



Impact of Different Organic Sources on Nutrient Content, Availability and Economics of *Kharif* Cowpea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study is reported at the Agronomy Instructional Farm of SDAU, Sardarkrushinagar during *kharif* season of 2020-2021. The experiment consisted of nine treatments viz., T₁-Absolute control, T₂-100% RDF (20 kg N + 40 kg P₂O₅ /ha), T₃- FYM @ 5.0 t/ha, T₄-FYM @ 2.5 t/ha + *Rhizobium* + PSB, T₅-vermicompost @ 2.0 t/ha, T₆-vermicompost @ 1.0 t/ha + *Rhizobium* + PSB, T₇-castor cake @ 2.0 t/ha, T₈-castor cake @ 1.0 t/ha + *Rhizobium* + PSB, T₉-Ghan Jeevamrut @ 250 kg/ha at sowing time + Seed treatment with *Beejamrut* @ 200 ml/kg seed+ *Jeevamrut* @ 500

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lit/ha with irrigation at sowing and 30 DAS were tested in randomized block design with four replications. The result revealed that the application of T₈-castor cake @ 1.0 t/ha + *Rhizobium* + PSB showed a significant improvement. Application of castor cake @ 1.0 t/ha + *Rhizobium* + PSB (T₈) resulted a significantly higher nitrogen, phosphorus content, uptake and microbial population in seed and stover. While significantly higher available nitrogen and phosphorus status in soil after harvest of cowpea crop was obtained under the treatment of FYM @ 5.0 t/ha (T₃) which was at par with FYM @ 2.5 t/ha + *Rhizobium* + PSB (T₄). Research showed that the application of castor cake @ 1.0 t/ha + *Rhizobium* + PSB (T₈) significantly enhance nutrient content, its availability and economic returns.

Keywords: *Rhizobium*; nitrogen; microbial population; irrigation.

1. INTRODUCTION

“Pulses are the edible seeds of leguminous plants; therefore, it also known as legumes and used for food purposes. Cowpea (*Vigna unguiculata* L.) is used in different parts of the world for its high-protein seeds, but also for its nutrient-rich edible leaves, fodder and soil enrichment. In Indian agriculture, cowpea is grown as a major pulse mainly in Kerala, Madhya Pradesh, Punjab, West Bengal Andhra Pradesh Gujarat and Utter Pradesh” (Chauhan et al., 2016). “It also contains carbohydrates (56.8%), protein (24.0 %), fiber (3.9%), ash (3.20%) and fat (1.3%). Peas are the most commonly known and consumed types of pulses. The staple dishes and cuisines from across the world feature pulses, from hummus in the Mediterranean to a traditional full English breakfast (baked navy beans) to Indian dal (peas or lentils). Major nutrients play an important role in various metabolic process of the plant growth and development” (Kalegore et al., 2018). Nitrogen is the most important constituent of protein and chlorophyll. “The net availability of the food grains per capita per day increased from 144.1 kg year⁻¹ in 1951 to 179.6 kg year⁻¹ in 2019, whereas, in pulses, the net availability per capita per day decreased from 25 kg year⁻¹ in 1961 to 17.5 kg year⁻¹ in 2019” (Singh et al., 2020). The increased production through organic nutrient sources involved the use of vermicompost, neem seed kernel, farmyard manure and biofertilizers resulting in increased the quality and quantity but also reduce the soil degradation, environmental pollution and living health. Considering the stakes, an alternative to conventional farming was inevitable and led to the emergence of a new agricultural production system. “This system substituted the chemicals with farmyard manure, vermicompost, vermiwash, and green manuring, among others. These help to increase the soil biological, physical and chemical properties” (Alabandan et

