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Responses of integrated nutrient management at yield attributes on Cluster Bean (*Cyamopsis tetragonoloba* L. Taub.) c.v. Pusa Navbahar at south-western semi arid region U.P.

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Abstract

Background: cluster bean is important legume vegetable mainly grown under irrigated condition during summer and rainy season. The crop also survives even at moderate salinity and alkalinity conditions. This investigation is intended to assess the integrated nutrient management responses on cluster bean green pod c.v. Pusa Navbahar.

Methods: The experiment was carried out during two consecutive years (2021 and 2022) of rainy season on cluster bean at horticultural research farm RBS college Bichpuri Agra U.P. with the combination of eight treatments viz. T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈, T₉, T₁₀, T₁₁, T₁₂ and three replications laid out in randomized block design using the variety Pusa Navbahar of cluster bean for green pod production.

Result: The pooled results showed super imposition of 100% RDF through organic manures (50% RDF through vermicompost+50% RDF through FYM) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹) (applied in soil prior to seed sowing) resulted in significant improvement in yield attributes characters i.e. Number of pods per cluster (8.11), Number of clusters per plant (26.12), Number of marketable clusters plot⁻¹ (435.66), Fresh weight of clusters (31.99 g) Fresh weight of pod per cluster (30.09 g), Yield of pods per plant (808.50 g), Length of raceme (12.54 cm), Length of pod (10.46 cm), Diameter of pod (1.11 cm), Fresh weight of pod (7.03g), Yield of marketable green pods (11053.07 kg/ha), Benefit-cost ratio 3.21. The combined effect of inorganic fertilizers (NPK), organic manure (FYM, vermicompost) and bio-fertilizers (Rhizobium, PSB) was significantly better than their individual effects in the present investigation observed on yield characters.

Keywords: Cluster bean, INM, FYM, Vermicompost, Rhizobium, PSB, Growth, quality

1. Introduction

Cluster bean [*Cyamopsis tetragonoloba* L. Taub] popularly referred as “Guar” is vegetable crop of Indian origin belonging to the family leguminosae [1]. It is an important legume crop mainly grown under irrigated as well as un irrigated condition during summer and rainy season. There is no other legume crop so hardy and drought tolerant as guar, which is particularly suited for the soil and climate of Agra region. Its tender green pods are used for culinary purpose and whole plant is used a roughages for cattle. There is a big demand for Indian gum products, food additives, and food thickener, Guar seed endosperm gum is used in numerous industries, including textiles, confectioneries, medicines, and cosmetics [2]. The aim of integrated nutritional management is to integrate the use of natural and artificial soil nutrients to increase crop productivity and maintain soil fertility without impairing soil health for future generations. In long-term imbalanced use of inorganic fertilizers will not maintain higher yields over the years due to paucity of secondary nutrients will result deterioration physical and chemical properties. Increased use of fertilizer will undoubtedly increase the production of raw materials significantly, but in the sustainable fertility it will have a negative impact on soil health. In case of INM approach, careful application of all nutrients can sustainably improve soil fertility and economic yields [3]. This current study shows the actual impact of the integrated use of inorganic fertilizers combined with organic fertilizers and bio-fertilizers on the growth, and quality of cluster bean and sustainable soil fertility.

Materials and methods

The study was conducted under irrigated condition during the year 2021 and 2022 cropping season in rainy season at R.B.S. College horticulture research farm, Bichpuri, Agra. The research farm is situated to the Agra-Bharatpur Road, 2 km away from Bichpuri, railway station, toward Bharatpur is located at a latitude of 27.2° North and longitude of 77.9° east with an elevation of 163.4 meters above means sea level. Agra has a semi arid and sub tropical climate with hot-dry summers and severe cold. The average annual maximum and minimum temperature is 36 C° and 4 C° respectively. The soil type in the area is light textured sandy loam.

The experiment was laid out randomized block design (RBD) with eight treatments, replicated three times this consist twenty four plots. The Pusa Novbahar variety of cluster bean planted at a 45×30 cm in flat plots consecutive both the years, Net plot size-2.25 m×1.5 m=3.375 mete².

