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Response of Integrated Nutrient Management on Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.) under Semi Arid Tracts of Andhra Pradesh, India

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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

Cluster bean [*Cyamopsis tetragonoloba* (L.) is an important legume crop grown mostly under rainfed conditions in arid and semi-arid districts of Andhra Pradesh during the kharif and rabi seasons. It is a tough, drought-tolerant crop. Its deep penetrating roots allow the plant to more efficiently use available moisture, making it better suited for rainfed agriculture. The crop was facing more nutrient deficiencies as it needs more nutrients to buildup body. As cluster bean being a legume crop which has the capacity to fix atmospheric nitrogen by its effective root nodules the major part of nitrogen is met through *Rhizobium* present in the root nodules. Besides, due to increase in cost of inorganic fertilizers there was a need to integrate inorganic fertilizers with organic manure to protect soil health and reduce the cost of cultivation. An experiment was carried out during rabi season of 2022-23 at college Farm, Sri Krishnadevaraya College of Horticultural Sciences, Ananthapuramu. The experiment was conducted in Randomized Block Design with three replications using cv. Pusa Navbahar, with seventeen treatments. The combination of organic manures, chemical fertilizers and reduced doses of chemical fertilizers along with organic manures were tested in comparison with Recommended dose of fertilizers. The yield attributes viz., number of clusters plant^{-1}, number of pods in a cluster, length and diameter of pod differed significantly due to the different integrated nutrient management treatments. The treatment 75% of recommended dose of inorganic fertilizers and 25% RDF through vermicompost recorded significantly highest pod yield (14.93 t ha^{-1}). For optimum growth, higher pod yield and high monetary returns from the crop should be supplied with the 75% of recommended dose of fertilizers and 25% RDF through vermicompost.

Keywords: Cluster bean; integrated nutrient management; manure; fertilizer and yield.

1. INTRODUCTION

"Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] is hardy and drought tolerant vegetable crop having deep root system which enables to utilize the available moisture and nutrients more effectively which sustain under rainfed conditions" [1]. "It is locally known as "guar" annual legume crop grown as vegetable, as green manure and as a forage crop for livestock. It is one of the best vegetable legume crop suitable for semi arid climatic conditions of Andhra Pradesh. In the recent years, this crop has assumed great significance in industrial sector due to the presence of good quality of gum (28 to 33 per cent) in the endosperm of its seed. The natural polysaccharide water-soluble polymer found in the endosperm" [2], as galactomannan gum, is the chief product used in many industries [3]. "In spite of huge potential, it is being cultivated in limited area due to its low productivity levels and can be attributed mainly due to inadequate fertilization. Minimize the use of chemical fertilizers by addition of organic manures" [4,5]. "Usage of Organic manures like farm yard manure, vermicompost and poultry manure showed an increased growth in terms of height and yield of the plant, it could be a better alternative to inorganic fertilizers" [6,7]. "Organic manures act as a microbial inoculant of microorganisms like bacteria, fungi already existing in nature. It can act as soil amendments in the abandoned soil being low cost pollution free and renewable source" [1]. An integrated strategy that makes use of both organic and inorganic nutrition sources appears to be a workable substitute in these circumstances for increasing cluster bean yields while maintaining acceptable quality. In order to maintain the soil fertility and the environment in the SAT regions of Andhra Pradesh, it is now accepted practice to investigate the effects of various organic and inorganic sources of nutrients, both separately and in combination, on the growth, yield, and quality of cluster beans.

2. MATERIALS AND METHODS

The field trail was carried out in Sri Krishnadevaraya College of Horticultural Sciences, Ananthapuramu farm (Orchard A-block) during *rabi* – 2023 with Pusa navbahar variety which was released from IARI having 65-80 days duration suitable for all seasons. The experimental site was sandy clay loam having pH of 7.4 and organic carbon of 0.46 per cent. The available nitrogen, phosphorus and potassium contents were 272.29, 17.93, and 309.24 kg ha^{-1} respectively. The experiment was laid out in randomized block design comprising of 17 treatments replicated thrice. Seventeen treatments were formed by considering different

