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Effect of Fertility Levels and Bio formulations on Growth, Yield and Quality of Clusterbean (*Cyamopsis tetragonoloba* L.)

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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

A field experiment was conducted during *kharif* 2024 at the Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur, to assess the impact of integrated nutrient management on crop performance under semi-arid conditions. The experiment was laid out in a factorial randomized block design with 16 treatment combinations involving four fertility levels (Control, 50%, 75%, and 100% RDF) and four bioformulations (No bioformulation, NPK liquid, Zn solubilizing, and NPK liquid + Zn solubilizing), replicated thrice. The soil of the experimental site was loamy sand with low organic carbon and available nitrogen. The results revealed that increasing fertility levels significantly enhanced growth parameters including plant height, dry matter accumulation, number of branches per plant, leaf area index, and chlorophyll content. At harvest, the highest plant height (95.2 cm), dry matter (97.2 g/plant), and number of branches (9.2)

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were recorded under 100% RDF, which was significantly superior to lower doses and control. Among bioformulations, the combined application of NPK liquid + Zn solubilizing recorded the maximum growth metrics. Yield attributes such as number of pods per plant (39.6), seeds per pod (8.56), and 1000-grain weight (28.10 g) were also highest under 100% RDF. Similarly, grain and straw yields were significantly influenced, with the maximum grain yield (1826 kg/ha) and straw yield (3325 kg/ha) recorded under 100% RDF. Among bioformulations, NPK liquid + Zn solubilizing led to the highest grain yield (1669 kg/ha), outperforming individual applications and the control. Nutrient content and uptake (N, P, K) in both grain and straw increased significantly with fertility and bioformulation treatments, with the highest uptake observed in the treatment receiving 100% RDF and NPK + Zn solubilizing bioformulation. Economic analysis revealed that the highest net return (₹52980/ha) and benefit-cost ratio (2.78) were obtained under 100% RDF, while among bioformulations, NPK + Zn solubilizing gave the maximum net return (₹47115/ha) and B:C ratio (2.69). The integrated use of 100% recommended dose of fertilizers along with combined bioformulations (NPK liquid + Zn solubilizing) proved most effective for improving growth, yield, nutrient uptake, and economic returns of clusterbean in semi-arid Rajasthan.

Keywords: Bioformulation; cluster bean; yield; uptake.

1. INTRODUCTION

Clusterbean (*Cyamopsis tetragonoloba* (L.), popularly known as guar, is an important drought-tolerant legume primarily cultivated during the *kharif* season in the arid and semi-arid regions of India (Singh *et al.,* 2022). Its ability to withstand moisture stress, improve soil fertility through biological nitrogen fixation, and provide multiple economic benefits makes it a crucial crop in dryland agriculture. Nutritionally, clusterbean is rich in proteins, essential amino acids, vitamins, calcium, phosphorus, and iron nutrients generally deficient in cereal-based diets (Bhardwaj *et al.,* 2024). Consequently, it serves as a valuable protective food for humans as well as a nutritious component in livestock feed. A major commercial advantage of clusterbean is its production of galactomannan gum, commonly known as guar gum, found in the seed endosperm. This natural, water-soluble polysaccharide has extensive industrial applications in textiles, paper, explosives, pharmaceuticals, cosmetics, oil drilling, and food processing. Varieties with gum contents exceeding 32% are especially sought after in global markets (Hussain & Mahajan, 2025). Rising international demand for guar gum has further increased the economic significance of the crop. In India, the major clusterbean-growing states include Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, and Maharashtra. The crop occupies nearly 3.9 million hectares with a production of about 1.6 million tonnes and an average productivity of 413 kg ha^{-1} (Maiya, 2024). Rajasthan is the dominant producer, accounting for most of the cultivated area and output. Despite its wide cultivation and ecological benefits, the productivity of clusterbean remains relatively low, particularly in rainfed regions where nutrient management practices are often inadequate. Clusterbean is a notable contributor to soil fertility because of its symbiotic association with Rhizobium bacteria, enabling biological nitrogen fixation ranging from 37 to 196 kg ha^{-1} annually. The crop is also reported to aid in the reclamation of saline and alkaline soils (Sharawat, 2025). However, nutrient deficiencies, especially of nitrogen (N), phosphorus (P), and potassium (K), significantly restrict growth and yield. Nitrogen is vital for chlorophyll formation, enzyme activity, and vegetative growth. Phosphorus plays a key role in root development, energy transfer, and nodulation—an essential process for nitrogen fixation in legumes. Potassium enhances water uptake, photosynthesis, and tolerance to abiotic stress. Application of the recommended fertilizer dose (20 kg N + 40 kg P_2O_5 ha^{-1}) has been shown to enhance yield, although responses differ depending on genotype and agro-climatic conditions. The soils of Rajasthan are typically low in organic matter and deficient in available N and P due to continuous cropping without adequate nutrient replenishment. This underscores the need for integrated nutrient management (INM), which combines chemical fertilizers with organic manures and bio-fertilizers. Bio-formulations such as Rhizobium and phosphate-solubilizing bacteria (PSB) provide eco-friendly alternatives to enhance nutrient availability. Rhizobium inoculation improves nitrogen fixation, while PSB release phosphorus from insoluble soil compounds. Their application can increase yields by 10–30% and improve soil health. Liquid NPK bio-formulations containing nitrogen-fixing bacteria (*Azotobacter, Azospirillum*), phosphate-solubilizing microbes

