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# Effect of enriched FYM and rice residue compost on growth, productivity and economics of pigeonpea (*Cajanus cajan*)

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) seasons of 2020 and 2021 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi to evaluate the performance of pigeonpea [*Cajanus cajan* (L.) Millsp] as affected by enriched organic formulations. The experiment comprised of seven nutrient sources, viz. control; 100% RDN through FYM; 100% RDN through improved RRC (Rice Residue Compost); 100% RDN through PHA (Paddy Husk Ash) enriched FYM; 75% RDN through PHA enriched FYM; 100% RDN through PPC (Potato Peel Compost) enriched FYM; and 75% RDN through PPC enriched FYM that were tested in randomized block design and replicated thrice. Significantly higher number of pods per plant was observed with the application of 100% RDN through PHA enriched FYM over control during both the years of study. The same treatment resulted into statistically higher yields of seed (1.89; 1.97 t/ha) and stover (7.83; 8.03 t/ha) over control and remained at par with 100% RDN through PPC enriched FYM and FYM during both the years. Results further indicated that highest gross returns, net returns and net B:C ratio (₹121.2 × $10^3$ and 131.9 × $10^3$/ha; ₹94.9 × $10^3$ and 104.6 × $10^3$/ha; 3.60 and 3.84) were obtained with 100% RDN through PHA enriched FYM over control and remain at par with treatment 100% RDN through PPC enriched FYM and FYM. Significantly maximum amount of available N in soil after harvest of pigeonpea crop was obtained under application of 100% RDN through PPC enriched FYM (229.1 and 231.9 kg/ha) over control. Further, application of 100% RDN through RRC showed superiority in increasing the available K (264.9 and 265.0 kg/ha) content in soil over control and other nutrient sources during both the years.

**Keywords**: Farmyard manure, Paddy husk ash, Pigeonpea, Potato peel compost, Rice residue compost, Seed yield

Pigeonpea [*Cajanus cajan* (L.) Millsp] commonly referred to as arhar, redgram or tur holds significant importance as a *kharif* pulse crop widely cultivated in India. It occupies about 5.01 million ha area with production of 3.89 mt and an average yield of 776 kg/ha (FAO 2020). Since the beginning of the green revolution, India's agriculture has witnessed a significant growth in the use of chemical fertilizers in crop fields (Gupta *et al.* 2020). In the current situation, relying solely on chemical fertilizers causes runoff loses and leaching of nutrients, especially N and P, resulting in degradation of environment as well as negative effects on soil health and product quality (Gupta *et al.* 2018, Kadam *et al.* 2022). The incorporation of organic materials enriches the soil humus, thereby enhancing the physical and biological characteristics of the soil (Paul *et al.* 2016, Behera and Mohapatra 2022).

Organic materials such as crop residues, municipal biosolids, and agro-industrial wastes should be added on a regular basis to keep agricultural soils fertile and productive. Moreover, raw materials required to make FYM are easily available to farmers. Rice straw conversion to value-added compost has the potential to increase crop output while reducing pollution and loss of plant nutrients and organic matter. Composting of these residues and their application may minimize this huge wastage of organic matter. Ashes from biomass combustion are the world's oldest mineral fertilizers (Schiemenz and Eichle-Loebermann 2010). Utilizing biomass ashes in agriculture has the potential to address both the issue of disposal and diminish the need for conventional fertilizer application (Bougnom and Insam 2009). Potato peel is not merely a household waste; small-scale firms and fast-food restaurants are now dealing with rising amount of potato peel waste. Farmers can benefit greatly from potato peel manure because the NPK content of the soil was progressively increased after application.

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The integration of organic manures and composts of residues of various crops available with farmers would be able to maintain soil fertility as well as sustain crop productivity. Therefore, the current study focused on assessing the impact of enriched organic formulations on growth, productivity and economics of pigeonpea crop.

## MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) seasons of 2020 and 2021 at the research farm of ICAR-Indian Agricultural Research Institute [latitude 28.38°N; 77.09°E; altitude 228.6 msl], New Delhi. Soil of the experimental site was sandy clay loam in texture (63.8% sand, 12.2% silt and 24.0% clay) along with *p*H 8.1 and EC 0.36 dS/m. The soil was low in organic carbon (0.37%) and available N (206.2 kg/ha), medium in available P (13.6 kg/ha) and K (236.0 kg/ha). The total rainfall received during July–Nov was 618.5 and 1426.6 mm during both the years, respectively. Higher and more evenly distributed rainfall was received during 2021–22 compared to the year 2020–21. The experiment comprised of seven nutrient sources, viz. control; 100% RDN through FYM; 100% RDN through improved RRC (Rice Residue Compost); 100% RDN through PHA (Paddy Husk Ash) enriched FYM; 75% RDN through PHA enriched FYM; 100% RDN through PPC (Potato Peel Compost) enriched FYM; and 75% RDN through PPC enriched FYM that were tested in RBD and replicated thrice. Based on the N equivalent basis and nutrient requirements of each crop in each treatment, organic nutrient sources were applied prior to sowing of crops. The improved RRC, PHA enriched FYM and PPC enriched FYM were prepared in Biomass utilization unit, ICAR-IARI New Delhi. The windrow composting method was used to prepare compost from rice residue. In this technique, the rice residue was finely chopped and arranged in windrows to accelerate decomposition. The windrows were periodically turned to enhance aeration and ensure proper mixing of compost components. It typically took approximately 6 to 8 weeks to obtain fully uniform compost. Paddy husk was produced during milling of rice. About 0.20 tonne of rice husk was produced from 1 tonne of paddy and 1 tonne of rice husk generates approximately 0.25 tonne of ash after burning, depending upon variety and climatic conditions. Potato peel waste is a residual product generated by the food processing industry. By recycling paddy husk ash and potato peel in agriculture, both the issue of its disposal and the need for excessive use of commercial fertilizers can be addressed. Thus, in this study, a formulation based on paddy husk ash (PHA) and potato peel compost (PPC) was developed by mixing it with FYM in 80:20 ratio. Nutrient concentrations of organic nutrient sources were analyzed and are presented in Table 1. Each treatment had a plot size of 5.0 m × 4.5 m. The pigeonpea seeds were subjected to a *Rhizobium* treatment @2 g/kg seed. The pigeonpea variety Pusa Arhar 16 was sown at 45 cm row spacing using seed rate of 10 kg/ha at about 4–5 cm depth. Thinning was carried out at 10 days after sowing (DAS) to achieve the desired plant population, while gap filling was done at 20 DAS so as to keep the plant-to-plant distance of 20 cm in rows. One hand weeding and hoeing was done at 20 DAS to each plot to minimize the growth and intensity of weed. Pigeonpea was sown in the first forth-night of July and harvested in November during both the years of experimentation. At harvest, the height of the 5 randomly selected plants was measured from ground level to tip of the plant. For above-ground dry matter estimation, 5 plants were randomly selected for leaf area measurements at 60, 90 DAS and harvest from each plot from sample row. These plant samples were dried under sun and further oven dried at 65±2°C for 24 h and weight was recorded as gram per plant. From each plot, number of branches form 5 selected tagged plants were recorded at harvest and the average was computed and calculated as number of branches per plant. At 90 DAS, from each plot, number of leaves from 5 selected tagged plants were computed and calculated as number of leaves per plant. Leaf area of randomly selected 5 plants from each plot was measured at maturity using leaf area meter. Total pods of randomly selected 5 plants at harvest from each plot were computed and calculated as number of pods per plant. Five plants were chosen at random from the sampled plants, and these plants were then threshed. The total number of seeds obtained was counted and averaged to determine the seed weight per pod. A sample of produce from each harvested plot was obtained, and the weight of 1000-seeds was recorded. After sun-drying and winnowing, all the pods picked from each plot and the finally harvested plants were threshed and cleaned. The produce was then weighed and computed as t/ha. Likewise, stover yield was calculated by deducting seed yield from total biological yield. Harvest index (H.I.) was calculated using the formula given by Singh and Stoskopf (1971). The data were then statistically analysed using F-test which was collected from two years of experimentation, using the formula given by Gomez and Gomez (1984). The soil samples were subjected to chemical analysis to determine the concentrations of available NPK as per standard procedures. The significant difference between treatment means was determined using LSD values of P = 0.05.

## RESULTS AND DISCUSSION

*Growth parameters*: Application of enriched organic formulations in pigeonpea significantly affected the growth parameters over control during both the years (Table 2). At harvesting stage, significantly taller plants (124.6 and 124.9 cm) with maximum number of branches (17.8 and 17.9) per plant were noticed with the application of 100% RDN through PHA enriched FYM and this treatment was found statistically similar to 100% RDN through PPC enriched FYM and FYM during both the years. Significantly highest number of leaves per plant (91.0 and 95.8) at 90 DAS was also observed with 100% RDN through PHA enriched FYM over 75% RDN through PPC enriched FYM and control and remained on par with rest of the treatments. Application of 100% RDN through PHA enriched FYM