organic, inorganic nutrient sources alone and combinations by decreasing the inorganic nutrient sources i.e., Control (T_1), 100 per cent NPK through fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) (T_2), and 100 per cent NPK through FYM (T_3), 100 per cent NPK through vermicompost (T_4), 100 per cent NPK through sheep manure (T_5), 100 per cent NPK through poultry manure (T_6), 75 per cent NPK through fertilizers (T_7), 75 per cent NPK through fertilizers + 25 per cent NPK through FYM (T_8), 75 per cent NPK through fertilizers + 25 per cent NPK through vermicompost (T_9), 75 per cent NPK through fertilizers + 25 per cent NPK through sheep manure (T_{10}), 75 per cent NPK through fertilizers + 25 per cent NPK through poultry manure (T_{11}), 50 per cent NPK through fertilizers (T_{12}), 50 per cent NPK through fertilizers + 50 per cent NPK through FYM (T_{13}), 50 per cent NPK through fertilizers + 50 per cent NPK through vermicompost (T_{14}), 50 per cent NPK through fertilizers + 50 per cent NPK through sheep manure (T_{15}), 50 per cent NPK through fertilizers + 50 per cent NPK through poultry manure (T_{16}) and 100 per cent NPK through FYM, vermicompost, sheep manure and poultry manure (T_{17}).

Cyamopsis tetragonoloba var. Pusa navbahar variety was used for sowing which takes around 95-100 days to mature. Seeds were sown in line manually with the spacing of plant to plant 15 cm and row to row 45 cm with depth of 3-4 cm. Well decomposed manures were applied to respective treatment plots before fortnight of sowing date and fertilizers were applied on the day of sowing. During the crop growing period, the weekly mean maximum temperature ranged from 29.18˚C to 38.11˚C with an average of 33.66˚C and weekly mean minimum temperature ranged from 16.69˚C to 26.82˚C with an average of 21.75˚C. The weekly mean relative humidity ranged from 46.71 to 83.49 per cent with an average of 65.10 per cent. A total rainfall of 321.52 mm was received in 19 rainy days. The weekly mean bright sunshine hours ranged from 0.93 to 7.86 hours day^{-1} with an average of 4.40 hours day^{-1}. "The data was recorded by randomly five plants in each treatment. The destructive samples like LAI and DMP were collected in gross plot, then the non-destructive samples were recorded by tagging plants and also for post - harvest parameters. All the data recorded in the study were subjected to statistical analysis using ANOVA for RBD" suggested by Panse and Sukkhatme [8].

3. RESULTS

From the data presented in Tables 1 and 2 it is revealed that, the growth and yield parameters were well influenced by integrated nutrient management in cluster bean and the results were well explained below.

3.1 Growth Parameters

The integrated nutrient management exhibited marked significant difference on growth parameters (Table 1). The integration of inorganic sources with organic sources of nutrients significantly influenced the growth characters viz. plant height (100.83 cm), number of branches (15.78), leaf area index (3.21), dry matter production (13.57 g $plant^{-1}$), days to 50 per cent flowering (29.10) and days to maturity (129.01) with application of 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost (T_9). Ramana et al. [9] also indicated that application of 75 per cent RDF and vermicompost significantly increases the plant height and branches per plant. The findings agree with the previous results of Choudhary et al. [10], Rathore et al. [11] and Deshmukh et al. [12]. The application of 100 per cent NPK through inorganic fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) (T_2) performed better next to T_9 and the rest of treatments are at par each other. Ayub et al. [13] found the application of 100 per cent N of recommended dose significantly increased the growth parameters. The lowest plant height (100.83 cm), number of branches (15.78), leaf area index (3.21), dry matter production (13.57 g $plant^{-1}$), days to 50 per cent flowering (29.10) and days to maturity (129.01) these findings were similar to the results of Anuradha et al. [1].