(Bacillus, Pseudomonas), and potassium-mobilizing organisms further enhance nutrient availability, promote root growth, and reduce reliance on chemical fertilizers (Shafiq *et al.,* 2025). Similarly, zinc-solubilizing microbes convert insoluble forms of zinc into plant-available forms, improving enzymatic activity, hormone synthesis, and chlorophyll production (Sethi *et al.,* 2025). These integrated approaches improve crop nutrition, yield, grain quality, and environmental resilience while minimizing nutrient losses. Given the economic and ecological importance of clusterbean in dryland regions, optimizing fertility management through the combined use of fertilizers and bio-formulations is essential for bridging the yield gap. The present investigation, therefore, aims to study the effects of fertility levels and bio-formulations on the growth, yield, nutrient uptake, and economic viability of clusterbean under Rajasthan's agro-climatic conditions. The objectives include evaluating growth and yield responses, assessing nutrient content and uptake, and determining the economic feasibility of different nutrient management treatments.

2. MATERIALS AND METHODS

A field experiment entitled "Effect of Fertility Levels and Bio-Formulations on Growth and Yield of Clusterbean" was conducted during *kharif* 2024 at the Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur, to assess the impact of integrated nutrient management on crop performance under semi-arid conditions. The experiment was laid out in a factorial randomized block design with 16 treatment combinations involving four fertility levels (Control, 50%, 75%, and 100% RDF) and four bioformulations (No bioformulation, NPK liquid, Zn solubilizing, and NPK liquid + Zn solubilizing), replicated thrice. The experimental soil was sandy loam with neutral to slightly alkaline in nature. The growth parameters *i.e*., plant height, dry matter production, leaf area index, branches/plant, pods/plant, seeds/pod, yield and yield attributes were measured from each and every plot from each plot of 5 selected plants.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The application of fertility levels and bio-formulations significantly influenced the plant height of clusterbean across all growth stages (Table 1). Increasing fertilizer levels resulted in a marked improvement in plant height, with the application of 100% RDF producing the tallest plants, 26.5 cm at 30 DAS, 81.5 cm at 60 DAS, and 95.2 cm at harvest. These values were substantially higher than those recorded under the control treatment (19.0, 62.1, and 68.3 cm, respectively), reflecting percent increases of 39.3%, 31.5%, and 39.4% at the respective growth stages. Alongside fertility levels, the application of bio-formulations also showed significant effects on plant height. The combined use of NPK liquid formulation and Zn-solubilizing bio-formulations resulted in the maximum plant height at all stages—20.9 cm at 30 DAS, 68.3 cm at 60 DAS, and 75.2 cm at harvest—followed by NPK liquid formulation alone and zinc-solubilizing bio-formulations applied separately. The lowest plant height was consistently recorded in the treatment where no bio-formulations were applied (17.0, 53.7, and 61.1 cm). Overall, the results demonstrate that optimal fertilizer application coupled with the synergistic use of bio-formulations markedly enhances vegetative growth in clusterbean. The data presented in Table 1 reveal that dry matter accumulation in clusterbean increased significantly with higher fertility levels, with 100% RDF consistently producing the greatest biomass at all growth stages. At 30 DAS, the maximum dry matter accumulation (32.2 g plant^{-1}) was recorded under 100% RDF, followed by 75% RDF (30.2 g plant^{-1}), whereas the control plot exhibited the lowest value (23.9 g plant^{-1}). Similar trends continued at 60 DAS and at harvest, where 100% RDF again registered the highest dry matter accumulation (81.5 and 95.2 g plant^{-1}, respectively), outperforming 75% RDF (77.3 and 87.3 g plant^{-1}) and 50% RDF (71.5 and 77.9 g plant^{-1}). The control treatment consistently produced the least dry matter across all stages. Bio-formulations also had a significant influence on dry matter accumulation. The combined use of NPK liquid formulation and Zn-solubilizing bioformulations resulted in the highest dry matter accumulation at each growth stage—26.0 g plant^{-1} at 30 DAS and 68.3 and 75.2 g plant^{-1} at 60 DAS and harvest, respectively. This treatment outperformed NPK liquid formulation alone (24.9 g plant^{-1} at 30 DAS) and Zn-solubilizing bioformulations applied individually, whereas the absence of bio-formulations produced the minimum dry matter accumulation throughout. These results clearly indicate that both optimal fertilizer application and the synergistic use of bio-formulations substantially enhance biomass production in clusterbean. Minimum was observed under no bio formulation plot, those are