al., 2009). “Soils with a high concentration of organic matter have been proven to improve the growth and yield of various plants as well as soil infiltration, soil compaction, and increase water retention capacity for seed germination and plant root development” (Thapa, 2021). “Besides organic farming, Subhash Palekar's Natural Farming is also an alternative to chemical farming wherein on-farm products are used as inputs by converting them into formulations such as Jiwamrita, Bijamrita and Ghanjiwamrita” (Chandran et al., 2024; Manzeke et al., 2017; Kumar et al., 2018). “Apart from supplying nutrients, this method helps increase the microbial population such as phosphorus-solubilizing bacteria, plant growth-promoting rhizobacteria, etc. However, frequent use of fertilizers made from soil can end up damaging its chemical, physical, and organic matter of the soil. On the other hand, organic fertilizers provide beneficial effects to the soil and increase nutrient uptake, which helps maintain the quality and yield of plants and is less expensive than inorganic fertilizers” (Moretti et al., 2002).

2. MATERIALS AND METHODS

The field experiment was conducted from July to October 2020, at the Research Farm of Sardar Krushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujrat, India. The soil of experimental site is loamy sand in texture, low in organic carbon, slightly alkaline with low available nitrogen (N), medium phosphorous (P) and high potassium (K) contents. The experiment consisted of nine treatments viz., T₁-Absolute control, T₂-100% RDF (20 kg N + 40 kg P₂O₅ /ha), T₃- FYM @ 5.0 t/ha, T₄-FYM @ 2.5 t/ha + *Rhizobium* + PSB, T₅-vermicompost @ 2.0 t/ha, T₆-vermicompost @ 1.0 t/ha + *Rhizobium* + PSB, T₇-castor cake @ 2.0 t/ha, T₈-castor cake @ 1.0 t/ha + *Rhizobium* + PSB, T₉-Ghan Jeevamrut @ 250 kg/ha at sowing time + Seed treatment with *Beejamrut* @ 200 ml/kg seed+ *Jeevamrut* @ 500

lit/ha with irrigation at sowing and 30 DAS were tested in a randomized block design with four replications. The crop cultivar GC-4 of cowpea [*Vigna unguiculata* (L.)] was grown with the recommended dose of fertilizers. In treatments, nutrients were applied as FYM, vermicompost, castor cake etc. To control weeds by hand weeded at 20 and 35 days after sowing (DAS) of cowpea. The crop was sown at a spacing of 45 × 10 cm in the first week of July and harvested in the second week of October. Soil samples were collected at harvest (October 2020) from soil 0-15 cm during two spots in each plot. Soil was composited for each replicate, air dried, and ground to pass an 8 mesh sieve prior to analysis. Organic carbon was determined by the Walkley and Black (1934). "Available nitrogen in soil samples was determined by adapting the alkaline permanganate method of Subbiah and Asija (1956). Available P₂O₅ was determined calorimetrically after the extraction of 1 g soil with 20 ml 0.5 N sodium bicarbonate (NaHCO₃) for a half hour" (Olsen et al., 1954). "Available potassium was determined using a flame photometer following soil extraction with 1N ammonium acetate (CH₃OONH₄)" (Hanway and Heidel, 1952). "The data was analysed statistically and treatment means were compared using LSD techniques at 5% probability appropriate for RBD" (Gomez and Gomez, 1984).

Meteorological observations: the mean maximum temperature ranged between 32.1 to 38.5°C, while the mean minimum temperature ranged between 15.8 to 27.4°C during the period of experimentation in *kharif* 2020. The total rainfall received between July to October 2020 was 1173.5 mm. As well as pan evaporation (mm/day) ranged between 3.1 to 7.3 mm/day during the crop period July 2020 to October 2020. The weekly mean bright sunshine duration varied between 0.0 to 10.2 hr during July to October 2020.

"Plant analysis and nutrient uptake: The plant and grain samples collected at the harvest of cowpea crop were cleaned with double distilled water and tipped with butter paper and air dried first. Then samples were dried in an oven at 62.5°C. These samples were powdered in a grinder and used for determining the concentration of major nutrients. Nutrient uptake was calculated by multiplying the nutrient concentration of crop (seeds and stover) with their respective yield. The total nutrient uptake was obtained by summation of the

nutrient uptake of seed and stover" (Olsen et al., 1954).