3.2 Yield and Yield Parameters

The significant difference was observed with integrated nutrient management on yield and yield attributes (Table 2). The application of 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost (T_9) recorded highest number of clusters $plant^{-1}$ (25.86), number of pods $plant^{-1}$(8.05), pod length (13.28 cm), pod diameter (5.98 cm), number of pods $plant^{-1}$(182.31), number of seeds $plant^{-1}$ (10.20), 1000 seed weight (29.82), pod yield (14.93 t ha^{-1}) and seed yield (13.15 q ha^{-1}). The lowest yield and yield attributes was observed in control treatment recording lowest number of

Table 1. Effect of integrated nutrient management on growth parameters of cluster bean

Treatments	Plant height at 90DAS (cm)	No. of branches plant^{-1} at 90DAS	LAI at 90DAS	DMP at 90DAS	Days to 50% flowering	Days to maturity
T_1 : Control	76.83	6.13	2.02	6.92	32.66	106.71
T_2 : RDF through fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1})	97.50	15.02	2.93	11.21	30.1	126.16
T_3 : 100 per cent NPK through FYM	88.83	13.78	2.64	9.04	30.46	123.22
T_4 : 100 per cent NPK through vermicompost	94.97	14.45	2.80	10.37	30.33	124.23
T_5 : 100 per cent NPK through sheep manure	87.83	10.12	2.64	8.77	31.55	117.98
T_6 : 100 per cent NPK through poultry manure	86.83	8.45	2.53	8.51	31.62	113.79
T_7 :75 per cent NPK through fertilizers	87.17	9.78	2.60	8.67	31.56	115.65
T_8 : 75 per cent NPK through fertilizers + 25 per cent NPK through FYM	92.17	11.78	2.83	10.71	31.11	122.04
T_9 : 75 per cent NPK through fertilizers + 25 per cent NPK through vermicompost	100.83	15.78	3.21	13.57	29.10	129.01
T_{10} : 75 per cent NPK through fertilizers + 25 per cent NPK through sheep manure	90.12	13.12	2.73	9.87	30.99	123.34
T_{11}: 75 per cent NPK through fertilizers + 25 per cent NPK through poultry manure	85.17	7.78	2.42	8.27	31.67	113.67
T_{12} : 50 per cent NPK through fertilizers	81.64	6.64	2.25	7.73	32.17	109.43
T_{13} : 50 per cent NPK through fertilizers + 50 per cent NPK through FYM	88.62	11.12	2.66	9.61	31.36	119.08
T_{14} : 50 per cent NPK through fertilizers + 50 per cent NPK through vermicompost	89.83	11.45	2.70	9.64	31.21	121.23
T_{15} : 50 per cent NPK through fertilizers + 50 per cent NPK through sheep manure	85.17	7.46	2.38	8.11	31.71	113.01
T_{16}: 50 per cent NPK through fertilizers + 50 per cent NPK through poultry manure	82.31	7.23	2.33	7.82	32.01	110.87
T_{17}: 100 per cent NPK through FYM, vermicompost, sheep manure and poultry manure	84.82	7.54	2.36	7.99	31.89	112.90
SEm±	0.81	0.25	0.10	0.21	0.36	0.61
CD at 5 per cent	2.37	0.72	0.26	0.57	1.04	1.78

Table 2. Effect of integrated nutrient management on Yield attributes of cluster bean