having lower number of branches per plant as compared to NPK Liquid + Zn Solubilizing and Zn Solubilizing. At 40 DAS, leaf area index (LAI) increased with higher fertility levels, with the maximum LAI recorded under 100% RDF (2.18 cm²/plant), which was statistically at par with 75% RDF (2.15 cm²/plant). The control plot showed the lowest LAI (2.02 cm²/plant). Among bio-formulations, the combination of NPK liquid formulation and Zn-solubilizing microbes produced the highest LAI (2.08 cm²/plant), followed by Zn-solubilizing bio-formulations alone (2.04 cm²/plant), while the control without bio-formulations recorded the lowest value. Chlorophyll content in clusterbean at 40 DAS increased steadily with higher fertility levels, peaking under 100% RDF, while the control had the lowest levels (Table 2). Similarly, bio-formulations enhanced chlorophyll concentration, with the combined NPK liquid and Zn-solubilizing treatment performing best and the no–bio-formulation treatment showing the lowest values. Overall, both balanced fertilizer application and integrated bio-formulations significantly improved chlorophyll synthesis and plant physiological activity. These results align with Singh *et al.* (2024), Priyadarshini *et al.* (2017), Meghana *et al.* (2024), Brar and Singh (2017), Brar and Paramjit (2017), and Yogi *et al.* (2019), all demonstrating that integrated nutrient management combining chemical, organic, and microbial inputs significantly enhances vegetative growth and resource-use efficiency in clusterbean.

Table 1. Effect of different fertility levels and bio formulations on plant height, dry matter accumulation and number of branches plant^{-1} of clusterbean

Treatments	Plant height (cm)			Plant dry matter (g plant^{-1})			Number of branches plant^{-1} at harvest
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	
Fertility Levels							
Control	19.0	62.1	68.3	23.9	64.1	70.3	7.80
50% RDF	21.7	71.5	77.9	26.8	73.5	79.9	8.70
75% RDF	24.3	77.3	87.3	30.2	79.3	89.3	9.00
100% RDF	26.5	81.5	95.2	32.2	83.5	97.2	9.20
SEm ±	0.52	1.07	2.20	0.58	1.21	2.47	0.15
CD	1.56	3.28	6.63	1.72	3.74	7.45	0.44
Bio formulations							
No bio formulation	17.0	53.7	61.1	20.8	55.7	63.1	6.50
NPK liquid formulation	19.8	64.9	69.2	24.9	66.9	73.2	8.30
Zn Solubilizing	18.4	55.6	66.1	22.9	57.6	68.1	7.20
NPK Liquid + Zn Solubilizing	20.9	68.3	75.2	26.0	70.4	77.2	8.70
SEm ±	0.47	0.97	1.97	0.52	1.07	2.18	0.13
CD	1.36	2.86	5.44	1.56	3.25	6.69	0.39
CV (%)	8.12	8.61	6.84	9.08	8.91	7.42	6.96

