in P levels had positive effect on pod as well as haulm yield of cowpea over their preceding level. Application of 60 kg P$_2$O$_5$ ha$^{-1}$ recorded higher pod and haulm yield which was comparable with that resulted with 40 kg P$_2$O$_5$ ha$^{-1}$ and both were superior over control (Table 3). Application of phosphorus might have resulted in increased the energy transfer as phosphorus is constituent of many enzymes and their remobilization to reproductive parts of the plants. Hence, resulted in increased flowering, fruiting and seed formation might attributed to more pod yield. These results are in conformity with the findings of Kumawat, (2006).

**Yield of little millet**

The grain and straw yield of little millet was higher due to residual effect of poultry manure followed by FYM incorporation, during both the years of study (Table 4 and 5). Similarly, residual effect of 60 kg P$_2$O$_5$ ha$^{-1}$ reflected on enhanced yield attributes and yield of succeeding little millet. However it was on par with those resulted with 40 kg P$_2$O$_5$ ha$^{-1}$.

In addition to the residual effect of manures reflected on yield of little millet, direct application of nitrogen also altered the yield attributes and yield. Higher grain and straw yield was recorded with 20 kg N ha$^{-1}$ (Table 4 and 5). This might be attributed to better availability and uptake of nitrogen which in turn lead to efficient metabolism and higher biomass accrual and efficient translocation of photosynthates from source to sink. The increase in sink capacity resulted in improved yield attributes and consequently enhanced the grain yield. The above results are in conformity with the findings of Kalaghatagi et al., 2000 and Hasan et al., 2013.

Regarding the interaction effect, the grain and straw yield of little millet was significant with combined effect of residual manures and direct nitrogen levels, where, the poultry manure residual effect along with 20 kg N ha$^{-1}$ resulted in higher grain and straw yield of little millet.

The experimental results concluded that in the areas where cowpea little millet crop sequence is followed, manures applied to preceding crop preferably poultry manure conserve the nitrogen dose to succeeding little millet crop and also poultry manure was the best source in increasing post-harvest soil microbial population in main and residual crops.

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