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Optimizing Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.) Var. Neelam-61 through Integrated Use of Inorganic Fertilizers, Organic Manure and Rhizobium Inoculation

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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

Organic matter decomposition is beneficial to plant growth and development. However, the overuse of chemical fertilizers poses risks to environmental sustainability and long-term soil health. The integration of organic fertilizers, such as poultry manure, offers a promising solution to reduce dependency on chemical inputs while maintaining crop productivity. The field experiment was conducted at Research Farm of the Department of Soil Science, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj U.P during *Kharif* season of 2023. An experiment was conducted in Factorial Randomized Block Design (FRBD) with three levels of N:P:K, Poultry manure and two levels of Rhizobium inoculation. The seeds were treated with Rhizobium. Based on the experimental data, the application of 100% Recommended Dose of Fertilizer (RDF), 100% Poultry manure and 100% Rhizobium inoculation not only resulted in maximum growth and yield attributes but also proved to be significantly superior to all other treatments.

Keywords: Cluster bean; poultry manure; Rhizobium inoculation; growth and yield.

1. INTRODUCTION

"Cluster bean (*Cyamopsis tetragonoloba* L.) commonly known as Guar in Rajasthan state of India. The word "Guar derives from Sanskrit word "Gau aahar" which means cow fodder or otherwise fodder of the animals. This crop is an outstanding legume crop grown mainly under a rainfed situation in arid and semi- arid regions of Rajasthan throughout *Kharif* season. Its deep penetrating roots allow the plant to uptake available moisture more efficiently and thus extend the much scope for rainfed cropping. It holds a significant status due to several industries like textiles, paper, oil, pharmaceuticals, food processing cosmetics, mining explosives, oil drilling etc. In terms of area and production, the state of Rajasthan is the first in India. Rajasthan, in India, is the principal guar growing state accounting for about 87.7% of the production and 91.5% of the acreage during 2020–21" [1]. Over the past few years, this particular crop has gained significant importance in the industrial sector due to the high-quality gum present in its seed endosperm, which contains 28 to 33 per cent gum content. The galactomannan gum, a natural water-soluble polysaccharide polymer found in the endosperm [2], serves as the primary product utilized in various industries [3]. Additionally, cluster bean contributes to soil fertility by fixing a significant amount of atmospheric nitrogen, making it a valuable addition to cattle fodder [4]. The soil can be enriched with approximately 37-196 kg of atmospheric nitrogen per hectare per year through the use of this crop. Additionally, it is commonly employed in the reclamation of saline and alkaline soils [5]. Fertilizers and organic manures are essential for achieving higher yields of cluster beans. Among the various plant nutrients, nitrogen is the most crucial for plant growth and development [6]. Organic manures *viz.,* farmyard manure (FYM), vermicompost (VC), poultry manure (PM) and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil [7]. These organic materials enhance soil microbiological activities, which play a crucial role in the transformation, recycling, and availability of nutrients to the crops. Furthermore, they also improve the physical properties of the soil, including its structure, porosity, and ability to resist compaction and crusting. Bio fertilizers offer an eco-friendlier approach. They have the ability to significantly contribute to fixing atmospheric nitrogen, enriching soil fertility, and improving overall soil quality. Among the various bio fertilizers available, Rhizobium inoculants designed for specific leguminous crops hold the highest importance in India. There is a need to seek alternative nutrient sources which could be cheap and eco–friendly so that farmers may be able to reduce the investment made on fertilizer along with maintaining good soil environmental conditions leading to ecological sustainable farming. Organic manure (Poultry manure) helps in reducing C:N ratio, increasing humic acid content, cation exchange capacity and water-soluble carbohydrates, which play a major role for producing the good quality and higher yield in cluster bean per unit area. Inoculation is the process of applying Rhizobium bacteria to legume seed to form a symbiotic relationship with the developing plant. Bacteria (*Rhizobium*) are capable of fixing atmospheric nitrogen (N) into forms usable by plants.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was conducted out during the *Kharif* season of 2023 at the Research farm of the Department of Soil Science, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj (U.P.) located at 25 0 24 30" North latitude 810 51'10" East longitude and 98m above mean sea level.