Treatments	No. of clusters plant^{-1}	No. of pods cluster^{-1}	Pod length (cm)	Pod diameter (mm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000 seed weight (g)	Pod yield (t ha^{-1})	Seed yield (q ha^{-1})
T_1 : Control	12.93	3.49	8.05	3.02	45.13	4.02	22.12	4.11	4.78
T_2 : RDF through fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1})	22.59	6.32	12.93	5.20	142.77	8.71	29.01	11.69	11.7
T_3 : 100 per cent NPK through FYM	18.59	5.54	11.59	4.74	102.99	6.50	27.90	8.43	9.98
T_4 : 100 per cent NPK through vermicompost	20.83	6.25	12.42	5.01	124.16	7.90	28.30	10.17	10.36
T_5 : 100 per cent NPK through sheep manure	18.24	5.36	11.28	4.74	97.77	6.30	27.25	8.01	7.87
T_6 : 100 per cent NPK through poultry manure	17.75	5.34	11.05	4.61	94.79	6.20	26.73	7.76	7.08
T_7 :75 per cent NPK through fertilizers	18.06	5.35	11.10	4.70	96.62	6.30	26.96	7.91	7.54
T_8 : 75 per cent NPK through fertilizers + 25 per cent NPK through FYM	19.93	6.23	12.63	5.14	130.19	6.00	28.77	10.66	9.06
T_9 : 75 per cent NPK through fertilizers + 25 per cent NPK through vermicompost	25.86	8.05	13.28	5.98	182.31	10.20	29.82	14.93	13.15
T_{10}: 75 per cent NPK through fertilizers + 25 per cent NPK through sheep manure	19.66	6.01	12.31	5.01	118.16	6.70	28.20	9.68	9.26
T_{11}: 75 per cent NPK through fertilizers + 25 per cent NPK through poultry manure	17.62	5.16	10.90	4.44	90.92	6.02	26.50	7.45	6.99
T_{12}: 50 per cent NPK through fertilizers	15.28	4.25	9.16	3.63	64.94	5.33	24.91	4.80	6.13
T_{13}: 50 per cent NPK through fertilizers + 50 per cent NPK through FYM	18.76	5.67	11.63	4.81	106.37	6.60	28.10	8.71	8.14
T_{14} : 50 per cent NPK through fertilizers + 50 per cent NPK through vermicompost	19.18	5.75	12.13	4.94	110.29	7.63	28.20	9.03	8.97
T_{15}: 50 per cent NPK through fertilizers + 50 per cent NPK through sheep manure	17.43	4.8	10.72	4.01	83.66	6.91	26.50	6.85	6.78
T_{16}: 50 per cent NPK through fertilizers + 50 per cent NPK through poultry manure	16.65	4.55	9.83	3.65	75.76	6.70	25.44	5.32	6.65
T_{17}: 100 per cent NPK through FYM, vermicompost, sheep manure and poultry manure	16.99	4.65	9.91	3.99	45.13	5.76	26.33	6.20	6.72
SEm±	1.11	0.57	0.24	0.22	9.97	0.45	0.29	1.02	0.48
CD at 5per cent	2.63	1.12	0.71	0.63	29.76	1.33	0.81	3.01	1.40

clusters plant^{-1} (12.93), number of pods plant^{-1} (3.49), pod length (8.05 cm), pod diameter (3.02 cm), number of pods plant^{-1}(45.13), number of seeds plant^{-1}(4.02), 1000 seed weight (22.12), pod yield (4.11 t ha $^{-1}$) and seed yield (4.78 q ha^{-1}). The application of 100 per cent NPK through inorganic fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) (T_2) performed better next to the treatment with application of 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost (T_9) and the treatments of 75 per cent NPK with organic manures and 50 per cent NPK with organic manures are at par with each other. Increase in the number of pods plant^{-1}, seeds pod^{-1} and seed yield with the application of 20 kg N and 40 kg P_2O_5 in cluster bean was reported by Rathore et al. [11]. Increase in the yield and yield contributing parameter in cluster bean was reported by Ayub et al. [14]. Highest number of pods plant^{-1}, 1000 seed weight, seed yield and stover yield of cluster bean were maximum with 100 per cent RDN through urea, Rhizobium and PSB [15]. Significantly higher yield with application of NPK was also reported by Singh [16]. Saxena et al. [17] also reported that "application of different levels of nitrogen, helps to increase the yield of cluster bean significantly over control. Naggar and Meena [18] reported that the seed yield was significantly and positively correlated with yield attributing characters of cluster bean".

