

Productivity, quality and resource utilization by clusterbean (*Cyamopsis tetragonoloba*) as influenced by nutrient management

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2004 and 2005 at Bikaner to study the effect of nutrient management on yield, quality, nutrient uptake, water-use efficiency and economics of rainfed clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] under hot arid, rainfed condition of western Rajasthan. Nutrient application showed significant influence on productivity, quality and resource utilization (nutrient and water) of clusterbean. Application of chemical fertilizer @ 100% RDF (20 kg N + 17.5 kg P/ha) recorded 50.9, 59.3 and 36.2% higher seed yield, gum yield and water-use efficiency respectively over the control. Among biofertilizers tested, dual inoculation (*Rhizobium* + phosphate-solubilizing bacteria) registered maximum improvement in yield, quality and nutrient uptake, followed by single inoculation of *Rhizobium* and PSB. Integration of chemical fertilizer @ 50% RDF with dual inoculation of biofertilizer registered 43.7 and 52.9% higher seed and gum yields respectively over the control. Dual inoculation of biofertilizer (*Rhizobium* + PSB) integrated with chemical fertilizer @ 50% RDF fetched maximum net returns (Rs 8,213/ha) and B : C ratio (1.6 : 1).

Key words: Biofertilizer, Chemical fertilizer, Clusterbean, Gum, Nutrient uptake, Water-use efficiency, Yield

Clusterbean is a short-duration legume, highly adapted to the harsh edapho-climatic conditions of hot arid zone of India. It is grown traditionally for feed and fodder and is an important component of cropping systems of the region. Clusterbean of late, has acquired the status of industrial crop because of high galactomanan content in the endosperm of its seed, which has multiple industrial uses and thus a main foreign-exchange earner for the area. Despite the maximum area of clusterbean in Rajasthan, the average productivity is only 0.25 t/ha compared with 0.37, 0.70 and 1.20 t/ha in Gujarat, Haryana and Punjab respectively (Henry, 2003). Poor soil fertility and lack of nutrient management are considered the major reasons of this dismally low productivity. Therefore, augmenting of the nutrient supply assumes prime significance to improve its productivity. Low and erratic rainfall, escalation in the price of chemical fertilizers along with poor socio-economic condition of the farmers make the extensive use of chemical fertilizer to augment crop productivity a risky proposition in this hot arid region. Therefore low-cost nutrient sources such as biofertilizers along with chemical fertilizer in the form of integrated plant nutrient-supply system may be a better option to supply nutrient requirement of the crops. Hence the present study was under-

taken to assess the effect of chemical and biofertilizers on the yield, quality, nutrient and water use of rainfed clusterbean under hot arid conditions.

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 2004 and 2005 at Regional Research Station, CAZRI, Bikaner. The soil was sandy with pH 8.2, having 0.1% organic C, 89.7 kg/ha available N, 8.0 kg/ha available P and 234.1 kg/ha available K. The experiment was laid out in randomized block design having three replications with 10 nutrient-management treatments, viz. T₁, the control, T₂, 50% of recommended dose of fertilizer (RDF); T₃, 75% of RDF; T₄, 100% of RDF; T₅, *Rhizobium*; T₆, phosphate-solubilising bacteria (PSB); T₇, *Rhizobium* + PSB; T₈, 50% of RDF + *Rhizobium*; T₉, 50% of RDF+PSB; and T₁₀, 50% of RDF+*Rhizobium* + PSB. The clusterbean variety 'RGC 936' was sown with hand-plough in 40 cm rows on 2 August 2004 and 30 June 2005. The net plot size was 5.0 × 3.2 m. The RDF was 20 kg of N + 17.5 kg P/ha, applied basal through urea and single superphosphate as per treatment. Biofertilizer was applied as seed treatment just before sowing. Five random plants were selected from each plot, excluding the border row, for taking observations on growth and yield attributes. The representative dry

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samples of shoots and seeds were analysed for ascertaining the nutrient (N, P and K) content. The N, P and K contents were analysed by micro-Kjeldahl, Vanado-molydophosphoric acid yellow-colour and flame photometer methods respectively. Gravimetric method was used for soil-moisture estimation. The total water use was computed by summing up water from irrigation, rainfall and contribution from soil profile during the entire crop season.