2.2 Details of experiment and treatments

The experiment was conducted in factorial randomized block design (FRBD) with three levels of N:P:K, Poultry manure and two levels of Rhizobium inoculation during *Kharif,* 2023. The Seeds were treated with Rhizobium. The treatments were replicated three times and were allocated at random in each replication. Crop has Seed rate: 25 kg ha^{-1}, Spacing: 30cm × 10cm. RDF of cluster bean 20:40:20 kg N:P:K per ha, recommended poultry manure (10t/ha) and recommended Rhizobium inoculation was 200gm/ 100g seed. Treatments RDF i.e., 0%, 50% and 100%, Poultry manure level was 0%, 50%, 100 % and Rhizobium inoculation 0%, 100%.

The various observations on growth, yield and yield attributing characters in cluster bean were collected from Ten plants selected at middle two rows from each of the 54 experimental plots of cluster bean and tagged permanently. Plant growth parameters *viz.* plant height (cm), plant dry weight and number of functional nodules/plants were recorded at 30, 60 and 90 days after sowing of cluster bean. Similarly, yield and its attributing parameters viz. Number of pods $plant^{-1}$ and yield (q ha^{-1}) were recorded after the harvesting of cluster bean. The data obtained were processed statistically to determine by Fisher's method for the effect of various treatments.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Inorganic fertilizers

The data presented in Table 1. on the response of plant height, plant dry weight and number of functional nodules/plants of cluster bean recorded at 30, 60 and 90 DAS as influenced by different levels N P K. The plant height, plant dry weight and number of functional nodules/plants of cluster bean were found to be increased significantly with the increase in levels of N P K. The maximum Plant height, plant dry weight & number of functional nodules/plants were recorded 28.33 cm, 0.83 g, & 23.26 at 30 DAS and 57.09 cm, 6.78 g, & 30.04 at 60 DAS and 75.60 cm, 11.79 g & 14.09 at 90 DAS with 100% RDF, respectively. While minimum Plant height, plant dry weight & number of functional nodules/plants were recorded 22.00 cm, 0.66 g & 17.22 at 30 DAS and 50.94 cm, 4.73 g, 22.00 at 60 DAS and 68.61 cm, 8.08 g & 9.37 at 90 DAS with 0 % RDF, respectively. This may be owing to an increased supply of multi-nutrients, and beneficial microflora released from poultry manure. Its addition to soil creates the most favorable conditions and improves with respect to the physicochemical and biological properties of the which promotes plant growth by ensuring a higher number of greener leaves with increased photosynthesis as a result of increased metabolism of the plant height and ultimately increased vegetative parameters. Similar results were reported by [8]. "Nutrient management had significant influence on dry matter accumulation at all the stages. Progressive improvement in dry matter accumulation was recorded with application of successive level of chemical fertilizers. These results are in conformity with the finding" Kumawat et al [8]. "This is due to the favorable effect of poultry manure on chemical physical and biological properties of soil leads to easy availability of nutrients might have reflected in higher growth parameter and it increases biomass of plant. The findings are in agreement with the results reported" by Kumawat et al [9] and Kumawat et al [10]. The increased availability of nutrients with application of chemical fertilizers and biological nitrogen fixation by Rhizobium increased solubilization of native and applied phosphorus by phosphate solubilizing bacteria. This might have favored the plant growth characters under aforesaid treatments. Similar results were reported by Kumawat et al [8].