Table 2. Effect of different fertility levels and bio formulations on leaf area index, chlorophyll content, number of plant^{-1} number of seeds pod^{-1} and test weight of clusterbean

Treatments	Leaf area index at 40 DAS	Chlorophyll content at 40 DAS	Number of pods per plant	Number of seeds per pod	Test weight (g)
Fertility Levels					
Control	2.02	1.83	30.1	6.54	22.56
50% RDF	2.11	2.76	35.5	7.99	26.47
75% RDF	2.15	3.14	38.3	8.12	27.32
100% RDF	2.18	3.55	39.6	8.56	28.10
SEm ±	0.01	0.06	0.39	0.12	0.40
CD	0.03	0.18	1.16	0.37	1.21
Bio formulations					
No bio formulation	1.99	1.53	29.3	6.18	21.45

Treatments	Leaf area index at 40 DAS	Chlorophyll content at 40 DAS	Number of pods per plant	Number of seeds per pod	Test weight (g)
NPK liquid formulation	2.06	2.23	36.0	7.78	26.35
Zn Solubilizing	2.04	1.98	33.4	7.16	25.86
NPK Liquid + Zn Solubilizing	2.08	2.79	37.2	8.10	27.77
SEm ±	0.03	0.05	0.35	0.10	0.39
CD	NS	0.15	1.09	0.31	1.17
CV (%)	7.62	6.34	7.13	8.45	7.88

3.2 Yield Attributes

Pod yield attributes of clusterbean were significantly enhanced by both fertility levels and bio-formulations (Table 2). Increasing fertilizer application led to progressive improvements in yield components. The highest number of pods per plant (39.6), seeds per pod (8.56), and test weight (28.10 g) were all recorded under 100% RDF, while the control consistently produced the lowest values (30.1 pods, 6.54 seeds per pod, and 22.56 g test weight). These increases—31.6% more pods, 30.9% more seeds per pod, and 24.6% higher test weight under 100% RDF—demonstrate the strong positive impact of balanced fertilization on reproductive development and seed quality. Bio-formulations also significantly improved pod-setting and seed development. The combined application of NPK liquid and Zn-solubilizing microbes resulted in the highest values for pods per plant (37.2), seeds per pod (8.10), and test weight (27.77 g), outperforming individual bio-formulations. The lowest values were consistently observed in treatments without bio-formulations. Overall, these results indicate that integrating balanced fertilization with synergistic microbial inputs substantially enhances pod formation, seed setting, and seed weight, contributing to improved productivity in clusterbean. These improvements highlight the role of integrated nutrient management in optimizing reproductive efficiency, nutrient uptake, and assimilate partitioning toward yield components. Similar findings were reported by Singh *et al.* (2014), Meghana *et al.* (2024), Gul *et al.* (2019), and Brahmbhatt *et al.* (2024), demonstrating that biofertilizers and organic-inorganic nutrient integration enhance pod formation, seed development, and overall crop productivity while reducing reliance on chemical fertilizers.