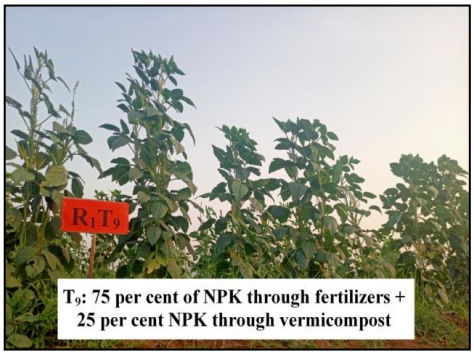

Fig. 1. Best treatment plot

Fig. 2. RDF treatment plot

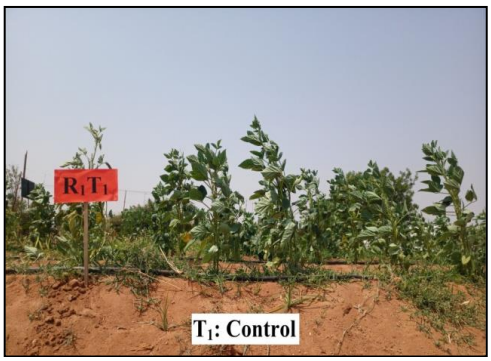

Fig. 3. Control treatment plot

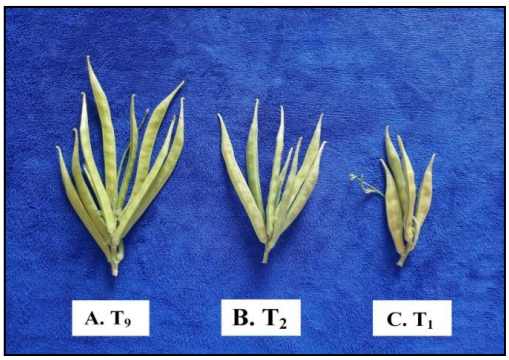

Fig. 4. Clusters of various treatments

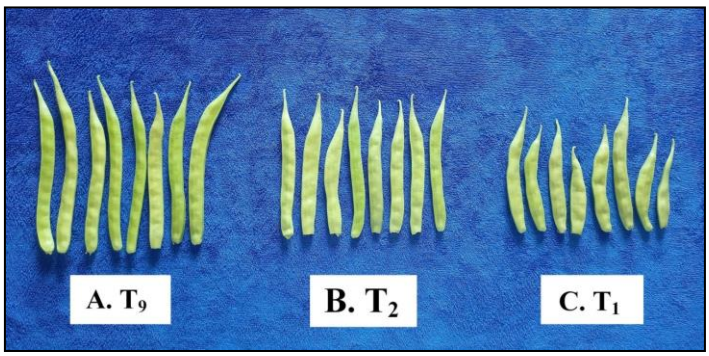

Fig. 5. Pods of cluster bean in various treatments

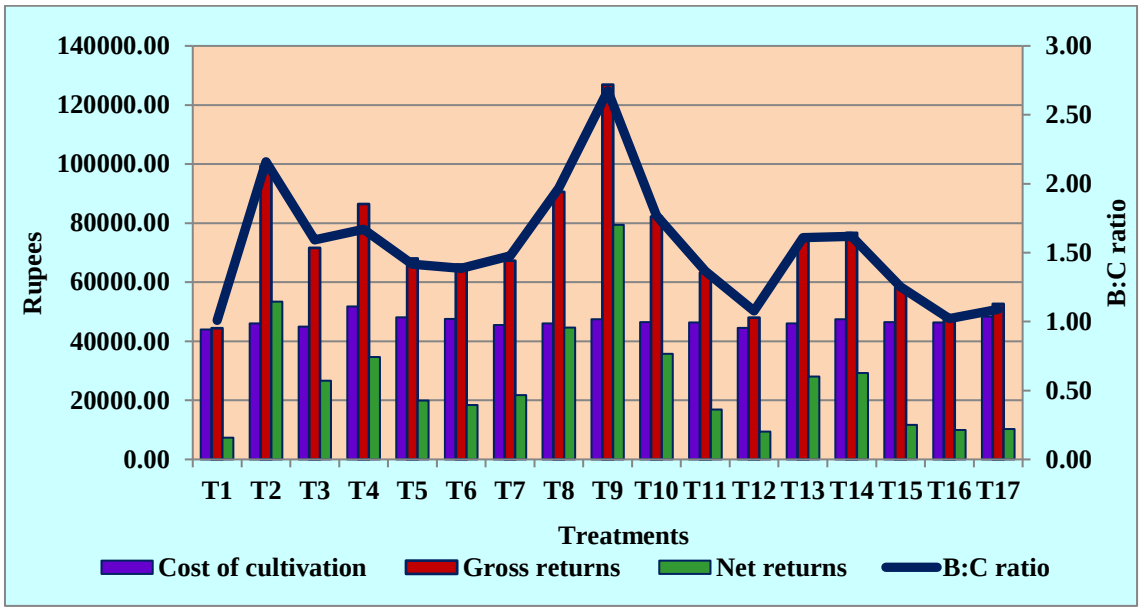

Fig. 6. Effect of integrated nutrient management on economics of cluster bean

3.3 Economics

The cost of cultivation was lowest in control plot treatment (₹ 44,000.00 ha^{-1}), and it was highest in treatment with application of 100 per cent NPK through vermicompost (T_4) (₹ 51,800.00 ha^{-1}). The maximum net return (₹ 79,455.00 ha^{-1}), and cost benefit ratio (2.67) was recorded with 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost (T_9) whereas the treatment with alone application of NPK through inorganic fertilizers (25 kg N, 50 kg P2O5 and 50 kg K_2O ha^{-1}) (T_2) was remunerative with higher benefit: Cost ratio (2.16) than other combinations and sole application of organic and inorganic sources of nutrients. The results were similar finding by Kumar et al. [15] recorded that the highest net return and Benefit Cost ratio (BCR) with the application of 100 per cent RDN through fertilizers. The application of recommended dose of fertilizers and vermicompost achieved higher monetary returns in cluster bean [19] and similar findings was recorded by Bhathal and Kumar [20].

4. DISCUSSION

"The selected sole and combinations of organic and inorganic sources of nutrients markedly influenced the growth parameters of cluster bean. The findings from the present investigation revealed that the maximum mean plant height, more number of branches per plant, high LAI , higher dry weight and other parameters throughout the phases of crop growth was observed in the treatment with application of 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost. Pronounced influence of organic manures and fertilizers might be due to improvement in physico-chemical and biological properties of soil with constant and optimum supply of nutrients to the plant enhanced yield attributing characters" [21].

"Application of vermicompost attributed to better growth of plant and yield by slow release of nutrients for absorption with making available additional nutrients like gibberellins, cytokinins and auxins and it also promote humification, increased microbial activity and enzyme production, which in turn, bring about the aggregate stability of soil particles resulting in better aeration and a property of binding mineral elements like Ca, Mg and K in the form of stable aggregates of soil particles for desired porosity to sustain the plant growth. Soil microbial biomass and enzyme activity improved as a result of vermicompost addition, which favored the total increase in plant produce" [22]. "Higher availability of all plant nutrients resulted in the improved plant characters like height, branches, dry matter production, partitioning, number of pods and yield" which are in conformity with the findings of, Kumar et al. [23] and Ashwini [24].