3.1.2 Poultry manure

The data presented in Table 1 on the response of plant height, plant dry weight & number of functional nodules/plants of cluster bean were recorded at 30, 60 and 90 DAS as influenced by different levels of poultry manure. The plant height, plant dry weight & number of functional nodules/plants of cluster bean were found to be increased significantly with the increase in levels of poultry manure. The maximum Plant height, plant dry weight & number of functional

nodules/plants were recorded 27.82 cm, 0.82 g & 22.75 at 30 DAS and 56.97 cm, 6.86 & 27.69 at 60 DAS and 75.54 cm, 11.29 g & 14.23 at 90 DAS with 100% poultry manure, respectively and minimum Plant height, plant dry weight & number of functional nodules/plants were recorded 22.88 cm, 0.68 g & 17.76 at 30 DAS and 51.10 cm, 4.82 g & 23.73 at 60 DAS and 68.82 cm, 8.86 g & 9.81 at 90 DAS with 0 % poultry manure, respectively. "An increased availability of multi nutrients with application of poultry manure and biological nitrogen fixation through Rhizobium and decomposition of organic manure increase the solubilization of applied phosphorus might have helped in increasing growth. Similar results were also reported" by Kumawat et al. [11] and Mahata et al. [12].

3.1.3 Rhizobium inoculation

The data presented in Table 1 on the response of plant height, plant dry weight & number of functional nodules/plants of cluster bean recorded at 30, 60 and 90 DAS as influenced by different levels of Rhizobium inoculation. The plant height, plant dry weight & number of functional nodules/plants of cluster bean were found to be increased significantly with the increase in levels of Rhizobium inoculation. The maximum Plant height, plant dry weight & number of functional nodules/plants were recorded 27.31 cm, 0.79 g & 21.89 at 30 DAS and 56.37 cm, 6.26 g & 24.63 at 60 DAS and 74.79 cm, 10.79 g & 13.51 at 90 DAS with 100% Rhizobium inoculation, respectively and minimum Plant height, plant dry weight & number of functional nodules/plants were recorded 23.44 cm, 0.72 g & 18.67 at 30 DAS and 52.13 cm, 5.39 g & 24.50 at 60 DAS and 69.96 cm, 9.31 g & 9.98 at 90 DAS with 0 % Rhizobium inoculation. "Rhizobium seems to be on account of their impact on nutritional environment and involvement in various physiological processes in the plant systems which are considered to be pre-requisites for growth of the crop. The present results are in accordance with that of" Mahata et al. [12]. "Application of inorganic fertilizer enhanced the availability of nutrients especially nitrogen which is mainly responsible for vegetative growth while phosphorus is important in root development and increases nodule activity in plant. The present findings are in close agreement with those reported" by Meena et al [13] and Patel et al [14]. This was probably due to the slow mineralization of manure hence slow nitrogen release. In addition, the additional phosphorus present in the manure perhaps resulted in the positive effect of manure on nodulation. These findings are the same as the results of several other researchers [15]. It might have increased nitrogenous activity and available P status of the soil. It may be due to the biosynthesis of growth promoting substances like vitamin-B12 and auxin. Similar findings were reported by Patel et al [16].

Table 1. Effect of Inorganic fertilizer, Organic manures and Rhizobium inoculation on growth attributes at successive growth stages of Cluster bean

Treatments	Plant Height (cm)			Plant Dry Matter (g Plant^{-1})			Number of Nodules Plant^{-1}		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
RDF									
0 %	22.00	50.94	68.61	0.66	4.73	8.08	17.22	22.00	9.37
50 %	25.80	54.74	72.91	0.76	5.97	10.28	20.36	26.17	11.76
100 %	28.33	57.09	75.60	0.83	6.78	11.79	23.26	30.04	14.09
S.Em ±	**0.38**	**0.37**	**0.47**	**0.01**	**0.13**	**0.26**	**0.35**	**0.49**	**0.31**
CD (P=0.05)	**1.10**	**1.06**	**1.34**	**0.03**	**0.38**	**0.74**	**1.01**	**1.39**	**0.88**
Poultry manure									
0 %	22.88	51.10	68.82	0.68	4.82	8.86	17.76	23.73	9.81
50 %	25.43	54.70	72.76	0.76	5.80	10.01	20.34	26.78	11.19
100 %	27.82	56.97	75.54	0.82	6.86	11.29	22.75	27.69	14.23
S.Em ±	**0.38**	**0.37**	**0.47**	**0.01**	**0.13**	**0.26**	**0.35**	**0.49**	**0.31**
CD (P=0.05)	**1.10**	**1.06**	**1.34**	**0.03**	**0.38**	**0.74**	**1.01**	**1.39**	**0.88**
Rhizobium inoculation									
0 %	23.44	52.13	69.96	0.72	5.39	9.31	18.67	24.50	9.98
100 %	27.31	56.37	74.79	0.79	6.26	10.79	21.89	27.63	13.51
S.Em ±	**0.31**	**0.30**	**0.38**	**0.01**	**0.11**	**0.21**	**0.29**	**0.40**	**0.25**
CD (P=0.05)	**0.90**	**0.86**	**1.10**	**0.03**	**0.31**	**0.61**	**0.82**	**1.14**	**0.72**