RESULTS AND DISCUSSION

Growth and yield

Growth attributes showed significant improvement owing to application of nutrients through chemical and bio-fertilizers (Table 1). Significant variation in plant height due to nutrient management was recorded at 60 days after sowing and harvesting stages. Maximum plant height at these stages was registered with application of 100% recommended dose of fertilizer (T_4), which was significantly superior to all other nutrient-management treatments except application of 75% RDF and dual inoculation of bio-fertilizers integrated with 50% RDF (T_{10}). Significant improvement in crop-growth rate was noticed with application of chemical and bio-fertilizers. Highest crop-growth rate (4.1 g/m²/day) was registered with application of chemical fertilizers @ 100% of RDF (T_4), followed by dual inoculation of biofertilizers integrated with 50% RDF (T_{10}). The increased availability of nutrients with application of chemical fertilizers and biological nitrogen fixation by *Rhizobium* increased the solubilization of native and applied P by PSB, which might have favoured the plant-growth characters under these treatments. Nutrient application had significant positive effect on yield attributes, viz. pods/plant and seeds/pod, of clusterbean (Table 1).

Application of chemical fertilizers @ 75 and 100% RDF (T_3 and T_4), and integration of biofertilizer with 50% RDF (T_8 , T_9 and T_{10}) resulted in significantly higher number of pods/plant than the control. Highest number of pods/plant (32.5) was recorded with application of 100% RDF (T_4), which was on a par with that of 75% RDF (T_3) and integrated use of 50% RDF with *Rhizobium* (T_8) and *Rhizobium* + PSB (T_{10}). The highest number of seeds/pod (6.5) were registered with application of 50% RDF with dual inoculation of *Rhizobium* and PSB (T_{10}), which was on a par with that of 100% RDF (T_4), 75% RDF (T_3), 50% RDF + PSB (T_9) and 50% RDF + *Rhizobium* (T_8). The variation in 1,000-seed weight under various treatments was non-significant. Better growth associated with increased availability of plant nutrients might have resulted in better development of yield attributes under these treatments.

Nutrient management had significant influence on the seed and stover yields of clusterbean (Table 1). Application of chemical fertilizer @ 50, 75 and 100% of RDF registered 20.7, 44.3 and 51.0% higher seed and 25.9, 38.5 and 44.8% higher stover yields respectively compared with the control. Inoculation of *Rhizobium* (T_5), phosphate solubilising bacteria (T_6) and *Rhizobium* + PSB (T_7) recorded 20.4, 13.1 and 24.2% higher seed yield than the control. Further integration of biofertilizer with 50% RDF significantly improved the seed yield compared with the respective dose of chemical fertilizer and sole inoculation of bio-fertilizer. Highest seed yield (863 kg/ha) was registered with application of 100% RDF (T_4), followed by 75% RDF (T_3), 50% RDF + *Rhizobium* + PSB (T_{10}) and 50% RDF + *Rhizobium* (T_8). The increased growth along with better expression of yield attributes might have led to increase in the seed yield under these treatments. The

Table 1. Effect of nutrient management on growth, yield attributes, yield and economics of clusterbean (mean data of 2 years)

Treatment	Plant height* (cm)	CGR 30-60 DAS** (g/m ² /day)	Pods/plant	Seeds/pod	1,000-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Net returns (Rs/ha)	B : C ratio
T_1 : Control	78.3	2.5	25.7	4.4	26.8	572	1,933	22.8	4,399	0.9:1
T_2 : 50% RDF	88.7	3.4	28.3	5.5	27.8	690	2,433	22.1	6,015	1.1:1
T_3 : 75% RDF	94.7	3.6	30.9	6.2	28.1	825	2,677	23.6	7,863	1.4:1
T_4 : 100% RDF	103.3	4.1	32.5	6.4	29.4	863	2,800	23.6	8,151	1.4:1
T_5 : <i>Rhizobium</i>	89.5	3.2	27.1	5.3	27.6	688	2,283	23.2	6,299	1.3:1
T_6 : PSB	58.0	3.2	27.5	5.2	27.6	647	2,225	22.5	5,724	1.2:1
T_7 : <i>Rhizobium</i> + PSB	92.3	3.4	28.3	5.5	27.9	710	2,438	22.6	6,704	1.4:1
T_8 : 50% RDF + <i>Rhizobium</i>	95.0	3.6	29.9	5.9	28.2	807	2,520	24.2	7,768	1.5:1
T_9 : 50% RDF + PSB	92.7	3.5	29.3	6.0	28.2	757	2,458	23.5	7,053	1.3:1
T_{10} : 50% RDF + <i>Rhizobium</i> + PSB	99.7	4.0	32.3	6.5	29.8	822	2,850	22.4	8,213	1.6:1
SEm±	2.8	0.2	0.9	0.3	0.7	38	104	1.1		
CD (P=0.05)	7.9	0.6	2.7	0.8	NS	110	295	NS		

*At harvesting stage, **DAS = days after sowing

highest stover yield was realized with inoculation of both bio-fertilizers with 50% RDF (T_{10}), which remained on a par with that of 75 and 100% RDF (T_3 , T_4). Meena *et al.* (2002), Palsania *et al.* (2002), Singh (2002) and Saxena *et al.* (2003) also reported significant improvement in yield of clusterbean with the application of nutrients.