"Yield is the index of morphological, physiological and biochemical parameters which comprises

the interaction of internal and external factors" [25]. "It largely depends on the production and mobilization of carbohydrates, uptake of water and nutrients from the soil, in addition the environmental factors to which the plant is exposed during growing period. The present study revealed that 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost recorded higher yield and yield components. The yield and yield components are high due to better assimilation of photosynthates and better partitioning into developing pod clusters, might have taken place and improved yield attributing characters like pod length and diameter" [22]. "The higher seed yield under the treatments of integrated nutrient management as compared to alone application of chemical fertilizers might be due to improvement in physico-chemical and biological properties of soil with constant and optimum supply of nutrients to the plant enhanced yield attributing characters" where these Similar observations were also recorded by Ashwini [24], Jaipaul et al. [26] and [21].

The results reveal that sole application of inorganic fertilizers and 75 per cent NPK through inorganic fertilizers + 25 per cent NPK through vermicompost gave better results as compare to all other treatments. When compared to the sole use of chemical fertilizers, integration nutrient management has demonstrated improved resource usage and management at the farm during the experimental study conducted in semi-arid circumstances. This has resulted in a minor statistical difference in certain yield-attributing features.

5. CONCLUSION

Cluster bean was well responded to the integration of inorganic fertilizers with the organic sources of nutrients and improved soil physico-chemical properties. In conclusion it is well described that integration of fertilizers with vermicompost provided the better nutritional environment in the root zone for proper crop growth and development. The results reveal that 75 per cent NPK through fertilizers + 25 per cent NPK through vermicompost and sole application of fertilizers (25 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) and gave better results as compare to all other treatments. In comparison to the sole use of chemical fertilizers, integration nutrient management has demonstrated improved resource consumption and management at the farm during the experimental study conducted in semi-arid settings. This has resulted in a minimal statistical difference in yield contributing features. It may be concluded that among the different treatments, 75 per cent NPK through fertilizers in combination with 25 per cent NPK through vermicompost was found to be the best for obtaining highest pod and seed yields, net return and benefit cost ratio in cluster bean. Since the finding is based on the research carried out in single season only it may be validated further for varieties and locations of SAT regions of Andhra Pradesh.

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 manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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