3.2 Yield and its Attributes

3.2.1 Inorganic fertilizers

The data presented in Table 2 and depicted in Fig. 1 on the response of yield attributes of cluster bean recorded as Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight influenced by different levels N P K. The yield attributes of cluster bean were found to be increased significantly with the increase in levels of N P K. The maximum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 38.60, 13.09 and 31.15 gm, respectively, with 100% RDF and minimum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 29.0, 8.61 and 29.50 gm, respectively with 0 % RDF. Better growth associated with increased availability of plant nutrients might have resulted in better development of yield attributes under a foresaid treatments. The results corroborate the findings of Kumawat et al [8].

3.2.2 Poultry manure

The data presented in Table 2 and depicted in Fig. 1 on the response yield attributes of cluster bean recorded as Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight influenced by different levels of poultry manure. The yield attributes of cluster bean were found to be increased significantly with the increase in levels of poultry manure. The maximum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 37.36, 13.56 and 30.75 gm, respectively, with 100% poultry manure and minimum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 31.01, 8.63 and 29.83 gm, respectively with 0 % poultry manure. This is due to the favorable effect of poultry manure on chemical physical and biological properties of soil leads to easy availability of nutrients might have reflected in higher growth and yield parameter. The findings are in agreement with the results reported by Kumawat et al [10] and Patel et al [17].

3.2.3 Rhizobium inoculation

The data presented in Table 2 and depicted in Fig. 1 on the response of yield attributes of cluster bean recorded as Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight influenced by different levels of Rhizobium inoculation. The yield attributes of cluster bean were found to be increased significantly with the increase in levels of Rhizobium inoculation. The maximum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 36.11, 12.15 and 30.63 gm respectively, with 100 % Rhizobium inoculation and minimum Numbers of pods plant^{-1}, Seeds pod^{-1} and Test weight was recorded 32.43, 9.57 and 30.13 gm, respectively with 0 % Rhizobium inoculation. It might be due to dual inoculation benefiting the plants by providing atmospheric N and rendering the insoluble phosphorus into available form. The enhanced availability of P favored N fixation and rate of photosynthesis and consequently led to better growth and yield attributes. Rhizobium + PSB seem to be on account of their impact on nutritional environment and involvement in various physiological processes in the plant systems which are considered to be pre-requisites for growth of the crop. The present results are in accordance with that of Patel et al [16] and Priyadarshini et al [18].

3.3 Yield (q ha^{-1})

3.3.1 Inorganic fertilizers

The data presented in Table 3 and depicted in Fig. 2 on the response of seed and haulm yields of cluster bean recorded as influenced by different levels N P K. The yields of cluster bean were found to be increased significantly with the increase in levels of N P K. The maximum seed and haulm yields were recorded 12.26 and 31.61 q ha^{-1} respectively, with 100% RDF and minimum seed and haulm yields were recorded 8.94 and 24.43 q ha^{-1} respectively, with 0 % RDF. Although there was no significant difference in harvest index with different levels of RDF, the findings are consistent with those of Rathore et al [19] and Reddy et al [20], who reported significant increases in seed yield with the application of inorganic fertilizers. These increases were attributed to the creation of a nutritionally balanced environment, which led to the production of a higher Number of pods plant^{-1}, Seeds pod^{-1} and increased 1000 Seed weight. Similar to this, significant increase in haulm yield under the influence of inorganic fertilizer application appears to be on account of its direct impact on the formation of dry matter at various stages and during harvest as well as an indirect effect *viz*., a rise in plant height [21] noted comparable outcomes.

