Productivity and Profitability of Clusterbean as Influenced by Fertility Levels and Bio-inoculants

Soni Divya, Dudwal B.L.*, Choudhary Roshan, Ghasil Anju and Dudwal S.K.
S.K.N. Agriculture University Jobner, Jaipur, Rajasthan, INDIA
*bldudwal.agro@sknau.ac.in

Abstract

A field experiment entitled "Productivity and Profitability of Clusterbean as Influenced by Fertility Levels and Bio-inoculants" was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during the Kharif, 2024 on loamy sand soil. The experiment was laid-out in factorial randomized block design replicated thrice consisting of 16 treatment combinations viz. four fertility levels [control, 40%, 80% and 100% RDF] and four bio-inoculants [control, Rhizobium, PSB and Rhizobium + PSB]. The results showed the significantly higher number of pods per plant (35.94), number of seeds per pod (8.51), test weight (29.14 g), seed yield (1495 kg/ha), haulm yield (3528 kg/ha) and biological yield (5023 kg/ha) along with net returns of ₹ 67,570/ha and B:C ratio of 3.09 in 100% RDF. Among different bio-inoculants, significantly higher number of pod/plant (35.22), number of seed/pod (8.30), test weight (29.01 g), seed yield (1489 kg/ha), haulm yield (3515 kg/ha) and biological yield (5003 kg/ha) where observed along with net returns of ₹ 67,556/ha and B:C ratio of 3.12 in Rhizobium + PSB. Treatment Rhizobium and PSB alone remained at par to each other but significantly higher than control.

Results also showed that combined effect of 80% RDF with Rhizobium + PSB significantly increased the number of pods per plant, number of seeds per pod, test weight, seed yield, haulm yield and biological yield along with net returns and B:C ratio and it was equally effective with combination of 100% RDF with Rhizobium + PSB.

Keywords: Yield, *Rhizobium*, PSB, Profitability, Clusterbean.

Introduction

Clusterbean, popularly known as guar [*Cyamopsis tetragonoloba* (L.) Taub], is an annual legume of the Fabaceae family. It is mainly cultivated in India's arid and semi-arid regions during the kharif and summer seasons. The crop has a coarse, upright and bushy growth pattern, making it a hardy summer legume well adapted to withstand drought conditions[14]. The tender green pods of clusterbean are widely eaten as a nutritious and tasty vegetable. It also acts as an important forage crop, supplying quality fodder for livestock. Owing to its ability to thrive under harsh conditions, clusterbean holds great importance in water-scarce and arid regions[4]. Clusterbean, a dicotyledonous crop, has seeds that consist of three major parts: the husk or hull (14–17%), the endosperm (35–42%) and the germ (43–47%).

In India, it is primarily cultivated in States like Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh and Maharashtra, covering 3.21 million hectares with a production of 1.78 million tonnes and an average yield of 556 kg/ha[2]. Rajasthan alone accounts for nearly 80% of the country's total clusterbean production, with major growing areas including Bikaner, Churu, Jaipur, Jhunjhunu and Sikar. The State cultivates clusterbean on 2.29 million hectares, producing 1.16 million tonnes with an average productivity of 540 kg/ha[1]. In the sandy soils of semi-arid areas, crop production is mainly constrained by drought stress and nutrient deficiencies, especially nitrogen and phosphorus.

Under such conditions, guar proves to be a promising cash crop due to its drought tolerance and soil-improving qualities. Its nitrogen-fixing ability not only enhances soil fertility but also contributes to maintaining long-term productivity[12]. Clusterbean improves soil fertility by efficiently fixing a significant amount of atmospheric nitrogen[19]. It has the capacity to fix approx 37-196 kg of atmospheric nitrogen per hectare per year into the soil while also contributing organic matter to the soil. Additionally, it is utilized in the reclaimation of saline and alkaline soils[10].

Fertilizers and bio-fertilizers play a crucial role in enhancing clusterbean yield. Nitrogen availability to the legumes can be increased either with manual inoculation or with application of commercial nitrogen fertilizer[13]. The primary limitation of pulse crop production in these regions is the lack of available moisture and nutrient especially phosphorus[17]. Phosphorus is second important plant nutrient after nitrogen. Phosphorus stands as the indispensable mineral nutrient for leguminous crops, crucial for fostering robust root growth and development. This helps in increasing efficiency in biological nitrogen fixation (BNF). Within legumes, phosphorus serves as a vital component of nucleic acids (RNA and DNA), as well as ADP and ATP molecules, nucleoproteins and various coenzymes[11].

Liquid biofertilizers are microbial formulations containing dormant propagules of target microorganisms, supplemented with essential nutrients and stabilizing agents that induce the formation of resistant structures such as spores or cysts. These attributes ensure prolonged shelf life and enhanced tolerance to environmental stresses.

Inoculation with suitable PSB isolates can significantly curtail the requirement for synthetic phosphorus fertilizers, thereby promoting sustainable nutrient management[8].