Microbial bacterial counts: The soil adhering or adjoining to the root surface was collected, which represented the samples. The viable microbial population of *Rhizobium spp.* and phosphate solubilizing bacteria (PSB) after harvest of crop was determined

Economics: To evaluate the most effective and remunerative treatment, the relative economics of each treatment were worked out in terms of gross, net realization and benefit: cost ratio.

Gross realization: The gross realization in terms of rupees per hectare was calculated from the income received from pod and haulm yield of each treatment with the prevailing, market price. The cost of cultivation was worked out considering the cost of all the operations right from the preparation of land to the harvesting of the crop and the cost of all the inputs involved.

Net realization: The net realization was worked out by deducting the total cost of cultivation from the gross realization per hectare for each treatment and recorded accordingly.

Benefit: Cost ratio: The benefit: cost ratio was calculated by using the formula given below.

$$\text{Benefit: Cost Ratio (BCR)} = \frac{\text{Gross realization (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

3. RESULTS AND DISCUSSION

3.1 Effect on nutrients content and their uptake

3.1.1 Nitrogen content in seed and stover (%)

Data pertaining to the nitrogen content by seed and stover is furnished in Table 1 which showed that the different treatments significantly influenced the nitrogen content by the seed and stover. Treatment T₈ (castor cake @ 1.0 t/ha + *Rhizobium* + PSB) resulted significantly higher content of nitrogen (3.57%) in seed which was at par with treatment of 100% RDF (T₂), FYM @ 5.0 t/ha (T₃), FYM @ 2.5 t/ha + *Rhizobium* + PSB (T₄), vermicompost @ 1.0 t/ha + *Rhizobium* + PSB (T₆) and *Ghan Jeevamrut* @ 250 kg/ha at sowing time + seed treatment with *Beejamrut* @

200 ml/kg seed + *Jeevamrut* @ 500 lit/ha with irrigation at sowing and 30 DAS (T₉). Treatment T₈ (castor cake @ 1.0 t/ha + *Rhizobium* + PSB) resulted a significant higher content of nitrogen (0.84 %) in stover which was at par with treatment of 100% RDF (T₂), FYM @ 5.0 t/ha (T₃), FYM @ 2.5 t/ha + *Rhizobium* + PSB (T₄), vermicompost @ 2.0 t/ha (T₅), vermicompost @ 1.0 t/ha + *Rhizobium* + PSB (T₆), castor cake @ 2.0 t/ha (T₇) and *Ghan Jeevamrut* @ 250 kg/ha at sowing time + seed treatment with *Beejamrut* @ 200 ml/kg seed + *Jeevamrut* @ 500 lit/ha with irrigation at sowing and 30 DAS (T₉). The lowest content of nitrogen in seed (2.95 %) and stover (0.66 %) was registered with treatment T₁ (Absolute control). This might be due to the application of N fixing bio fertilizers *Rhizobium* which enhanced the seed yield, nitrogenase activity and soil nitrogen status, which helped in absorbing more nitrogen. Moreover, PSB was also responsible for P availability which, helped in nitrogen fixing through increasing the activity of *Rhizobium*. The results agree with those reported by Dekhane et al. (2011), Khandelwal et al. (2012) and Khan et al. (2017).

3.1.2 Phosphorus content in seed and stover (%)

The mean data related to phosphorus content in seed and stover as influenced by different treatments are presented in Table 1. Different treatments imparted their significant influence on P content in seed and stover of cowpea. Significantly higher P content in seed and stover (0.66 and 0.25%, respectively) were found with T₈ (castor cake @ 1.0 t/ha + *Rhizobium* + PSB). However, it remained statistically at par with treatment T₂ (100% RDF) and T₄ (FYM @ 2.5 t/ha + *Rhizobium* + PSB) in case of P content in seed and T₄ (FYM @ 2.5 t/ha + *Rhizobium* + PSB) in case of stover P content. Significantly minimum P content in seed (0.51 %) and stover (0.20 %) was recorded under absolute control (T₁). This might be due to the ample availability of all three major nutrients from organic manure and bio-fertilizer which leading to more assimilation of phosphorus by the crop o fcowpea resulting an increase in the content of phosphorus. Similar conclusion was drawn by Dekhane et al. (2011) and Pargi et al. (2018).

