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Manjeet Singh
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Harish Kumar Bijarnia
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Pooja Naruka
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Balram Dhakar
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Vishnu Kumar Sharma
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Corresponding Author:
Harish Kumar Bijarnia
Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Effect of fertility levels and liquid biofertilizers on growth, yield and quality of clusterbean [*Cyamopsis tetragonolba* (L.) Taub.]

Manjeet Singh, Harish Kumar Bijarnia, Pooja Naruka, Balram Dhakar and Vishnu Kumar Sharma

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Abstract
A field experimented was conducted during *kharif* season of 2023 at Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur to study the effect of fertility levels and biofertilizers on growth and yield of clusterbean. The results reveals that the application of 100% RDF + Liquid *Rhizobium* registered significantly higher values of growth and yield of clusterbean under the agro-climatic condition of Jaipur.

Keywords: Clusterbean, liquid biofertilizers, fertility levels, *Rhizobium* and phosphorus solubilizing bacteria

1. Introduction
Clusterbean [*Cyamopsis tetragonaloba* (L.) Taub], a *kharif* pulse crop is considered as one of the most drought tolerant deep-rooted and annual legume in India (Meena *et al.*, 2016) [11]. The crop is grown for fresh vegetable and for gum purpose. The crop survives best even at moderate levels of salinity and alkalinity. In India, the crop is mainly grown in the dry habitats of Rajasthan, Haryana, Gujarat and Punjab and to a limited extent in Uttar Pradesh and Madhya Pradesh. The crop is grown for different purposes such as vegetables green fodder, green manure and seed. Guar seed is used as concentrate for animals and for extraction of gum. Gum is one of the products because of which the crop has emerged as a new industrial crop of export value. The use of guar gum has increased tremendously, as it is the natural absorbent. It has diversified uses like in textile, printing, cosmetic, mining, explosives and pharmaceutical industries, oil industry and toilet goods. India occupies top position in the world trade for guar gum. The guar meal which remains after extraction of gum from the seed is a high protein cattle feed (Khan *et al.*, 2017) [7].
The average productivity of crop is low mainly due to cultivation of traditional low yielding varieties without or with little fertilization. Thus, it offers a great scope for increasing its productivity through fertilization. Clusterbean is highly responsive to nitrogen fertilizers.
Improper nutrient management under limited moisture are considered as major limiting factors for achieving higher productivity of clusterbean in semi-arid region. The nutrient management thus assumes importance to sustain its productivity. Due to poor socioeconomic conditions of farmers coupled with low and erratic rainfall distribution, the intensive use of chemical fertilizers is a risky proposition in these regions. So low cost nutrient supplementation through biofertilizers as integrated nutrient supply system may be a better option to fulfill nutrient requirement of the crop (Ayub *et al.*, 2016) [1].
Clusterbean is leguminous crop and can fix 37-196 kg N ha^{-1} $year^{-1}$. Nitrogen promotes the leaf, stem and other vegetative growth. It also increase protein content in clusterbean. Phosphorus enhances the activity of rhizobia and increase the formation of root nodules. It involves in metabolic activities as a constituent of nucleoproteins, nucleotides and also play a key role in the formation of energy rich phosphate bond like ADP and ATP. Phosphorus fertilization also improves the quality of clusterbean grains (Kumar *et al.*, 2016) [9].

Biofertilizers play an important role in increasing availability of nitrogen and phosphorus. They increase the biological fixation of atmospheric nitrogen and enhance phosphorus availability to the crop. Inoculation of seed with *Rhizobium* culture is a very low cost method of nitrogen fertilization in legumes and it is reported to increase the yield to the extent of 15-20 kg ha^{-1} (Saharan and Singh, 2023) [17]. However, information regarding fertility levels and biofertilizers on growth and yield of clusterbean in Rajasthan is lacking. Keeping in view the above discussed facts of sufficient information and sparse related research, the present investigation was undertaken to find out the effect of fertility levels and biofertilizers on growth and yield of clusterbean.

2. Materials and Methods

An experiment was conducted during *kharif* season of 2023 at Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (located at 26°92' North, 75°77' East). The soil was loamy sand in texture having a pH of 8.2 (Alkaline), EC 1.1 (dS m^{-1}), low in organic carbon (0.14%) and low available nitrogen (132.7 kg ha^{-1}), medium in available phosphorus (16.3 kg ha^{-1}) and low in available potassium (150.4 kg ha^{-1}). The experiment was conducted in randomized block design with replicate thrice consisted of ten treatments *viz.* Control, 50% RDF + Liquid *Rhizobium*, 50% RDF + Liquid Phosphorus Solubilizing Bacteria, 50% RDF + Liquid Potassium Solubilizing Bacteria, 75% RDF + Liquid *Rhizobium*, 75% RDF + Liquid Phosphorus Solubilizing Bacteria, 75% RDF + Liquid Potassium Solubilizing Bacteria, 100% RDF + Liquid Rhizobium, 100% RDF + Liquid Phosphorus Solubilizing Bacteria and 100% RDF + Liquid Potassium Solubilizing Bacteria. The treatments were allocated randomly to each plot. Urea and di ammonium phosphate were used as a source of nitrogen and phosphorus. The crop was fertilized with 20 kg N, 40 kg P_2O_5 and 0 kg K_2O ha^{-1} giving a full dose of all the fertilizers as basal dose at the time of sowing. While, biofertilizers were used for seed treatment @ 10 ml kg^{-1} of seed. RGC-1002 variety of clusterbean was used as a test crop. Other crop management methods were accompanied as per the recommendation of the area.