3.3.2 Poultry manure

The data presented in Table 3 and depicted in Fig. 2 on the response seed and haulm yields of cluster bean recorded as influenced by different levels of poultry manure. The yields of cluster

bean were found to be increased significantly with the increase in levels of poultry manure. The maximum seed and haulm yields were recorded 12.09 and 30.16 q ha^{-1} respectively, with 100 % poultry manure and minimum seed and haulm yields were recorded 9.33 and 25.89 q ha^{-1} respectively, with 0 % poultry manure. There was no significant difference in harvest index with different level of poultry manure. This improvement in available nutrient content, along with enhanced physical, chemical and biological properties of the soil in plots treated with organic

Table 2. Effect of Inorganic fertilizer, Organic manures and Rhizobium inoculation on yield attributes of Cluster bean

Treatments	Pods $Plant^{-1}$	Seeds Pod^{-1}	Test Weight (gm)
RDF			
0 %	29.05	8.61	29.50
50 %	35.17	10.89	30.49
100 %	38.60	13.09	31.15
S.Em ±	**0.46**	**0.57**	**0.48**
CD (P=0.05)	**1.32**	**1.64**	**NS**
Poultry manure			
0 %	31.01	8.63	29.83
50 %	34.45	10.39	30.56
100 %	37.36	13.56	30.75
S.Em ±	**0.46**	**0.57**	**0.48**
CD (P=0.05)	**1.32**	**1.64**	**NS**
Rhizobium inoculation			
0 %	32.43	9.57	30.13
100 %	36.11	12.15	30.63
S.Em ±	**0.38**	**0.46**	**0.39**
CD (P=0.05)	**1.08**	**1.34**	**NS**