The introduction of an efficient *Rhizobium* strain into soil can improve productivity by increasing the *Rhizobium* population and enhancing biological nitrogen fixation. Phosphate-solubilizing bacteria play a crucial role in converting unavailable phosphorus in the soil into available form. Therefore, the combined approach of fertilization and seed inoculation with *Rhizobium* and phosphate-solubilizing bacteria promotes nodulation, enhances crop growth, facilitates nutrient uptake and ultimately increases crop yield[16].

Material and Methods

The experiment was laid-out in factorial randomized block design replicated thrice consisting of 16 treatment combinations *viz.* four fertility levels [control, 40%, 80% and 100% RDF] and four bio-inoculants [control, *Rhizobium*, PSB and *Rhizobium* + PSB] on 11 July 2024 at Agronomy farm, S.K.N. College of Agriculture, Jobner. Geographically, Jobner is situated 45 km west of Jaipur at 26º 05' North latitude, 75º 28' East longitude and at an altitude of 427 m above mean sea level. The area falls in agro climatic zone-IIIA (Semi-arid eastern plain zone) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. The average annual rainfall of this tract ranges between 400-500 mm, most of which is contributed by the S-W monsoon during the months of July and August. The relative humidity fluctuates between 43 to 87 per cent. The maximum and minimum temperatures during the crop season ranged between 31.4-37.8 ºC and 17.2-27.8 ºC respectively. A total of 677.1 mm rainfall was recorded during crop season, major part of which was received in the July-August months. The relative humidity fluctuated between 61 to 97 per cent, while the average sunshine hours ranged between 0.68 to 8.51 hrs./day during crop season.

Seeds of the clusterbean variety RGC – 1038 were sown in rows spaced at 30 cm apart, using seed rate of 20 kg/ha. Minerals N and P were supplied through urea and single super phosphate respectively. Seeds were inoculated with *Rhizobium*, PSB and *Rhizobium* + PSB. For absolute control, nothing was applied for entire crop season. The observation were recorded at harvest was analysed by statistical methods[7].

Results and Discussion

Yield attributes and yield: An assessment of data (Table 1) revealed that successive increases in fertility levels up to 100% RDF (20 kg N + 40 kg P_2O_5 + 00 kg K_2O/ha) significantly enhanced yield attributes *viz*. pods per plant, seeds per pod, test weight, seed yield, haulm yield and biological yield of clusterbean, as compared to the control, 40% RDF and 80% RDF. However, the response at 100% RDF remained statistically at par with 80% RDF. The improvement in plant vigour and growth can be attributed to an adequate nitrogen supply during the early growth stages, which stimulates vegetative development and biomass accumulation. Consequently, nitrogen fertilization plays a vital role in improving seed set and enhancing yield traits of clusterbean, as reported by Brar and Singh[5].

Phosphorus also played a crucial role in yield improvement by facilitating energy transfer within the plant. During the early growth stages, it supported the storage of assimilates, which were subsequently remobilized to seeds and pods during the reproductive phase, particularly when current photosynthetic activity was insufficient to meet the plant's demand. This remobilization, occurring during seed filling and leaf senescence, contributed to greater seed weight and improved seed yield. Enhanced physiological activity during the reproductive stage further promoted metabolite synthesis and translocation to the developing pods and seeds, resulting in better seed filling and ultimately higher test weight.

The results of this study are in line with earlier findings by Singh and Kumar[18] and Raiger et al[15] in clusterbean. Further assessment of data (Table 1) indicated that the combined application of *Rhizobium* + PSB significantly increased the yield attributes *viz*. number of pods per plant, number of seeds per pod, test weight, seed yield, haulm yield and biological yield of clusterbean compared to all other treatments. Inoculation with *Rhizobium* and PSB individually remained at par with each other but both significantly increased the seed, haulm and biological yields over control. Enhanced microbial activities, particularly biological nitrogen fixation and phosphorus solubilization mediated by efficient microbial strains, contributed to improved rhizospheric conditions and subsequently increased crop yield. According to Verma and Yadav[20], these growth factors increased availability of nitrogen, phosphorus in the soil might playing a role in increasing the seed, haulm and biological yield of clusterbean. A significant interaction (Tables 2, 3, 4 and 5) between fertility levels and bio-inoculants application was observed for pods/plant, seed yield, haulm yield and biological yield. The combination of *Rhizobium* + PSB with 80% RDF yielded results statistically at par with 100% RDF, indicating the potential to reduce chemical inputs without compromising productivity or profitability.

Economics: A close study of data presented in table 6 shows that net returns (₹67570 /ha) and B:C ratio (3.09) of clusterbean were successively and significantly improved with the application of fertilizers up to 100% RDF which was statistically at par with 80% RDF. Despite the slightly higher cost of applying 100% RDF, the notable enhancement in yield and its components resulted in a substantial rise in income, thereby boosting overall profitability. These findings align with previous studies by Daisy et al[6] in cotton and Kumawat et al[9] in clusterbean.