Table 1. seed yield, stover yield, nitrogen, phosphorus content and uptake influence by organic nutrient sources

Treatments	Yield (kg ha ⁻¹)		Nutrient content (%)				Nutrient Uptake (kg ha ⁻¹)	
			Nitrogen		Phosphorus			
	Seed	Stover	Seed	Stover	Seed	Stover	Nitrogen	Phosphorus
T ₁ : Absolute control	707	1367	2.95	0.66	0.51	0.20	29.71	6.30
T ₂ : 100% RDF	1037	1825	3.32	0.81	0.60	0.22	49.09	10.12
T ₃ : FYM @ 5.0 t/ha	945	1733	3.22	0.79	0.55	0.22	44.01	8.89
T ₄ : FYM @ 2.5 t/ha + <i>Rhizobium</i> + PSB	1054	1840	3.44	0.83	0.63	0.24	51.23	10.83
T ₅ : Vermicompost @ 2.0 t/ha	901	1699	3.27	0.78	0.52	0.21	42.70	8.08
T ₆ : Vermicompost @ 1.0 t/ha + <i>Rhizobium</i> + PSB	1033	1813	3.31	0.83	0.56	0.22	49.22	9.61
T ₇ : Castor cake @ 2.0 t/ha	958	1721	3.25	0.80	0.52	0.20	44.90	8.37
T ₈ : Castor cake @ 1.0 t/ha + <i>Rhizobium</i> + PSB	1109	1986	3.57	0.84	0.66	0.25	56.03	12.16
T ₉ : <i>Ghan Jeevamrut</i> @ 250 kg/ha at sowing time + Seed treatment with <i>Beejamrut</i> @ 200 ml/kg seed + <i>Jeevamrut</i> @ 500 lit/ha with irrigation at sowing and 30 DAS	891	1596	3.38	0.77	0.53	0.21	42.34	7.94
S.Em. ±	50	88	0.09	0.03	0.02	0.01	2.04	0.36
C.D. at 5 %	146	257	0.26	0.09	0.06	0.02	5.96	1.06
C.V. %	10.41	10.18	5.48	7.50	7.37	7.90	8.98	7.95

3.1.3 Nitrogen uptake by crop (kg ha⁻¹)

Significantly higher nitrogen uptake (56.03 kg ha⁻¹) was registered with treatment T8 (castor cake @ 1.0 kg ha⁻¹ + Rhizobium + PSB). However, it remained statistically at par with treatment T4 (FYM @ 2.5 t/ha + Rhizobium + PSB). The lowest nitrogen uptake by crop (29.71 kg ha⁻¹) was noted with treatment of T1 (absolute control). The reason behind the highest uptake of N (kg ha⁻¹) under treatment T8 (castor cake @ 1.0 t/ha + Rhizobium + PSB) is directly related to the yield and N content in seed and stover. This treatment received maximum yield and N content in seed and stover which would have resulted in overall higher N uptake with this treatment. The findings are in close proximity with the findings of Dekhane et al. (2011) and Khandelwal et al. (2012).

3.1.4 Phosphorus uptake by cowpea (kg ha⁻¹)

Significantly higher phosphorus uptake (12.16 kg ha⁻¹) was registered with treatment T8 (castor cake @ 1.0 kg ha⁻¹ + Rhizobium + PSB). The lowest phosphorus uptake by crop (6.30 kg ha⁻¹) was noted with treatment T1 (absolute control). As the uptake is a product of nutrient content and seed yield, so in accordance with this, T8 (castor cake @ 1.0 kg ha⁻¹ + Rhizobium + PSB) having higher phosphorus content and seed yield contributed to higher uptake of phosphorus. Similar results were presented by Dekhane et al. (2011) and Khandelwal et al. (2012).