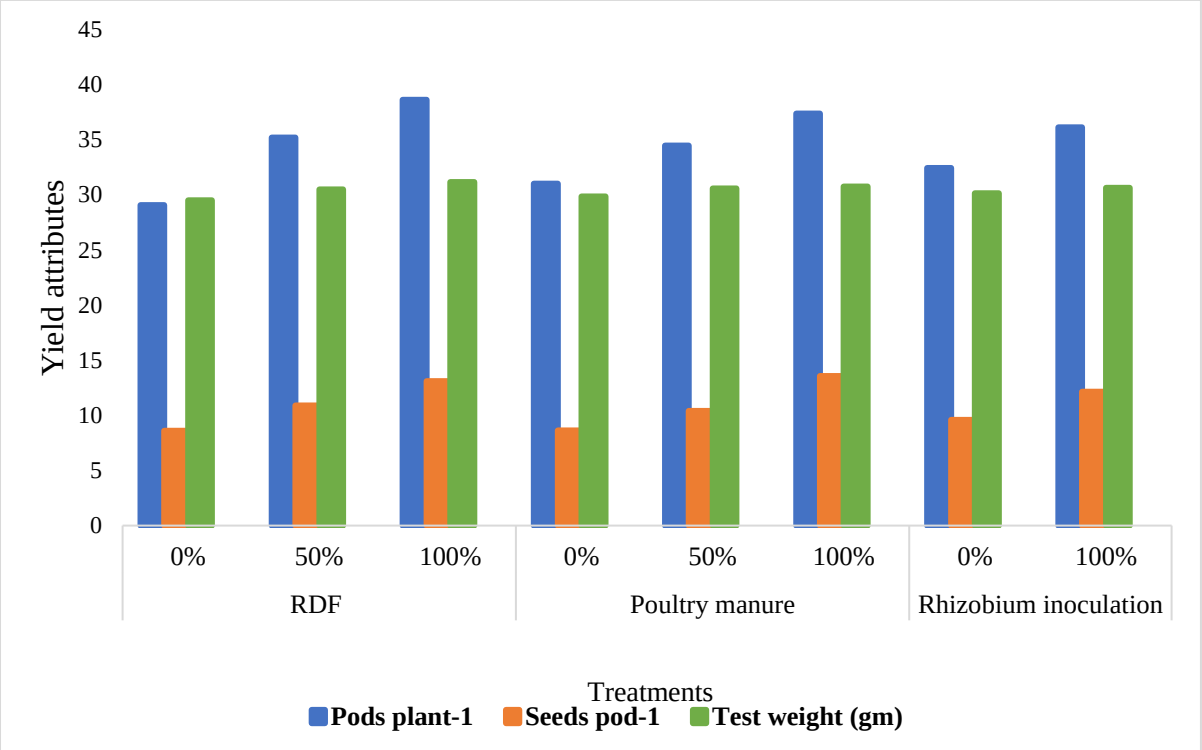

Fig. 1. Effect of Inorganic fertilizer, Organic manures and Rhizobium inoculation on yield attributes of Cluster bean

Table 3. Effect of Inorganic fertilizer, Organic manures and Rhizobium inoculation on yields (q/ha) of Cluster bean

Treatments	Seed Yield	Haulm Yield	Harvest Index
RDF			
0 %	8.94	24.43	26.70
50 %	10.31	28.08	26.84
100 %	12.26	31.62	27.54
S.Em ±	**0.26**	**0.47**	**0.36**
CD (P=0.05)	**0.76**	**1.35**	**NS**
Poultry manure			
0 %	9.33	25.89	26.39
50 %	10.09	28.07	26.43
100 %	12.09	30.16	28.25
S.Em ±	**0.26**	**0.47**	**0.36**
CD (P=0.05)	**0.76**	**1.35**	**NS**
Rhizobium inoculation			
0 %	9.64	27.08	26.20
100 %	11.37	29.01	27.85
S.Em ±	**0.22**	**0.38**	**0.29**
CD (P=0.05)	**0.62**	**1.10**	**0.84**