Statistical analysis and interpretation of data: Data recorded on various parameters of clusterbean crop in the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984) [5]. The levels of significance used in 'F' and 't' test was p= 0.05. Critical difference values were calculated where F test was found significant.

3. Results and Discussion

An examination of the data shows marked effect on fertility levels and liquid biofertilizers on growth characters at harvest stage (Table 1). A critical scanning of the data indicated that application of (T_8) 100% RDF + Liquid Rhizobium recorded significantly higher plant height (94.19 cm), plant dry matter (168.59 g $plant^{-1}$) and number of branches $plant^{-1}$ (11.34) which was statistically at par with application of (T_9) 100% RDF + Liquid Phosphorus Solubilizing Bacteria and (T_{10}) 100% RDF + Liquid Potassium Solubilizing Bacteria. However, least values of growth characters was recorded under (T_1) control treatment during course of study. The overall improvement in crop growth under the influence of fertility levels with biofertilizers could possibly be attributed to better development of roots and increased microbial activities due to better soil health.

The combined inoculation of nitrogen and phosphate fixers benefits the plant more than either group of organisms alone and might have added advantages in the present agro-ecosystem. These results are in close conformity with the findings of Rathore *et al.* (2005) [15]; Reddy *et al.* (2011) [16] and Singh and Kumar (2016) [9] in clusterbean and Singh and Pareek (2003) [20] in mungbean and Meena *et al.* (2013) [14] in chickpea.

The data pertaining to yield attributes of clusterbean as influenced by fertility levels and liquid biofertilizers are presented in Table 2. Among the treatments, application of (T_8) 100% RDF + Liquid *Rhizobium* recorded significantly higher number of pods (38.80 $plant^{-1}$) and number of seeds pod^{-1} (7.72) which was statistically at par with (T_9) 100% RDF + Liquid Phosphorus Solubilizing Bacteria over rest of the treatments.. While, test weight was found to be non-significant.

Yield and harvest index were also significantly influenced by the application of fertility levels and biofertilizers (Table 3). The maximum seed yield (1008.73 kg ha^{-1}), haulm yield (2701.79 kg ha^{-1}), biological yield (3710.52 kg ha^{-1}) and harvest index (27.19%) were recorded with application of (T_8) 100% RDF + Liquid *Rhizobium* which was statistically at par with (T_9) 100% RDF + Liquid Phosphorus Solubilizing Bacteria and (T_{10}) 100% RDF + Liquid Potassium Solubilizing Bacteria over rest of the treatments except for seed yield and harvest index. However, least values were observed with (T_1) control during course of investigation.

This might be due to improvement in overall growth and development due to higher fertility levels coupled with Rhizobium biofertilizers increased net photosynthesis on one hand and greater mobilization of photosynthetic and nutrients towards reproductive structures on the other might have increased the yield attributes significantly. Conversely, deficiency of nutrients in the experimental field as such affecting the crop growth and development (flowering and seed setting) adversely under unfertilized control. The seed yield, being a function primarily of the yield attributes, their cumulative effect also enhanced the seed yield significantly. The results of present investigation are in line with those of Rathore *et al.* (2005) [15], Reddy *et al.* (2011) [16] and Singh and Kumar (2016) [4] in clusterbean and Nadeem *et al.* (2003) [13] in pea, Suman *et al.* (2007) [22] in greengram, Ilavarasi *et al.* (2007) [6] and Choudhary and Yadav (2011) [4] in cowpea who obtained increased yield attributes, seed yield $plant^{-1}$, seed, haulm and biological yields with the combined application of fertilizers up to optimum level.