Table 1
Effect of fertility levels and bio-inoculants on yield attributes and yield of clusterbean

Treatment	Pod/plant	Seed/pod	Test weight (g)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Biological yield (kg/ha)
Fertility level						
Control	29.12	7.04	26.88	1169	2901	4070
40% RDF	31.50	7.31	27.86	1298	3214	4512
80% RDF	34.82	8.11	28.76	1462	3485	4990
100% RDF	35.94	8.51	29.14	1495	3528	5023
SEm±	0.34	0.15	0.22	20	21	31
CD(P=0.05)	1.02	0.45	0.62	60	63	93
Bio-inoculant						
Control	29.93	7.18	26.69	1207	2983	4190
Rhizobium	32.92	7.79	28.02	1357	3327	4664
PSB	32.25	7.66	27.58	1312	3283	4595
Rhizobium + PSB	35.22	8.30	29.01	1489	3515	5003
SEm±	0.34	0.15	0.22	20	21	31
CD(P=0.05)	1.02	0.45	0.62	60	63	93
CV%	7.23	8.33	7.31	8.27	7.47	7.37

Table 2
Interactive effect of fertility levels and bio-inoculants on pod/plant

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	26.16	28.53	28.36	31.42
F_1	27.60	32.89	31.14	35.37
F_2	31.14	35.73	33.06	39.28
F_3	32.79	35.92	34.02	40.01
Factor	**SEm±**	**CD**		
B x F	0.68	2.04		

Table 3
Interactive effect of fertility levels and bio-inoculants on seed yield

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	1008	1156	1127	1285
F_1	1194	1313	1286	1439
F_2	1288	1427	1413	1620
F_3	1375	1509	1498	1690
Factor	**SEm±**	**CD**		
B x F	40	120		

Table 4
Interactive effect of fertility levels and bio-inoculants on haulm yield

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	2518	2870	2861	3356
F_1	2833	3379	3239	3406
F_2	3271	3437	3428	3694
F_3	3310	3499	3431	3701
Factor	**SEm±**	**CD**		
B x F	42	126		

Table 5
Interactive effect of fertility levels and bio-inoculants on biological yield

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	3656	4036	3987	4601
F_1	3987	4692	4525	4845
F_2	4458	4974	4941	5275
F_3	4660	5033	4927	5391
Factor	**SEm±**	**CD**		
B x F	62	186		

Table 6
Effect of fertility levels and bio-inoculants on economics of clusterbean

Treatment	Net returns (₹/ha)	B:C ratio
Fertility level		
Control	49927	2.70
40% RDF	56454	2.86
80% RDF	65289	3.00
100% RDF	67570	3.09
SEm±	839	0.03
CD(P=0.05)	2425	0.09
Bio-inoculant		
Control	51119	2.69
Rhizobium	60218	2.95
PSB	57446	2.86
Rhizobium + PSB	67556	3.12
SEm±	839	0.03
CD(P=0.05)	2425	0.09
CV%	7.72	7.79

Table 7
Interactive effect of fertility levels and bio-inoculants on net returns

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	43091	49380	47949	56700
F_1	49859	58612	56040	63782
F_2	51196	64166	62910	76885
F_3	59820	68715	66886	78857
Factor	**SEm±**	**CD**		
B x F	1679	4851		

Table 8
Interactive effect of fertility levels and bio-inoculants on B:C ratio

Mean				
B x F TABLE	**B_0**	**B_1**	**B_2**	**B_3**
F_0	2.471	2.678	2.644	2.90
F_1	2.671	2.954	2.859	3.03
F_2	2.820	3.010	3.008	3.20
F_3	2.725	3.098	2.911	3.39
Factor	**SEm±**	**CD**		
B x F	0.06	0.18		

Further assessment of data (Table 6) indicated that the combined application of *Rhizobium* + PSB significantly increased the net returns (₹67556 /ha) and B:C ratio (3.12) of clusterbean. Bio-inoculants application improved seed yield, leading to higher net returns and B:C ratio. These findings are consistent with Anupama et al[3] and Verma and Yadav[20]. A significant interaction (Table 7 and 8) between fertility levels and bio-inoculants application was observed

for net returns and B:C ratio. The combination of *Rhizobium* + PSB with 80% RDF yielded results statistically at par with 100% RDF.

Conclusion

It is concluded that fertility level of 100% RDF resulted in the highest pod/plant, seed yield, haulm yield, biological yield, net returns and B:C ratio. Among bio-inoculants, application of *Rhizobium* + PSB was found as most efficient treatment in terms of pod/plant, seed yield, haulm yield, biological yield, net returns and B:C ratio. In combined effect, the highest pod/plant, seed yield, haulm yield, biological yield, net returns and B:C ratio were recorded with the treatment combination of 100% RDF along with *Rhizobium* + PSB applied, which showed the similar influence with 80% RDF along with *Rhizobium* + PSB.

Hence, the integration of 80% RDF along with *Rhizobium* + PSB emerged out as the best treatment for maximizing clusterbean productivity and profitability in the semi-arid eastern plain zone (IIIa) of Rajasthan.

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