- 1. Data analysis:** All significant pairs of treatment means were compared using the critical difference (CD) at 5% level of significance, coefficient of variation (C.V.) and standard error of mean (SEM).
- 2. Treatment details:** following treatment combination viz. T₁ {Control 100% RDF (25:60:60) N: P: K kg ha⁻¹}, T₂ {RDF +Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed +PSB 5 kg ha⁻¹)}, T₃ {FYM (25 t ha⁻¹)}, T₄ {Vermicompost (10 t ha⁻¹)}, T₅ {75% RDF through inorganic fertilizers + 25% RDF through vermicompost + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}, T₆ {75% RDF through inorganic fertilizers + 25% RDF through FYM + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}, T₇ {50% RDF through

inorganic fertilizers + 50% RDF through FYM + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed +PSB 5 kg ha⁻¹)}, T₈ {50% RDF through inorganic fertilizers + 50% RDF through vermicompost + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}, T₉ {FYM (25 t ha⁻¹) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}, T₁₀ {Vermicompost (10 t ha⁻¹) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}, T₁₁ {100% RDF through organic manures (50% RDF through vermicompost+50% RDF through FYM), and T₁₂ {100% RDF through organic manures (50% RDF through vermicompost+50% RDF through FYM) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}.

Results and Discussion:

1. Number of pods per cluster: An examination of data arranged in Table-1 specified that maximum number of pods per cluster was recorded in treatments T₁₂ (8.11), followed by treatments T₁₁, T₁₀, T₉, T₇, T₈, T₆, and T₅ (i.e., 7.22, 7.10, 7.03, 5.33, 5.25, 5.16, and 5.01 respectively), and treatment T₁₂ proved the significantly superiority than the rest of treatments in the present investigation while the impact of treatment T₉, T₁₀, and T₁₁ were at par. whereas the minimum number of pods per cluster was observed under treatment T₁ (4.07). It is concluded that application of 100% RDF through organic fertilizers, (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹) showed to be superior (8.00 pods and 8.22 pods) during both the years with respect to increase in number of pods per cluster. These results are in accordance with the [10, 15, 17].

Table 1: Performance of different INM combinations on yield attributes studied for cluster bean cv. Pusa Navbahar

Treatment	Number of pods per cluster			Number of clusters per plant			Number of marketable clusters			Fresh weight of clusters (g)			Fresh weight of pod per cluster (g)			Yield of pods per plant (g)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T ₁	3.99	4.15	4.07	20.66	20.33	20.49	325.66	324.66	325.16	24.99	25.03	25.01	20.94	20.98	20.96	343.01	348.67	345.84
T ₂	4.70	4.94	4.82	22.15	21.04	21.77	337.33	332.66	335.00	26.36	25.95	26.16	22.11	22.11	22.11	404.95	419.57	412.26
T ₃	6.44	6.14	6.29	24.03	24.33	24.18	411.00	411.66	411.33	28.33	28.44	28.38	27.38	27.37	27.37	577.44	590.92	584.18
T ₄	6.25	6.11	6.18	24.22	24.22	24.22	414.66	414.33	414.50	28.36	28.44	28.40	27.36	27.37	27.36	587.60	601.06	594.33
T ₅	4.99	5.03	5.01	22.21	22.55	22.38	375.00	374.33	374.66	26.81	26.04	26.42	24.55	24.53	24.54	452.52	455.30	463.91
T ₆	5.22	5.11	5.16	22.66	22.88	22.77	377.33	375.66	376.50	26.66	26.40	26.53	25.25	25.63	25.44	505.82	506.9	505.95
T ₇	5.33	5.33	5.33	22.88	23.44	23.16	380.33	377.33	378.83	27.18	27.44	27.31	26.08	26.08	25.73	514.34	535.39	524.86
T ₈	5.14	5.36	5.25	23.44	23.33	23.38	383.66	382.33	383.00	27.99	28.36	28.18	25.59	25.38	26.59	555.66	545.36	550.51
T ₉	7.07	7.00	7.03	24.44	24.77	24.60	417.33	415.66	416.50	29.33	29.70	29.51	28.33	26.60	28.46	695.27	703.37	699.32
T ₁₀	7.10	7.11	7.10	24.36	24.66	24.51	419.00	418.66	418.83	29.77	29.81	29.79	28.44	28.60	28.40	712.00	711.56	711.78
T ₁₁	7.11	7.33	7.22	24.99	25.22	25.10	429.00	425.00	427.00	30.55	30.88	30.71	28.99	28.37	28.99	755.85	751.85	753.86
T ₁₂	8.00	8.22	8.11	25.70	26.55	26.12	434.66	436.66	435.66	31.88	32.11	31.99	29.81	30.36	30.09	810.81	806.20	808.50
S.Em+/-	0.22	0.19	0.14	0.21	0.28	0.25	1.27	1.41	0.95	0.27	0.28	0.19	0.24	0.27	0.27	3.42	3.88	3.65
CD at 5%	0.66	0.56	0.42	0.62	0.83	0.50	3.72	4.15	2.72	0.81	0.82	0.56	0.71	0.81	0.81	10.03	11.38	10.42