3.3 Yield and Economics

Grain and straw yields of clusterbean were significantly improved by both fertility levels and bio-formulations (Table 3). Grain yield increased progressively with higher fertilizer application, with 100% RDF producing the highest yield (1826 kg/ha), representing a 48.1% increase over the control. This improvement is attributed to enhanced vegetative growth, more pods per plant, better seed setting, and greater test weight under adequate nutrient supply. Similarly, bio-formulations had a strong positive influence, with the combined application of NPK liquid and Zn-solubilizing microbes yielding the highest grain output (1669 kg/ha), a 53.2% increase over the no-bio-formulation control. Straw yield followed a similar trend, rising significantly with increased fertility levels. The maximum straw yield (3325 kg/ha) was obtained under 100% RDF, 36.9% higher than the control, due to greater biomass accumulation. Among bio-formulations, the combined treatment again produced the highest straw yield (3177 kg/ha), followed by Zn-solubilizing microbes and NPK liquid alone, while the control had the lowest. Harvest index values ranged narrowly between 33.69% and 35.45% and were not significantly affected by either fertility levels or bio-formulations. Although 100% RDF and the combined bio-formulation treatment recorded the highest values within their categories, the differences were statistically non-significant, indicating that while these treatments enhanced total biomass and grain yield, they did not substantially alter dry matter partitioning efficiency. Economic analysis showed that profitability of clusterbean cultivation increased significantly with higher fertility levels. Net returns and B:C ratio were lowest in the control (₹32,224/ha; 2.16) and improved progressively with fertilizer application, reaching maximum values under 100% RDF (₹52,980/ha; 2.78). This indicates that adequate nutrient supply substantially enhances economic returns by boosting yield performance. Bio-formulations also contributed to improved profitability. The absence of bio-formulations resulted in the lowest net returns (₹29,652/ha) and B:C ratio (2.11), whereas applying NPK liquid or Zn-

Table 3. Effect of different fertility levels and bio formulations on yield (kg ha^{-1}), harvest index and economics of clusterbean

Treatments	Grain yield	Straw yield	Biological yield	Harvest Index (%)	Net returns (₹)	B:C ratio
Fertility Levels						
Control	1233	2427	3660	33.69	32224	2.16
50% RDF	1576	2997	4573	34.46	44514	2.56
75% RDF	1745	3165	4910	35.54	49679	2.69
100% RDF	1826	3325	5151	35.45	52980	2.78
SEm ±	21	32	51	0.44	1230	0.03
CD	63	98	156	NS	3673	0.10
Bio formulations						
No bio formulation	1089	2267	3356	32.45	29652	2.11
NPK liquid formulation	1256	2796	4052	32.45	40643	2.52
Zn Solubilizing	1488	3097	4585	31.00	37837	2.34
NPK Liquid + Zn Solubilizing	1669	3177	4846	34.44	45033	2.63
SEm ±	17	30	45	0.69	1230	0.03
CD	57	89	135	NS	3673	0.10
CV (%)	7.38	6.88	7.43	5.46	7.24	7.20

Table 4. Effect of different fertility levels and bio formulations on nutrient content (%), uptake (kg/ha) and protein content (%) of clusterbean

Treatments	N content		N uptake		Protein content	P content		P uptake		K content		K uptake	
	Grain	Straw	Grain	Straw		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Fertility Levels													
Control	2.54	0.84	31.32	20.39	15.88	0.35	0.11	4.37	2.61	0.42	0.94	5.18	22.83
50% RDF	2.68	0.87	42.24	26.07	16.75	0.37	0.11	5.90	3.36	0.44	0.99	6.86	29.75
75% RDF	2.72	0.88	47.46	27.85	17.44	0.38	0.11	6.63	3.59	0.44	1.01	7.68	31.88
100% RDF	2.83	0.90	51.68	29.93	17.69	0.40	0.12	7.23	3.87	0.45	1.05	8.22	34.85
SEm ±	0.02	0.01	0.55	0.33	0.30	0.01	0.04	0.06	0.07	0.01	0.01	0.07	0.43
CD	0.06	0.04	1.62	1.01	0.91	0.03	NS	0.17	0.21	0.03	0.04	0.22	1.31
Bio formulations													
No bio formulation	2.42	0.82	26.35	18.59	15.13	0.34	0.10	3.67	2.38	0.41	0.90	4.46	20.32
NPK liquid formulation	2.58	0.85	32.40	23.77	16.69	0.36	0.11	4.52	3.05	0.43	0.96	5.34	26.72
Zn Solubilizing	2.67	0.87	39.73	26.94	16.13	0.37	0.11	5.55	3.47	0.44	0.99	6.47	30.63
NPK Liquid + Zn Solubilizing	2.73	0.89	45.56	28.28	17.06	0.38	0.11	6.37	3.65	0.45	1.01	7.43	32.12
SEm ±	0.02	0.01	0.51	0.30	0.29	0.01	0.03	0.06	0.06	0.01	0.01	0.06	0.40
CD	0.06	0.04	1.49	0.93	0.88	0.03	NS	0.16	0.19	0.03	0.03	0.20	1.21
CV (%)	5.45	5.67	5.43	4.56	6.68	5.20	4.75	5.18	5.35	5.35	5.89	6.45	4.67

