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Effect of different residue based composts and bio fertilizers on uptake of nutrients and protein yield of pigeonpea (*Cajanus Cajan* (L.) Millsp.)

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Abstract
A field experiment was conducted at Main Agricultural Research Station, Dharwad on medium black soil during *Kharif*-2016 to evaluate the effect of different residue based composts and biofertilizers on seed protein content, protein yield, nutrient uptake and yield of pigeonpea. There were 9 treatments consist of T_1- T_6: sesame, wheat, pigeonpea, cotton and maize residue composts and FYM along with RDF and biofertilizers, respectively and T_7: FYM without biofertilizers along with RDF, T_8-RDF with biofertilizers and T_9-RDF alone. At harvest, T_6 has recorded significantly higher uptake of nitrogen, phosphorus and potassium (143.76, 22.68 and 36.17 kg ha^{-1}, respectively) over other treatments and While, significantly lower uptake of nitrogen, phosphorus and potassium (92.27, 12.31 and 22.49 kg ha^{-1}, respectively) were recorded with RDF alone. Significantly higher seed protein content and protein yield (24.38 % and 480.00 kg ha^{-1}) was recorded in T_6 as compared to T_8 (21.71 % and 307.62 kg ha^{-1}, respectively) and T_9 (22.19% and 278.61 kg ha^{-1}, respectively) and all other treatments were found on par with T_6. Similarly significant higher seed yield (2,158 kg/ha) and haulm yield (5,176 kg/ha) was recorded in T_6 as compared to T_8 (1,387 and 4,313 kg/ha, respectively) and T_9 (1,283 and 4,183 kg/ha, respectively) and other treatments were found on par with T_6. Application of crop residue based composts (sesame, wheat, pigeonpea, cotton and maize) or FYM along with biofertilizers and RDF were found optimum to get substantial pigeonpea yield.

Keywords: Residue based composts, biofertilizers, seed protein content, protein yield and pigeonpea yield.

Introduction

Pigeonpea (*Cajanus Cajan* (L.) Millsp.) Is one of the important pulse of Indian origin, plays a vital role in daily diet. It is known by the common names *viz.*, arhar, tur, redgram, congopea, no eye pea etc. and is the second most important pulse crop of India after chickpea. Its seeds are highly nutritious and rich in protein (21.7 %), carbohydrates, fibers and minerals. Among the major countries growing pigeonpea, India ranks first with about 75 per cent of the world area and 67 per cent of production. It occupies an area of about 3.5 million ha with a total production of 4.23 million tonnes, with an average productivity of 753 kg ha^{-1} (Anon., 2016). It is grown mostly as rainfed crop in dry land areas. However, it is also grown under irrigated conditions in about 0.16 million ha. Among the states, Maharashtra leads in both area (1.09 million ha) and production (0.96 million tonnes) followed by Karnataka with an area and production of 0.6 million ha and 0.28 million tonnes, respectively (Anon, 2014). The highest productivity is observed in Bihar (1,455 kg ha^{-1}) followed by Gujarat (1,127 kg ha^{-1}) and Tamil Nadu (1,025 kg ha^{-1}). The pigeonpea yield is limited by number of factors such as agronomic, pathogenic, entomological, genetic factors and their interaction with environment. Among the different agronomic practices, inadequate and imbalanced nutrient application of nitrogen and phosphorus are considered more important for low and unstable yield in pigeonpea. Farmers are interested to cultivate crops under organic farming because of the escalating cost of inorganic fertilizers, decreased soil fertility, environmental and health concerns due to pesticide usage and higher premium prices for organic produce (Ramesh *et al.* 2005). Crop residues are good sources of plant nutrients and are important component for stability of the agricultural ecosystem. The sustained crop productivity depends upon organic as well as mineral fertilizers. Combining compost with sufficient N fertilizer to meet crop requirements is an appealing alternative that (i) Utilize composts at lower rates than fertilizer, (ii) Reduce the amount of N inorganic fertilizer applied to soil and (iii) Reduce the accumulation of non-nutrient constituents in soils (Sikora and Enkiri, 1999). Since livestock population is decreasing now a days getting FYM is difficult, to address this problem use of on farm residue compost (prepared by using compost culture helps in faster decomposition) along with biofertilizers are an alternative nutrient sources for FYM. Crop residues can be an important source of nutrients to subsequent crops. It has been estimated that India generates about 679 million tonnes of crop residues. Among different crops, cereals generate maximum residues (352 million tonnes), followed by fibers (66 million tonnes), oilseeds (29 million tonnes), pulses (13 million tonnes), sugarcane (12 million tonnes) and cotton generates (53 million tonnes). In which 201 million tonnes is actually available for recycling, that has nutrient potential of about 4.86 million tonnes of NPK. The 312.5 million tonnes of residues are generated from the 10 major crops (rice, wheat, sorghum, pearl millet, barley, finger millet, sugarcane, potato tubers and pulses), that have nutrient potential of about 6.46 million tonnes of NPK. It has been estimated that all animal excreta can potentially supply 17.77 million tonnes of NPK, where the present usage is only 33.3 per cent (Anon., 2014). Organic manures provide nutrients for the soil micro-organisms thus increase activity of microbes in soil, which in turn help to convert unavailable plant nutrients to available form for plant growth promotion. The biofertilizers are having positive contribution to soil fertility, resulting in an increase in crop yield without causing any environmental, water or soil pollution hazards. The utilization of crop residues to prepare composts using compost culture and their application in the limited availability of FYM in recent days is having pivotal role in improving sustainable yields. Compost provides a stable organic product that improves the physical, chemical and biological properties of soils thereby enhancing soil quality and crop production. Balanced and efficient fertilizer application by combining inorganic, organic and biofertilizers in pigeonpea realizing the higher yield and reducing the cost of production of pigeonpea which helps to obtain higher net returns. The present investigation was undertaken with composts prepared by improved method of composting using inoculums of efficient micro-organisms (compost culture involving *Trichoderma viridae, Phanerochaete chrysosporium*, *Pleurotus* and *Aspergillus sidowia*) using different on-farm available residues (sesame, wheat, pigeonpea, cotton and maize, respectively). The effect of these bioaugmented composts along with biofertilizers are compared with FYM with biofertilizers and recommended dose of chemical fertilizers on the productivity of pigeonpea. The salient results of the experiment on the Effect of different residue based composts and biofertilizers on uptake of nutrients and protein yield of pigeonpea (*Cajanus Cajan* (L.) Millsp.), were discussed in this article.