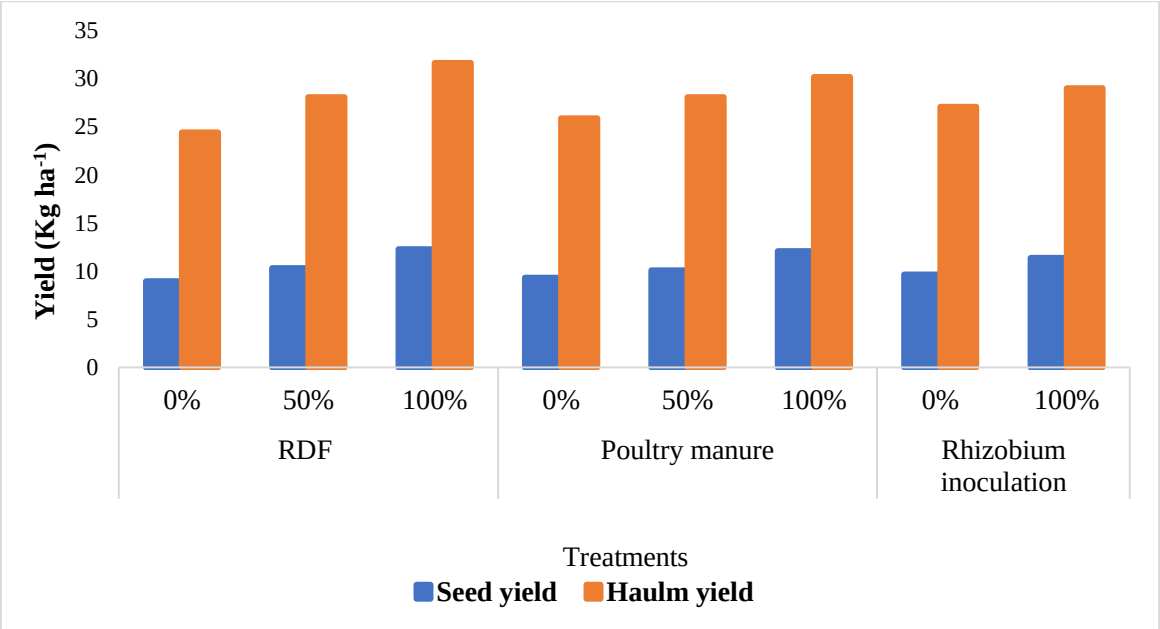

Fig. 2. Effect of Inorganic fertilizer, Organic manures and Rhizobium inoculation on yields (q/ha) of Cluster bean

materials compared to the control, may have accelerated plant growth. This ultimately resulted in increased crop and straw yields. Similar results were also reported by Seerangan et al [22], Seerangan et al [23] and Singh and Usha [24].

3.3.3 Rhizobium inoculation

The data presented in Table 3 and depicted in Fig. 2 on the response of seed and haulm yields of cluster bean recorded as influenced by different levels of Rhizobium inoculation. The yields of cluster bean were found to be increased significantly with the increase in levels of Rhizobium inoculation. The maximum seed and haulm yields were recorded 11.37 and 29.01 q ha^{-1} respectively, with 100% Rhizobium inoculation and minimum seed and haulm yields were recorded 9.64 and 27.08 q ha^{-1} respectively, with 0 % Rhizobium inoculation.

There was no significant difference in harvest index with different level of Rhizobium inoculation. Sole inoculation of biofertilizer have positive effect on stover yield and magnitude of improvement was highest with combined inoculation of Rhizobium+ fertilizers. The results corroborate the findings of Kumawat et al [8].

4. CONCLUSIONS

Based on the experimental results, the combination of 100% RDF (Recommended Dose of Fertilizers), 100% Poultry Manure, and 100% Rhizobium inoculation showed superior performance in enhancing plant growth parameters and yield attributes for cluster bean. This combination outperformed other treatments in terms of plant height, dry weight, functional nodules and yield, making it the most effective approach for maximizing productivity in cluster bean cultivation.

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.

REFERENCES

1. Amin AM, Ahmad AS, Yin YY, Yahya N, Ibrahim N. Extraction, purification and characterization of durian (*Durio zibethinus*) seed gum. Food Hydrocolloids. 2007;21(2):273-279.
2. Anonymous. (Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi. 2023; 262.
3. Bhakti V, Vaidya KP, Biradar SU, More SS. Effect of integrated nutrient management on growth, yield and quality of lablab bean (*Lablab purpureus*). The Pharma Innovation Journal. 2021;10(12):2225-2228.
4. Dharwe DS, Dixit HC, Dotaniya CK, Doutaniya RK, Mohbe S, Tarwariya MK. Effect of phosphorus and sulphur on yield attributes, nutrient content and nutrient uptake of greengram in Bundelkhand soil. International Journal of Current Research. 2019;11(11):8225-8229.
5. Joshi D, Gediya KM, Patel JS, Birari MM, Gupta S. Effect of organic manures on growth and yield of summer cowpea [*Vigna unguiculata* (L.) Walp] under middle Gujarat conditions. Agriculture Science Digest. 2016;36(2):134-137.
6. Kumawat S, Kharia SK, Yadav SR, Jinger D. Performance of clusterbean (*Cyamopsis tetragonoloba*) under long-term prescription-based fertilizer recommendation in Western Rajasthan. Indian Journal of Agronomy. 2021b;66 (4):42-46.
7. Kumawat S, Kharia SK, Yadav SR, Shekhawat PS. Impact of long-term nutrient management on soil quality under cluster bean-wheat cropping system in hyper arid region. Journal of Soil and Water Conservation. 2023a;22(2):204-211.
8. Kumawat S, Kharia SK, Yadav SR, Meena AK, Sanwal RC, Sunda SL. Assessing changes in physical and biological properties in soil by soil test crop response approach. Frontiers in Crop Improvement. 2021a;9(4):2549-2553.
9. Kumawat S, Kharia SK, Yadav SR, Shekhawat PS, Sharma Y, Kumawat S, Yadav B. Impact of long-term nutrient management on carbon dynamics under cluster bean-wheat cropping system in Western Rajasthan, India. International Journal of Plant & Soil Science. 2023b;35(20):788-800, ISSN: 2320-7035.
10. Kumawat S, Yadav SR, Shekhawat PS, Kharia SK, Kumawat S. Effect of organic sources and fertilizer levels on soil aggregate fractions in western Rajasthan. The Pharma Innovation Journal. 2023;SP-12(10):341-344.
11. Kumawat S, Yadav SR, Rathore RS, Sharma BD, Kumawat S. Effect of organic sources and fertilizer levels on physiological response of Garlic by Using Infrared Gas Analysis (IRGA) in Western Rajasthan, India. International Journal of Plant & Soil Science. 2023c;35(20):1002-1008, ISSN: 2320-7035.
12. Mahata KR, Singh DP, Ismail AM. Crop and natural resource management for high and stable productivity in coastal saline areas. Limited Proceedings; 2009.
13. Meena KK, Meena RS, Kumawat SM. Effect of sulphur and iron fertilization on