2. Number of clusters per plant: The data depicted in Table-1 of the pooled data study for two years, combined effect of INM treatments showed significance influence on number of clusters per plant. However treatment T₁₂ was recorded maximum number of clusters per plant (26.12) and proved significant trustworthy over rest of the treatment which was followed by T₁₁, T₉, T₁₀, T₄, T₃, T₈, T₇, T₆, T₅, and T₂ respectively. While minimum number of clusters per plant was counted under treatment T₁. Application of proper integration of 100% RDF through organic manures {(50% RDF through vermicompost, and 50% RDF through FYM) + bio-fertilizers (Rhizobium 25 g kg⁻¹ seed treatment + PSB

5 kg ha⁻¹ soil application)}, these maximum number of clusters per plant were obtained which was also significantly higher than other treatment including T₁. Similar results were also quoted by [10, 15-17].

3. Number of marketable clusters plot⁻¹: An examination of pooled data proclaimed significant effect on maximum number of marketable clusters per plot (435.66) was recorded in treatment T₁₂, [100% RDF through organic manures {(50% RDF through vermicompost, and 50% RDF through FYM) + bio-fertilizers (Rhizobium 25 g kg⁻¹ seed treatment + PSB 5 kg ha⁻¹ soil application)}], followed by

T₁₁, T₁₀, T₉, T₈, T₇, T₆, and T₅ (i.e., 427.00, 418.83, 416.50, 383.00, 378.83, 376.50 and 374.66 respectively). However, the minimum clusters per plot was noted T₁ (325.16). Similar results were also reported by [15].

4. Fresh weight of clusters: An examination of Table-1 showed pooled data that Statistically highest fresh weight of cluster (g) of cluster bean were noted in treatment T₁₂ (31.88, 32.11 and 31.99) during the first year, second and pool data where the cluster bean was grown under the field condition and lowest fresh weight of cluster (g) were observed in treatment T₁ (24.99, 25.03, and 25.01) during the both years and pool data. The probable reason for gaining higher fresh weight of cluster (g) might be due to integration of 100% RDF through organic fertilizers, (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹) was most effective treatment which might have made favourable condition for the plant growth. This result was conformity with [17].

5. Fresh weight of pod per cluster: Data depicted in Table-1 showed pooled data that the maximum fresh weight of pod per cluster (g) (30.09) was recorded under treatment T₁₂, followed by T₁₁ (28.99), While the minimum fresh

weight of pod per cluster (g) was treatment T₁ (20.96), followed by T₂ (22.11). it was found that application of 100% RDF through organic manures (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed treatment + PSB 5 kg ha⁻¹ soil application) (T₁₂), highest fresh weight of pod per cluster (g) (29.81g and 30.36 g) yielded maximum fresh weight of pods per cluster which was also significantly higher than the other rest treatments. Similar results were also delineated by [14, 15].

6. Yield of pods per plant: The pooled data exhibited the maximum yield (g) of pods per plant (808.50) was recorded in treatment T₁₂, followed by treatments T₁₁, T₁₀, T₉, T₈, T₇, T₆, and T₅ respectively. While the minimum yield (g) of pods per plant was noted T₁ (345.84), followed by T₂ (412.26) (Table-1). it was observed that application of 100% RDF through organic manures (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed treatment + PSB 5 kg ha⁻¹ soil application) (T₁₂), Yield of pods per plant (g) (810.81g and 806.20 g) yielded the maximum yield which was also significantly higher than other lower treatments. Similar results were also delineated by [8, 11, 15, 16, 17].