Seed inoculation with *Rhizobium* and PSB significantly increased the yield and yield attributes. This might be due to fact that *Rhizobium* inoculation increased the root through better root development, nodulation, more nutrient availability resulting in vigorous plant growth and dry matter production which in turn resulted in better flowering, pod formation and ultimately seed yield. Since PSB might have helped in reducing phosphorus fixation by its chelating effect and also solubilized the fixed form phosphorus leading to more uptake of nutrients and reflected in better yield attributes. The synergistic effect of *Rhizobium* and PSB might have increased yield attributes and yield due to increased nitrogenise activity and available phosphorus status of soil. These findings corroborate the results of Chattopadhyay and Dutt (2003) [3] and Khan *et al.* (2012) [8] in cowpea, Singh and Pareek (2003) [20] in mungbean and Balachandran *et al.* (2005) [2] in greengram and Kumawat and Khangarot (2002) [10], Nagar and Meena (2004) [14] and Singh *et al.* (2012) [21] in clusterbean.

Table 1: Growth characters of clusterbean as influenced by fertility levels and liquid biofertilizers at harvest

Treatments	Plant growth characters at harvest		
	Plant height (cm)	Dry matter plant^{-1} (g)	No. of branches plant^{-1}
T_1: Control	53.31	95.42	6.42
T_2: 50% RDF + Liquid Rhizobium	69.12	123.73	8.33
T_3: 50% RDF + Liquid Phosphorus Solubilizing Bacteria	65.05	116.43	7.83
T_4: 50% RDF + Liquid Potassium Solubilizing Bacteria	63.97	114.51	7.71
T_5: 75% RDF + Liquid Rhizobium	79.67	142.60	9.60
T_6: 75% RDF + Liquid Phosphorus Solubilizing Bacteria	75.89	135.84	9.14
T_7: 75% RDF + Liquid Potassium Solubilizing Bacteria	73.80	132.10	8.89
T_8: 100% RDF + Liquid Rhizobium	94.19	168.59	11.34
T_9: 100% RDF + Liquid Phosphorus Solubilizing Bacteria	88.32	158.09	10.64
T_{10}: 100% RDF + Liquid Potassium Solubilizing Bacteria	86.03	154.00	10.36
SEm±	3.61	3.83	0.29
LSD (*P = 0.05*)	10.72	11.39	0.88

Table 2: Yield attributes of clusterbean as influenced by fertility levels and liquid biofertilizers at harvest

Treatments	Yield attributes		
	No. of pods plant^{-1}	No. of seeds pod^{-1}	Test weight (g)
T_1: Control	21.96	4.37	35.24
T_2: 50% RDF + Liquid Rhizobium	28.47	5.67	36.04
T_3: 50% RDF + Liquid Phosphorus Solubilizing Bacteria	26.79	5.33	35.95
T_4: 50% RDF + Liquid Potassium Solubilizing Bacteria	26.35	5.25	35.87
T_5: 75% RDF + Liquid Rhizobium	32.82	6.53	36.75
T_6: 75% RDF + Liquid Phosphorus Solubilizing Bacteria	31.26	6.22	36.72
T_7: 75% RDF + Liquid Potassium Solubilizing Bacteria	30.40	6.05	36.34
T_8: 100% RDF + Liquid Rhizobium	38.80	7.72	37.11
T_9: 100% RDF + Liquid Phosphorus Solubilizing Bacteria	36.38	7.24	36.92
T_{10}: 100% RDF + Liquid Potassium Solubilizing Bacteria	35.44	7.05	36.83
SEm±	1.01	0.20	0.63
LSD (*P = 0.05*)	3.00	0.60	NS

Table 3: Yield (kg ha^{-1}) and harvest index (%) of clusterbean as influenced by fertility levels and liquid biofertilizers at harvest

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Seed yield	Haulm yield	Biological yield	
T_1: Control	570.94	1879.21	2450.15	23.29
T_2: 50% RDF + Liquid Rhizobium	740.31	2265.46	3005.77	24.63
T_3: 50% RDF + Liquid Phosphorus Solubilizing Bacteria	696.63	2174.13	2870.76	24.25
T_4: 50% RDF + Liquid Potassium Solubilizing Bacteria	685.13	2160.69	2845.82	24.06
T_5: 75% RDF + Liquid Rhizobium	853.22	2413.89	3267.11	26.12
T_6: 75% RDF + Liquid Phosphorus Solubilizing Bacteria	812.74	2345.49	3158.23	25.73
T_7: 75% RDF + Liquid Potassium Solubilizing Bacteria	790.37	2299.21	3089.58	25.58
T_8: 100% RDF + Liquid Rhizobium	1008.73	2701.79	3710.52	27.19
T_9: 100% RDF + Liquid Phosphorus Solubilizing Bacteria	945.89	2561.80	3507.69	26.97
T_{10}: 100% RDF + Liquid Potassium Solubilizing Bacteria	921.39	2552.29	3473.68	26.52
SEm±	26.23	70.24	96.47	0.09
LSD (*P = 0.05*)	77.92	208.70	286.62	0.27

4. Conclusion

On the basis of one year experiment it may be concluded that application of 100% RDF + Liquid *Rhizobium* registered significantly higher values of growth and yield of clusterbean under the agro-climatic condition of Jaipur.

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