yield attributes, yield and nutrient uptake of mungbean (*Vigna radiata*). Indian Journal of Agricultural Sciences. 2013;83(4):472–476.
14. Patel AD, Patel DD, Patel TU, Prajapati DR. Effect of integrated nutrient management on growth parameters, yield attributes and yield of summer greengram (*Vigna radiate* L.) under South Gujarat condition. An International e-Journal. 2015; 4(1):72-78.
15. Patel HS, Patel KD. Effect of organic fertilizers on growth and economics of cluster bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Navbahar. International Journal of Chemical Studies. 2018;6(5):861-864.
16. Patel H, Parmar V, Patel P, Mavdiya V. Effect of organic fertilizers on yield and yield attributes of cluster bean (*Cyamopsis tetragonoloba* L.) Cv. Pusa Navbahar. International Journal of Chemical Studies. 2018;6(4):1797-1799.
17. Patel JS, Sharkey PJ, Atkins CA. Nutrition of a developing legume fruit functional economy in terms of carbon, nitrogen, water. Plant Physiology. 1977;59(3):506-510.
18. Priyadarshini S, Rawat GS, Dwibedi SK. Effects of levels of primary plant nutrients and row spacing on growth and yield attributes of some promising varieties of cluster bean (*Cyamopsis tetragonoloba* L.). International Journal Current Microbial and Appllied Science. 2017;6(12):17-27.
19. Rathore VS, Singh JP, Soni ML, Beniwal RK. Effect of nutrient management on growth, productivity and nutrient uptake of rainfed cluster bean in arid region. Indian Journal of Agricultural Science. 2007;77: 349-353.
20. Reddy K, Mohan GK, Satla S, Gaikwad S. Natural polysaccharides: Versatile excipients for controlled drug delivery systems. Asian Journal of Pharma Science. 2011;6(6): 275-286.
21. Sarvanan T, Panneerselvum P. Effect of organic manures and rock phosphate on growth and yield of Bengal gram (*Cicer arietinum* L.). Asian Journal of Soil Science. 2014;9(22):203-207.
22. Seerangan G, Sha K, Muraleedharan A. Effect of organic inputs and inorganic nutrients on growth and yield of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Journal of Pharmacognosy and Phytochemistry. 2019;SP2:580-581.
23. Seerangan G, Sha K, Muraleedharan A. Effect of organic inputs and inorganic nutrients on growth and yield of Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub. Journal of Pharmacognosy and Phytochemistry. 2019;SP2:580-581.
24. Singh B, Usha K. Nodulation and symbiotic nitrogen fixation of cowpea genotypes as affected by fertilizer nitrogen. Journal of Plant Nutrition. 2003;26(2):463-473.

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