solubilizing microbes increased profitability. The combined application of both bio-formulations produced the highest net returns (₹45,033/ha) and B:C ratio (2.63), demonstrating a synergistic effect. Overall, integrating recommended fertilizer doses with bio-formulations offers the most profitable strategy for clusterbean cultivation. Brahmbhatt *et al.* (2024) and Meghana *et al.* (2024) highlight that integrated nutrient management, combining organic and inorganic inputs or biofertilizers, enhances soil fertility, yield stability, and economic efficiency. Such strategies promote sustainable productivity and long-term financial benefits.

3.4 Nutrient Content and Uptake

Nutrient content and uptake in clusterbean were significantly influenced by both fertility levels and bio-formulations (Table 4). Nitrogen content in seed and straw increased with higher fertilizer doses, reaching maximum values of 2.83% and 0.90% under 100% RDF, while the control recorded the lowest levels. Bio-formulations also enhanced nitrogen content, with the combined NPK liquid + Zn-solubilizing treatment achieving the highest values (2.73% in seed, 0.89% in straw). Phosphorus content followed a similar trend, with 100% RDF producing the highest seed and straw P concentrations (0.40% and 0.12%), and the combined bio-formulation treatment providing the greatest improvement among microbial treatments. Phosphorus uptake also rose markedly with higher fertility levels, peaking at 7.23 kg/ha (seed) and 3.87 kg/ha (straw) under 100% RDF. The combined bio-formulation treatment recorded the highest P uptake among bio treatments, while the control remained lowest. Potassium content and uptake were likewise enhanced by increasing fertility levels. Seed and straw potassium content reached maxima of 0.45% and 1.05% under 100% RDF, with the lowest levels in the control. The integrated NPK liquid + Zn-solubilizing formulation again produced the highest K content among bio-formulations. Potassium uptake increased significantly with fertility level, with 100% RDF achieving 8.22 kg/ha in seed and 34.85 kg/ha in straw. Bio-formulations, especially the combined treatment, also improved K uptake compared to untreated control. The combined microbial formulation consistently outperformed individual biofertilizers and the control, demonstrating the strong synergistic effect of integrated nutrient management on nutrient accumulation, uptake efficiency, and overall seed quality in clusterbean. These results align with Singh *et al.* (2014), who reported improved nutrient-use efficiency with Rhizobium inoculation alongside reduced RDF, and with Brahmbhatt *et al.* (2024), who observed higher N, P, and K uptake when biofertilizers were integrated with farmyard manure. Additionally, findings from Gul *et al.* (2019) and Yogi *et al.* (2019) confirm that biofertilizer use and higher fertility levels enhance nutrient uptake, chlorophyll content, and overall physiological performance in clusterbean.

4. CONCLUSION

Application of 100% recommended dose of fertilizers (RDF) consistently produced superior results in terms of plant height, dry matter accumulation, branching, chlorophyll content, and leaf area index. Economically, 100% RDF resulted in the highest net return (₹52,980/ha) and benefit: cost ratio (2.78), proving its agronomic and financial viability. Among bioformulations, the combined application of NPK Liquid + Zn Solubilizing formulation was found to be the most effective. This treatment enhanced growth traits, yield parameters, and nutrient content due to the synergistic role of beneficial microbes in nutrient solubilization, rhizosphere enhancement, and overall plant health. It also recorded the highest net returns (₹45,033/ha) and B:C ratio (2.63), outperforming the untreated control. In nutshell, it may be concluded that conjunctive application of 100% RDF and NPK liquid + Zn solubilizing formulations emerged as most effective treatment with respect to seed yield, net returns and B:C ratio. However, 75% RDF remained equally good as 100% RDF in net returns and B:C ratio, hence may be recommended in addition to the above treatments for enhancing productivity and profitability of clusterbean in semiarid eastern plain zone of Rajasthan.

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 the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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