Table 2: Performance of different INM combinations on yield attributes studied for cluster bean cv. Pusa Navbahar

Treatment	Length of raceme (cm)			Length of pod (cm)			Diameter of pod (cm)			Fresh weight of pod (g)			Yield of marketable green pods (kg/ha)			Benefit-cost ratio (b: c)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Mean
T ₁	9.54	9.33	9.53	6.46	6.46	6.46	0.71	0.72	0.71	3.34	3.28	3.31	7521.18	7474.66	7497.92	2.10	2.08	2.09
T ₂	9.77	9.76	9.77	7.17	7.11	7.14	0.80	0.82	0.81	3.90	4.23	4.06	8014.33	7873.79	7960.84	2.28	2.22	2.26
T ₃	11.43	11.36	11.40	9.04	9.22	9.13	0.93	0.92	0.92	5.07	5.35	5.21	9542.93	9465.33	9504.13	1.77	1.74	1.76
T ₄	11.46	11.42	11.44	9.20	9.24	9.22	0.92	0.93	0.92	5.11	5.25	5.18	9615.60	9523.14	9569.37	1.04	1.02	1.03
T ₅	10.15	10.13	10.14	7.43	7.60	7.52	0.77	0.84	0.81	4.46	4.19	4.32	8163.66	8106.00	8134.83	2.21	2.18	2.19
T ₆	10.27	10.29	10.28	7.50	7.87	7.69	0.80	0.86	0.83	4.68	4.57	4.62	8218.11	8144.96	8181.53	2.23	2.20	2.21
T ₇	10.47	10.45	10.46	8.16	8.09	8.13	0.82	0.87	0.84	4.87	4.82	4.84	8267.13	8219.44	8243.29	2.16	2.14	2.15
T ₈	10.76	10.87	10.81	8.30	8.70	8.50	0.85	0.88	0.86	4.94	4.99	4.96	8397.16	8379.80	8388.48	2.29	2.28	2.29
T ₉	11.86	11.61	11.74	9.50	9.53	9.52	0.95	0.99	0.97	6.23	6.07	6.15	9710.36	9611.23	9660.80	1.72	1.69	1.71
T ₁₀	11.93	11.79	11.86	9.60	9.70	9.65	0.96	0.97	0.96	6.27	6.39	6.33	9800.83	9700.33	9750.48	1.03	1.01	1.02
T ₁₁	12.37	12.02	12.19	9.74	9.89	9.81	1.00	1.01	1.00	6.47	6.31	6.39	10736.36	10327.67	10532.01	3.27	3.11	3.20
T ₁₂	12.71	12.37	12.54	10.38	10.54	10.46	1.11	1.10	1.11	6.81	7.25	7.03	11205.80	10900.33	11053.07	3.28	3.14	3.21
S.Em+/-	0.081	0.07	0.07	0.21	0.21	0.15	0.02	0.03	0.02	0.11	0.27	0.14	153.40	123.69	139.34	2.10	2.08	2.09
CD at 5%	0.23	0.22	0.15	0.63	0.61	0.43	0.08	0.09	0.06	0.32	0.81	0.42	449.91	362.78	280.82	2.28	2.22	2.26

7. Length of raceme: The pooled data showed that the significantly maximum length of raceme (12.54 cm) was recorded in T₁₂, followed by T₁₁ (12.19). While the minimum length of raceme (cm) was noted in treatment T₁ (9.53), followed by T₂ (9.77). Further examination of the data showed that treatments T₂, T₃ and T₄ (9.77, 11.40 and 11.44) significantly improved length of raceme (cm) over treatment T₁ (9.33) (Table- 2). Increased in length of raceme (cm) may be associated with the production of growth promoting substances, FYM, vermicompost and bio-fertilizers, which might have led to helped in general way to activate the physiological processes in the plant system. Similar results were also reported by [17].

8. Length of pod: The pooled data study for two year, The highest length of pod during both years (10.46) was observed in treatment T₁₂ {100% RDF through organic manures (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed

treatment + PSB 5 kg ha⁻¹ soil application)}, while the minimum length of pod (cm) (6.46) during both the years was recording under treatment T₁(RDF N: P: K kg ha⁻¹ 25:60:60). It could be revealed that integration of 50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed treatment + PSB 5 kg ha⁻¹soil application) might have accelerated the rate of metabolic activities in the plant system that might have resulting in increasing length of pod. These results were in conformity with the finding of [4, 5, 7, 13, 14, 16, 17].