Materials and Methods

The experiment was conducted *kharif* season of 2016-17 at Main Agricultural Research Station, University of Agricultural Sciences Dharwad, Karnataka ($15^0$26' N latitude and $75^0$01' E longitude and at an altitude of 678 m above mean sea level). The soil type of experimental site was medium black clay soil. The initial soil was medium in organic carbon (0.52 %), low in nitrogen (250.6 kg/ha), medium in phosphorous (24.32 kg/ha) and high in potassium (398 kg/ha) with pH 7.20 and electrical conductivity (EC) 0.32 dS/m. The treatments comprised of T_1:Sesame residue compost at 6 t ha^{-1} + RDF + Biofertilizers, T_2:Wheat residue compost at 5.4 t/ha + RDF + Biofertilizers, T_3:Pigeonpea residue compost at 4 t/ha + RDF + Biofertilizers, T_4:Cotton residue compost at 7.1 t/ha + RDF + Biofertilizers, T_5:Maize residue compost at 6.4 t/ha + RDF + Biofertilizers, T_6:FYM at 6 t/ha + RDF + Biofertilizers, T_7:FYM at 6 t/ha + RDF + without Biofertilizers, T_8:RDF + Biofertilizers and T_9:RDF alone. The five crop residues (sesame, wheat, pigeonpea, cotton and maize) were composted in pits for 90 days using compost culture (Lata *et al*. 2005) (*viz., Trichoderma viridae, Phanerochaete chrysosporium, Pleurotus, Aspergillus sidowia*). These composts were analysed for NP and K contents (Table 1) and these were applied on N equivalent basis as that of FYM. The experiment was laid out in Randomized Complete Block Design in with three replications. Nitrogen was applied through DAP as starter dose (25:50) as per the treatments. Composts were applied before 15 days of sowing. Seeds were treated using *Rhizobium* and PSB @ 1,250 g/ha and mycorhyzae was applied to soil @ 20 kg/ha at the time of sowing. Two seeds per hill were dibbled 5 cm deep in furrows at a spacing of 120 cm x 20 cm and the variety used was TS-3(R). The crop was sown during second week of July. The crop was harvested at its physiological maturity, grain and straw yields of pigeonpea were recorded at harvest. Composite plant (leaves, stalk and pods) sample were collected at harvest and was analyzed for Nitrogen, phosphorus and potassium uptake by the plants and were calculated by the following formula.