3.2 Effect on Available Nutrients in Soil After Harvest of Crop

3.2.1 Available nitrogen (kg ha⁻¹)

The set of data in Table 2 revealed that different treatments exercised their significant influence on available N (kg ha⁻¹) status of soil. Significantly higher available nitrogen (155.52 kg ha⁻¹) status in soil after the harvest of cowpea crop was obtained under treatment T₃ (FYM @ 5.0 kg ha⁻¹) which was at par with FYM @ 2.5 kg ha⁻¹ + Rhizobium + PSB (T₄), vermicompost @ 2.0 kg ha⁻¹ (T₅) and castor cake @ 2.0 t/ha (T₇). However, significantly lower N availability (134.71 kg/ha) was observed under treatment T₁ (absolute control). Significantly higher available N contribution by organic manure along with bio fertilizer, the increment was due to the slow release of nutrients through organic manure and enriching the available pool of nitrogen. The higher available nitrogen after the harvest of cowpea crop might be due to the direct addition

of nitrogen through organic manure and greater multiplication of soil microbes, which helps to convert organically bound nitrogen in to inorganic form Bio-fertilizers had improved the nitrogen status of soil due to synergism in *Rhizobium* and PSB might have also resulted in better nodulation with their dual inoculation as against no inoculation. The results are in close conformity with the findings of Dekhane et al. (2011), Khan et al. (2013) and Joshi et al. (2016).

3.2.2 Available phosphorus (kg ha⁻¹)

Data furnished in Table 2 indicated that different treatments exerted their significant effect on available phosphorus content in soil after the harvest of the crop. Significantly higher available phosphorus (41.10 kg ha⁻¹) was observed under the treatment T₇ (castor cake @ 2.0 kg ha⁻¹), which was at par with FYM @ 5.0 kg ha⁻¹ (T₃), FYM @ 2.5 kg ha⁻¹ + Rhizobium + PSB (T₄), vermicompost @ 2.0 kg ha⁻¹ (T₅) and castor cake @ 1.0 kg ha⁻¹ + Rhizobium + PSB (T₈), while the lower phosphorus availability (35.40 kg ha⁻¹) was observed under treatment T₁ (absolute control). The reason for the significant higher phosphorus might be due to the release of organic acid during microbial decomposition of organic manure, which might help in increasing solubility of native phosphates, thus increased available phosphorus pool in the soil. Similar results were also reported by Dekhane et al. (2011), Khan et al. (2013) and Joshi et al. (2016).

3.2.3 Available potassium (kg ha⁻¹)

The data presented in Table 2 disclosed that available potassium (kg ha⁻¹) was not significantly varied due to different treatments. However, marginally higher available potassium (kg ha⁻¹) was observed in treatment T₇ castor cake @ 2.0 t/ha (203.62 kg ha⁻¹) than rest of treatments.

3.3 Effect on Soil Microbial Population

An appraisal of results presented in Table 2 showed that significantly a greater number of *rhizobium* (21 × 10⁵ g/soil) count was recorded with T₄ (FYM @ 2.5 t/ha + Rhizobium + PSB), T₆ (vermicompost @ 1.0 t ha⁻¹ + Rhizobium + PSB) and T₈ (castor cake @ 1.0 t ha⁻¹ + Rhizobium + PSB). While a greater number of PSB (27 × 10⁴ g/soil) count was recorded with T₈ (castor cake @ 1.0 t/ha + Rhizobium + PSB). However, it remained statistically at par with treatment T₄ (FYM @ 2.5 t/ha + Rhizobium + PSB) in case of PSB. Minimum population of

Rhizobium (9×10^5 g/soil) and PSB (4×10^4 g/soil) were noted in absolute control treatment. Moreover, seed inoculation of bio-fertilizers (*Rhizobium* + PSB) facilitated robust growth of plants and soil health and thereby increased nodulation (Table 3). Increase in nodulation is directly related to increase in microbial count in soil. Similar findings have been reported by Lyngdoh et al. (2017) and Pargi et al. (2018).