9. Diameter of pod: The pooled data confirmed that the significantly maximum diameter of pod (cm) (1.11) was recorded in T₁₂, followed by treatments T₁₁, T₁₀ T₉, T₈, T₇, T₆, and T₅ respectively. However the minimum diameter of pod (cm) was seen under T₁ (0.71) followed by T₂ (0.81). The diameter of pod (cm) was found to be maximum under the treatment T₁₂ {100% RDF through organic fertilizers, 50% RDF through vermicompost, and 50% RDF through

FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹) during the both years 2021 and 2022 respectively, while minimum diameter of pod (cm) was observed that (0.71 cm and 0.72 cm) under the treatment T₁ during the both years. Similar results quoted by [4, 13, 14, 17].

10. Fresh weight of pod: The pooled data exhibited the maximum fresh weight of pod (g) (7.03) was recorded under the treatment T₁₂ [100% RDF through organic manures (50% RDF through vermicompost+50% RDF through FYM) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)], followed by treatment T₁₁ (6.39) While, lowest (3.34 g and 3.28 g) was recorded under RDF N: P: K kg ha⁻¹ (25:60:60) (T₁). Similar results were also reported by [4, 8, 9, 13, 14, 15, 17].

11. Yield of marketable green pods: (11053.07 kg/ha) The pooled data put on view that the maximum yield of marketable green pods (kg/ha) (11053.07) was recorded in the treatment T₁₂ followed by treatment T₁₁ (10532.01) during both years of study. However, the minimum yield of marketable green pods (kg/ha) was seen under treatment T₁ (7497.92), followed by T₂ (7960.84). The magnitude of increase in yield of green pods (kg/ha) with T₁₂ treatment was 47.41% than treatment T₁. Effect of treatments T₂, T₃, and T₄ significantly improved yield of green pods (kg/ha) better than treatment T₁. The probable reason for higher yield of green pods might be due to integration of 100% RDF through organic fertilizers, (50% RDF through vermicompost, and 50% RDF through FYM) and bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹) was effective which might have made favorable condition for the root growth and development and induced changes in root morphology. Which in turn, affected the assimilation of nutrients. Enhanced accumulation of nutrients, increased growth and yield attributes and ultimately yield of cluster bean. There is parity of results of [4, 5, 9, 6, 17].

12. Benefit-cost ratio: The mean value of data showed that the maximum benefit cost- ratio (3.21) was calculated under the treatment T₁₂ followed by treatment T₁₁ (3.20), while the minimum benefit-cost ratio was recorded under the treatment T₁₀ (1.02), followed by treatment T₄ (1.03). The mean data of two years revealed that 100% RDF through organic manures 50% RDF through vermicompost, and 50% RDF through FYM + Bio fertilizers Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹ significantly increased the benefit-cost ratio of cluster bean c.v. Pusa Navbahar, whereas application of bio-fertilizers with RDF (T₂) could not brought out any remarkable effect on the benefit cost ratio. Except for this, all other INM treatment combinations also showed beneficial effects over treatment T₁ {RDF [NPK 30:60:60]} alone. Similar results were also reported by [10, 12].

Conclusion

It is concluded that The inorganic and organic fertilizers or manures along with bio-fertilizers alone or in combination were found to have significant effect on growth characters as compared to RDF treatment. It is evident from Table 1 and table 2 that among all the twelve treatments, T₁₂ {100% RDF through organic manures (50% RDF through vermicompost+50% RDF through FYM) + Bio-fertilizers (Rhizobium 25 g kg⁻¹ seed + PSB 5 kg ha⁻¹)}. recorded the

highest Number of pods per cluster (8.11), Number of clusters per plant (26.12), Number of marketable clusters plot⁻¹ (435.66), Fresh weight of clusters (31.99 g) Fresh weight of pod per cluster (30.09 g), Yield of pods per plant (808.50g), Length of raceme (12.54 cm), Length of pod (10.46 cm), Diameter of pod (1.11 cm), Fresh weight of pod (7.03g), Yield of marketable green pods (11053.07 kg/ha), Benefit-cost ratio 3.21. The reason might be due to higher availability of nutrients as a result of integration of organic and inorganic sources with bio-fertilizers Pusa Navbahar Variety cluster bean. hence above treatment recommended to the farmers like agro climatic zone south-western semi arid region U.P.

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