Nitrogen in Plants Determined by Micro Kjeldahl's Method.

$$\text{N uptake (kg ha}^{-1}) = \frac{\text{N concentration (\%) in seed} \times \text{Seed yield (kg ha}^{-1})}{100} + \frac{\text{N concentration (\%) in stalk} \times \text{Stalk yield (kg ha}^{-1})}{100}$$

Phosphorus Was Estimated By Van ado Moly date Method in Tri-Acid Mixture as Outlined by Jackson (1967) By Using Spectro-Meter at 420 Nm.

$$\text{P uptake (kg ha}^{-1}) = \frac{\text{P concentration (\%) in seed} \times \text{Seed yield (kg ha}^{-1})}{100} + \frac{\text{P concentration (\%) in stalk} \times \text{Stalk yield (kg ha}^{-1})}{100}$$

Potassium Was Estimated By Flame Photometer As Described By Jackson (1967).

$$\text{K uptake (kg ha}^{-1}) = \frac{\text{K concentration (\%) in seed} \times \text{Seed yield (kg ha}^{-1})}{100} + \frac{\text{K concentration (\%) in stalk} \times \text{Stalk yield (kg ha}^{-1})}{100}$$

Nitrogen content in the seed of pigeonpea was estimated by Kjeldhal method (Jackson, 1967) and the protein percentage (%) in the seed was calculated by multiplying the nitrogen content with a factor 6.25.

$$\text{Protein yield (kg ha}^{-1}) = \frac{\text{Seed protein content (\%)} \times \text{Seed yield (kg ha}^{-1})}{100}$$

The data of the experiment was analyzed statistically following procedure described by Gomez and Gomez (1984). The level of significance used in 'F' test was p=0.05.

Results and Discussion

Yield and yield attributes: T_6 treatment recorded significantly higher number of pods per plant (222.11), seed weight per plant (64.00 g), 100-seed weight (12.86 g), seed yield (2,158 kg/ha) and haulm yield (5,176 kg/ha) as compared to T_8 (144.78, 47.22 g, 11.07 g, 1,387 kg/ha and 4,313 kg/ha, respectively) and T_9 (142.44, 42.44 g, 9.88 g, 1,283 kg/ha and 4,183 kg/ha, respectively) (Table 2). Where, T_1, T_2, T_3, T_4, T_5 and T_7 were found on par with T_6. The increase in grain yield was mainly due to increase in the yield parameters (Table 2). Higher yield components with combined application of organics, inorganic and biofertilizers was mainly due to the reason that chemical fertilizers along with organic manures and biofertilizers possibly increased the concentration of N, P and K ions of soil solution, ultimately influenced the formation of more number of root nodules, vigor, root growth and development, better N fixation and better development of plant growth leading to higher photosynthetic activity and translocation of photosynthates to the sink which in turn resulted in better development of yield attributes and finally higher seed yield these results are in conformity with Jat and Ahlawat (2010) and Aher *et al*. (2015). Patil and Padmini (2007), who also reported that increase in these attributes, might have been on an account of the improvement in vegetative growth of plants, due to the application of composts, FYM and biofertilizers along with RDF, Which favorably influenced the flowering, fruiting and ultimately resulted into increased number of pods plant^{-1}, seeds pod^{-1} and seed weight plant^{-1}. Whereas, these yield components were significantly lower in RDF alone and RDF with biofertilizers due to improper and imbalanced nutrient management throught the growing season. These results are in conformity with Jat and Ahlawat (2010) and Aher *et al*. (2015),

Seed protein content and protein yield: Significantly higher seed protein content (27.83 %) and protein yield (480.00 kg ha^{-1}) was recorded T_6 and was on par with T_1, T_2, T_3, T_4, T_5 and T_7 (Table 3). Significantly lower seed protein content and protein yield was recorded with T_9 (23.50 % and 278.61 kg ha^{-1}) and T_8 (25.21 % and 307.62 kg ha^{-1}). This might be due to direct effects of bacteria on root growth, greater mineral uptake and transformation of nitrogen to plants. These results are in agreement with findings of Gharib *et al*. (2008) and Singh *et al*. (2009).

Plant nutrient uptake:

Nitrogen uptake: At harvest, T_6 recorded significantly higher nitrogen uptake (143.76 kg ha^{-1}) over other treatments and was on par with T_4, T_2, T_3, T_1, T_5 and T_7 (139.79, 137.09, 136.49, 135.28, 134.60 and 138.32 kg ha^{-1}, respectively). While, significantly lower nitrogen uptake (92.27 kg ha^{-1}) was recorded with T_9 which was on par with T_8 (101.69 kg ha^{-1}) (Table 3).

Phosphorus uptake: At harvest, significantly higher phosphorus and potassium uptake was recorded in T_6 (22.68 kg ha^{-1}) over other treatments and was on par with T_4 (21.38 kg ha^{-1}). While, significantly lower phosphorus uptake (12.31 kg ha^{-1}) was recorded with T_9 (Table 3).