3.4 Economics

The details of gross realization, net realization as well as total cost of cultivation and benefit: cost Ratio (BCR) of cowpea as influenced by various integrated nutrient management treatments are outlined in Table 3.

3.4.1 Net realization (₹/ha)

A perusal of data on net return as influenced by various integrated nutrient management treatments are presented in Table 3 revealed that higher net realization of ₹56,353/ha was recorded by fertilizing the crop with castor cake @ 1.0 t/ha + *Rhizobium* + PSB (T₈) followed by treatment of FYM @ 2.5 t/ha + *Rhizobium* + PSB (T₄) and 100% RDF (T₂). The lowest net realization (₹32,343/ha) was fetched under treatment absolute control (T₁).

3.4.2 Benefit: Cost Ratio (BCR)

The data on benefit: cost Ratio (BCR) as influenced by various integrated nutrient management treatments are furnished in Table 3

Table 2. nitrogen, phosphorus and potassium availability and microbial population influence by different treatments

Treatments	Available nutrients in soil (kg ha ⁻¹)			Microbial population	
	N	P ₂ O ₅	K ₂ O	<i>Rhizobium</i> (CFU × 10 ⁵ /g soil)	PSB (CFU × 10 ⁴ /g soil)
T ₁	134.71	35.40	194.30	9	4
T ₂	140.71	37.49	195.80	11	21
T ₃	155.52	39.01	201.28	17	11
T ₄	150.53	38.70	201.00	21	25
T ₅	147.25	39.54	199.50	15	10
T ₆	143.83	37.65	199.40	21	22
T ₇	147.87	41.10	203.62	15	18
T ₈	145.32	39.80	199.49	21	27
T ₉	137.47	36.78	196.80	15	9
S.Em. ±	3.27	1.00	4.89	0.87	0.81
C.D. at 5 %	9.55	2.92	NS	2.54	2.37
C.V. %	4.52	5.21	4.92	10.81	9.93

Table 3. Economics of *kharif* cowpea as influenced by different integrated nutrient management treatments

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
T ₁	707	1367	54,958	22,615	32,343	2.43
T ₂	1037	1825	79,890	25,370	54,520	3.15
T ₃	945	1733	73,082	28,135	44,947	2.60
T ₄	1054	1840	81,140	25,981	55,159	3.12
T ₅	901	1699	69,866	35,135	34,731	1.99
T ₆	1033	1813	79,562	29,221	50,341	2.72
T ₇	958	1721	73,944	35,135	38,809	2.10
T ₈	1109	1986	85,574	29,221	56,353	2.93
T ₉	891	1596	68,754	25,931	42,823	2.65

indicated that higher benefit: cost ratio (BCR) of 3.15 was obtained with treatment of 100% RDF (T₂) followed by treatment of FYM @ 2.5 t/ha + *Rhizobium* + PSB (T₄) (3.12). The lowest benefit: cost Ratio (BCR) of 1.99 was noted with treatment of vermicompost @ 2.0 t/ha (T₅)

4. CONCLUSION

The present study shows the application of castor cake @ 1.0 t/ha + *Rhizobium* + PSB (T₈) resulted significantly higher nitrogen, phosphorus content, uptake and microbial population in seed and stover. While significantly higher available nitrogen and phosphorus status in soil after the harvest of cowpea crop was obtained under the treatment of FYM @ 5.0 t/ha which was at par with FYM @ 2.5 t/ha + *Rhizobium* + PSB and available potassium in soil after the harvest of crop did not vary due to different treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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