Table 1 Chemical composition of organic formulations used in experiment

| Parameter | Nutrient sources | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | FYM | | RRC | | PHA enriched FYM | | PPC enriched FYM | |
| | 2020–21 | 2021–22 | 2020–21 | 2021–22 | 2020–21 | 2021–22 | 2020–21 | 2021–22 |
| Total N (%) | 0.72 | 0.70 | 0.55 | 0.58 | 0.65 | 0.63 | 0.70 | 0.68 |
| Total P (%) | 0.25 | 0.27 | 0.22 | 0.21 | 0.25 | 0.26 | 0.26 | 0.28 |
| Total K (%) | 0.52 | 0.49 | 1.27 | 1.34 | 0.63 | 0.62 | 0.59 | 0.57 |
| Fe (mg/kg) | 708.6 | 778.8 | 501.2 | 562.6 | 1663.0 | 1730.8 | 1838.6 | 1872.7 |
| Mn (mg/kg) | 341.7 | 328.6 | 232.5 | 254.3 | 327.4 | 317.0 | 330.2 | 316.0 |
| Cu (mg/kg) | 36.2 | 40.5 | 25.6 | 30.5 | 34.4 | 38.8 | 40.7 | 41.9 |
| Zn (mg/kg) | 127.5 | 115.4 | 81.7 | 93.4 | 120.8 | 111.1 | 122.1 | 114.9 |

recorded significantly maximum leaf area (146.1 and 156.2 $cm^2$) at 90 DAS and DMA per plant at 60 DAS (16.1 and 18.0 g), 90 DAS (40.0 and 41.1 g) and harvest (51.4 and 53.1 g) during both the years and remained on par with 100% RDN through PPC enriched FYM and FYM during both the years. The improvement in growth parameters such as plant height and DMA under organic nutrient sources could be ascribed to the extended period of available moisture, nutrients and favourable soil conditions hence, improved photosynthetic activity. The positive impact of combining FYM with other nutrient sources could be attributed to the influence of organic matter in enhancing the soil's physical and biological conditions, which create a favourable environment for improved plant growth. These findings are similar to those of Patil and Padmani (2007) and Dhandayuthapani *et al.* (2015).

*Yield attributes and yield*: Data (Table 2) clearly demonstrates that all treatments resulted in a significantly greater number of pods per plant as compared to control, being highest with the application of 100% RDN through PHA enriched FYM (124.7 and 130.2) which remained on par with 100% RDN through PPC enriched FYM and FYM during both the years. However, there was no significant variation in the number of seeds per pod and the 1000-grain weight due to different organic nutrient sources. The enhanced yield attributes could be attributed to increased photosynthetic rates and accumulation of more assimilates, resulting in increasing sink size. Enhanced microbial activity within the rhizosphere due to the application of organic manure could potentially have led to a well-balanced nutrient supply, increased microbial activity, optimal moisture levels, and pathogen resistance. These factors, in turn, might have contributed to improved growth, yield characteristics, and overall crop yield (Reddy *et al.* 2011).

Further, the seed (1.89; 1.97 t/ha) and stover (7.83; 8.03 t/ha) yield was superior under 100% RDN through PHA enriched FYM over control and remained at par with 100% RDN through PPC enriched FYM and FYM during both the years. The treatment 100% RDN through PHA enriched FYM registered 41.8 and 42.0% higher seed yield over control, respectively. Harvest index of pigeonpea did not differ significantly due to different enriched organic formulations during both the years (Table 3). The beneficial response of FYM in conjunction with PHA to yield can be ascribed to continuous availability of abundant plant nutrients throughout the entire growth period, resulted in improved nutrient uptake, increased plant vigour, and ultimately higher yields. The significant increase in seed yield resulting from application of enriched organic formulations can be ascribed to their positive impact on yield attributes and the cumulative influence of these attributes, which are primarily responsible for enhanced productivity. The results corroborate with the findings of Thakur *et al.* (2011).