Potassium uptake: Potassium uptake (Table 3) was significantly higher in T_6 (36.17 kg ha^{-1}) over other treatments and was on par with T_7 and T_4 (35.21 and 34.83 kg ha^{-1}, respectively). However, T_9 (22.49 kg ha^{-1}) was recorded significantly lower potassium uptake than other treatments.

The production of photosynthates and their translocation to sink depends largely upon adequate supply of soil mineral nutrients. Most of the photosynthetic pathways are dependent on enzymes and co-enzymes, which are synthesized and catalyzed by nutrient elements such as nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, manganese, zinc and molybdenum. The contents of N, P and K in both seed and stalk were found at par with residue based composts treatments and FYM along with biofertilizers and RDF. Cotton residue composts increased the N content in seeds and were on par with FYM compared to all other treatments. The uptake of nutrients (NPK) usually followed the yield pattern (Table 2) this might be due to more biological nitrogen fixation by the microbial consortia, N-assimilation and increased availability of P in soil due to greater solubalization of insoluble phosphate compounds by PSB and mobilization of nutrients through Mycorrhiza and also release of mineral N, P and K from FYM. Significantly lower N, P and K in seed and stalk were recorded with RDF alone and RDF with biofertilizers. The increased nutrient uptake is mainly due to the increased enzyme activity in soil, this indicated the crucial role in the turnover of major plant nutrients. This might be due to soil biota which involved in the soil organic matter cycle by activating specific enzymatic pathway through which complex carbon structures are transformed into simple organic and inorganic molecules that can be taken up by the plants. These results are in agreement with the findings of Pane *et al*. (2015).

Conclusion

The explosion of Indian population demand of pulses. The high human population needs higher pulse production for satisfying the nutritive protein requirements. We are celebrated 2016 as International pulse years and we will produce more amounts of pulses in upcoming centuries. Significant enhancement in the nutrient uptake and protein yield of pigeonpea with integrated application with crop residue based composts as compared to chemical fertilizer application alone or along with biofertilizers. Grain yield and stover yield of pigeonpea were also significantly higher with these treatments. Based on the results obtained, it may be concluded that the residue based composts of sesame, wheat, pigeonpea, cotton and maize applied on N equivalent basis as that of FYM along with biofertilizers and RDF could be used as an alternative to FYM for higher productivity and profitability of pigeonpea.

Table 1: Nutrient content of composts

Sl. No.	Particulars	% nutrient content		
		N	P	K
Compost nutrient content				
1	Sesame	0.45	0.17	0.7
2	Wheat	0.5	0.19	1.0
3	Pigeonpea	0.66	0.45	1.10
4	Cotton	0.38	0.20	0.43
5	Maize	0.42	0.22	0.44
6	FYM	0.45	0.20	0.48

Table 2: Effect of different residue based composts and biofertilizers on yield and yield parameters of pigeonpea

Treatments	Number of pods per plant	Seed weight per plant (g)	100-seed weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)
T_1	184.00	59.00	11.44	1,882	4,713
T_2	187.89	59.35	11.65	1,986	4,857
T_3	185.22	58.33	11.63	1,939	4,794
T_4	208.33	60.37	12.15	2,012	4,959
T_5	182.14	58.00	11.43	1,709	4,710
T_6	222.11	64.00	12.86	2,158	5,176
T_7	197.44	60.29	11.89	1,960	4,886
T_8	144.78	47.22	11.07	1,387	4,313
T_9	142.44	42.44	10.70	1,283	4,183
S. Em. ±	13.47	2.20	0.54	155	191
C. D. at 5 %	40.39	6.60	1.62	464	573

Table 3: Effect of different residue based composts and biofertilizers on seed protein content, protein yield and uptake of nutrients in pigeonpea

Treatments	Seed protein content (%)	Protein yield ($kg ha^{-1}$)	Nitrogen uptake ($kg\ ha^{-1}$)	Phosphorus uptake ($kg\ ha^{-1}$)	Potassium uptake ($kg\ ha^{-1}$)
T_1	22.82	448.33	135.28	21.00	31.05
T_2	22.88	454.25	137.09	21.48	33.49
T_3	23.96	464.39	136.49	21.32	32.36
T_4	24.17	472.65	139.79	21.81	34.83
T_5	23.75	446.62	134.60	20.75	29.42
T_6	24.38	480.00	143.76	22.68	36.17
T_7	23.85	467.51	138.32	21.80	35.21
T_8	22.19	307.62	101.69	13.31	25.05
T_9	21.71	278.61	92.27	12.31	22.49
S. Em. ±	0.52	11.73	3.24	0.70	0.71
C. D. at 5 %	1.56	35.17	9.23	2.10	2.14

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