*Economics*: The economics of pigeonpea (Table 3) influenced significantly due to different enriched organic formulations when compared to control during both the years of experimentation. Application of 100% RDN through PHA enriched FYM resulted in higher gross and net returns, net B:C ratio (₹121.2 × $10^3$ and 131.9 × $10^3$/ha; ₹94.9 × $10^3$ and 104.6 × $10^3$/ha; 3.60 and 3.84) over control and remained at par with 100% RDN through PPC enriched FYM and FYM. This could be ascribed to higher yield obtained from FYM and the relatively lower cost associated with FYM during both the years which had increased the net returns. The higher seed (1.89 and 1.97 t/ha) and stover (7.83 and 8.03 t/ha) yield with 100% RDN through PHA enriched FYM resulted in increased net returns and net B:C ratio. Application of 100% RDN through PHA enriched FYM to pigeonpea increase the cost of cultivation by ₹4,630 and 4,762/ha, whereas gross income of pigeonpea over control increased by ₹30,320 and 35180/ha, which lead to increase in net income of pigeonpea cultivation by ₹25,690 and 30,418/ha with this treatment over control during both the years. Patil and Padmani (2007) reported that crop manured with farmyard manure @5 t/ha recorded higher net profit of ₹13367/ha along with net B:C of 6.3:1 over control.

*Soil-fertility status*: Among the different enriched organic formulations, application of 100% RDN through PPC enriched FYM resulted in higher amount of available N (229.1 and 231.9 kg/ha) in soil over control after the harvest of pigeonpea crop and remained at par with 100% RDN through PHA enriched FYM and FYM during both the years of study. The increase in available nitrogen content of soil could be attributed to favourable soil conditions i.e. water holding capacity, aeration, porosity etc. under organic

Table 2 Effect of enriched organic formulations on growth parameters and yield attributes of pigeonpea

| Treatment | Plant height (cm) | | Branches/ plant | | Leaves/ plant | | Leaf area ($cm^2$/plant) | | Dry matter accumulation (g/plant) | | | | | | Pods/ plant | | Seeds/ pod | | Test weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | At harvest | | At harvest | | 90 DAS | | 90 DAS | | 60 DAS | | 90 DAS | | At harvest | | | | | | | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| Control | 90.7 | 91.8 | 12.4 | 12.6 | 65.9 | 68.2 | 111.0 | 120.2 | 10.2 | 11.1 | 28.0 | 29.4 | 37.0 | 38.7 | 91.6 | 93.0 | 3.27 | 3.33 | 69.4 | 70.1 |
| FYM | 118.5 | 119.9 | 16.9 | 17.3 | 86.9 | 91.4 | 140.7 | 151.8 | 14.7 | 16.1 | 38.0 | 39.8 | 47.9 | 50.1 | 118.8 | 121.1 | 3.53 | 3.67 | 74.8 | 75.3 |
| Improved RRC | 108.7 | 109.6 | 15.5 | 15.8 | 80.9 | 85.8 | 132.5 | 146.9 | 13.2 | 14.6 | 34.9 | 36.2 | 44.7 | 47.0 | 110.1 | 115.1 | 3.47 | 3.53 | 73.4 | 74.2 |
| PHA enriched FYM (100% RDN) | 124.6 | 124.9 | 17.8 | 17.9 | 91.0 | 95.8 | 146.1 | 156.1 | 16.1 | 18.0 | 40.0 | 41.1 | 51.4 | 53.1 | 124.7 | 130.2 | 3.67 | 3.80 | 76.7 | 77.0 |
| PHA enriched FYM (75% RDN) | 108.0 | 109.6 | 15.3 | 15.7 | 80.5 | 85.6 | 132.0 | 146.1 | 12.8 | 14.1 | 34.7 | 36.0 | 44.1 | 46.4 | 109.2 | 111.6 | 3.47 | 3.53 | 73.1 | 74.1 |
| PPC enriched FYM (100% RDN) | 119.1 | 120.2 | 17.1 | 17.4 | 87.7 | 91.5 | 141.5 | 152.1 | 15.0 | 16.7 | 38.5 | 40.4 | 49.1 | 51.1 | 121.5 | 125.7 | 3.60 | 3.67 | 75.0 | 75.4 |
| PPC enriched FYM (75% RDN) | 106.5 | 107.9 | 14.9 | 15.0 | 77.9 | 82.3 | 129.9 | 143.1 | 12.2 | 13.2 | 33.2 | 34.8 | 43.6 | 45.7 | 107.1 | 109.2 | 3.40 | 3.40 | 72.1 | 73.0 |
| SEm ± | 5.1 | 4.9 | 0.7 | 0.7 | 3.8 | 3.6 | 6.1 | 5.9 | 0.6 | 0.6 | 1.7 | 1.5 | 2.1 | 2.0 | 4.7 | 4.5 | 0.15 | 0.11 | 3.5 | 3.6 |
| LSD (P=0.05) | 15.8 | 15.2 | 2.3 | 2.1 | 11.6 | 11.1 | 18.8 | 18.1 | 2.0 | 1.7 | 5.1 | 4.8 | 6.6 | 6.0 | 14.4 | 13.9 | NS | NS | NS | NS |

Table 3 Effect of enriched organic formulations on yield and harvest index, economics and available N, P and K status of soil after harvest of pigeonpea

| Treatment | Seed yield (t/ha) | | Stover yield (t/ha) | | Harvest index (%) | | Gross returns (× $10^3$ ₹/ha) | | Net returns (× $10^3$ ₹/ha) | | B:C ratio | | Available N (kg/ha) | | Available P (kg/ha) | | Available K (kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| Control | 1.33 | 1.39 | 5.59 | 5.78 | 19.4 | 19.4 | 85.6 | 93.1 | 63.9 | 70.6 | 2.94 | 3.14 | 205.4 | 203.3 | 12.8 | 11.2 | 235.2 | 232.0 |
| FYM | 1.74 | 1.81 | 7.30 | 7.46 | 19.3 | 19.5 | 111.7 | 121.5 | 85.8 | 94.7 | 3.32 | 3.53 | 223.2 | 223.1 | 16.3 | 16.0 | 245.4 | 247.1 |
| Improved RRC | 1.65 | 1.71 | 6.80 | 6.96 | 19.5 | 19.7 | 105.8 | 114.7 | 78.6 | 87.0 | 2.90 | 3.14 | 218.2 | 218.5 | 15.4 | 15.0 | 264.9 | 265.0 |
| PHA enriched FYM (100% RDN) | 1.89 | 1.97 | 7.83 | 8.03 | 19.5 | 19.7 | 121.2 | 131.9 | 94.9 | 104.6 | 3.60 | 3.84 | 225.1 | 226.6 | 16.9 | 16.6 | 257.6 | 258.2 |
| PHA enriched FYM (75% RDN) | 1.64 | 1.69 | 6.72 | 6.87 | 19.6 | 19.7 | 105.1 | 113.1 | 79.9 | 87.0 | 3.18 | 3.34 | 215.8 | 215.6 | 15.2 | 14.9 | 244.7 | 246.8 |
| PPC enriched FYM (100% RDN) | 1.81 | 1.87 | 7.54 | 7.68 | 19.4 | 19.6 | 116.1 | 125.3 | 90.1 | 98.3 | 3.46 | 3.65 | 229.1 | 231.9 | 16.5 | 16.1 | 250.8 | 251.3 |
| PPC enriched FYM (75% RDN) | 1.59 | 1.64 | 6.61 | 6.81 | 19.4 | 19.4 | 102.2 | 109.9 | 77.2 | 84.1 | 3.10 | 3.25 | 217.9 | 217.5 | 14.6 | 14.2 | 240.6 | 239.7 |
| SEm ± | 0.08 | 0.08 | 0.32 | 0.33 | 0.9 | 0.9 | - | - | 4.7 | 5.3 | 0.19 | 0.20 | 3.4 | 3.8 | 0.3 | 0.2 | 5.7 | 5.6 |
| LSD (P=0.05) | 0.23 | 0.25 | 0.99 | 1.03 | NS | NS | - | - | 14.4 | 16.2 | 0.57 | 0.62 | 10.4 | 11.7 | 1.1 | 0.7 | 17.7 | 17.2 |
| Initial value | - | - | - | - | - | - | - | - | - | - | - | - | 206.2 | 211.8 | 13.6 | 14.2 | 236.0 | 239.2 |

nutrient sources. These conditions may have facilitated the mineralization of nitrogen, resulting in higher accumulation of available N in soil. Application of 100% RDN through PHA enriched FYM remaining at par with 100% RDN through PPC enriched FYM; and FYM observed greater amount of available P (16.9 and 16.6 kg/ha) in soil and found significantly superior over 100% RDN through RRC, 75% RDN through PHA enriched FYM, 75% RDN through PPC enriched FYM and control. The addition of FYM increased Olsen-P through release of different organic acids in soil during organic matter decomposition (Rajkhowa *et al.* 2003). Further, application of 100% RDN through RRC remaining at par with 100% RDN through PHA enriched FYM and PPC enriched FYM showed superiority in increasing the available K (264.9 and 265.0 kg/ha) content in soil over control and other nutrient sources after harvest of pigeonpea during both the years. As FYM was found to enhance soil cation exchange capacity and reduce soil K fixation, the observed rise in available potassium in these treatments was attributed to increased release of non-exchangeable potassium from soil (Bhattacharyya *et al.* 2008).

Based on the results of present investigation, it can be concluded that application of 100% recommended dose of nitrogen through PHA enriched FYM was found to be most effective in achieving the higher growth, productivity and profitability in pigeonpea.

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