Nutrient uptake

Significant variation in nitrogen and phosphorus uptake at various stages of crop was noticed under different nutrient-management treatments (Table 3). At 30 DAS, significantly higher N and P uptake over the control was recorded with application of chemical fertilizer @ 75 and 100% RDF (T_3 and T_4) and integrated use of chemical fertilizer @ 50% RDF with *Rhizobium* (T_8), PSB (T_9) and *Rhizobium* + PSB (T_{10}). At the later stages, i.e. 60 DAS and harvesting stage, all the nutrient application treatments significantly improved the N and P uptake over the control. Application of chemical fertilizer @ 50, 75 and 100% RDF (T_2 , T_3 and T_4) gave 42.7, 76.8 and 84.6% more N uptake and 24.0, 42.0 and 62.0% more total P uptake over the control respectively. Highest total N and P uptake was recorded with application of chemical fertilizer @ 100% RDF (T_4). Increased nutrient uptake might be attributed to better availability of nutrients under these treatments. Singh and Singh (1990) recorded higher uptake of nutrients by clusterbean with application of chemical and bio-fertilizers.

Protein content and yield

Nutrient management had significant influence on the content and yield of seed protein (Table 2). Progressive increment in protein content was recorded with increasing application of chemical fertilizer up to 75% RDF. Single and dual inoculation of biofertilizers recorded significant

increase in protein content over the control. Application of chemical fertilizer @ 50, 75 and 100% RDF recorded 42.0, 88.3 and 99.3% respectively higher protein yield over the control. Among biofertilizer treatments, single inoculation of *Rhizobium* (T_5) and inoculation of *Rhizobium* + PSB (T_7), recorded respectively 43.9 and 48.5% higher protein yield over the control. Maximum protein yield was noticed with application of 100% RDF (T_4), followed by 50% RDF + *Rhizobium* + PSB (T_{10}), and 75% RDF (T_3). The increased protein yield might be attributed to higher content of protein and seed yield under these treatments.

Gum content and yield

Nutrient management failed to significantly improve the gum content of seed. All the nutrient-management treatments except application of chemical fertilizers @ 50% RDF (T_2) and single inoculation of *Rhizobium* and PSB recorded significantly higher gum yield over the control (Table 2). Application of chemical fertilizer @ 50, 75 and 100% RDF recorded 19.2, 50.7 and 59.4% higher gum yield respectively over the control. Among biofertilizer treatments, inoculation of *Rhizobium* (T_5), PSB (T_6) and *Rhizobium* + PSB (T_7) recorded 19.9, 15.4 and 26.2% respectively higher gum yield over the control. Maximum gum yield was noticed with application of 100% RDF (T_4), followed by 75% RDF (T_3), 50% RDF + *Rhizobium* (T_8), and 50% of RDF + *Rhizobium* + PSB (T_{10}), and the difference in gum yield among these treatment was non-significant.

Water use

Considerable variation in consumptive use (CU) of water and water-use efficiency of clusterbean was observed under different nutrient-management treatments (Table 2). Highest consumptive use of water (211.3 ha-mm) was

Table 2. Protein, gum content, their yield, nutrient uptake, consumptive use and water-use efficiency of clusterbean as influenced by nutrient management (mean data of 2 years)

Treatment	Protein content (%)	Protein yield (kg/ha)	Gum content (%)	Gum yield (kg/ha)	Nutrient uptake (Rs/ha)				CU (ha-mm)	WUE (kg/ha-mm)
					N		P			
					Seed	Stover	Seed	Stover		
T ₁	20.4	117	25.1	144	18.8	17.0	1.8	3.2	193.2	3.0
T ₂	24.0	166	24.8	171	26.8	24.3	2.2	4.0	200.2	3.4
T ₃	26.6	219	26.2	216	35.2	28.1	2.7	4.4	208.5	4.0
T ₄	27.0	233	26.5	229	37.3	28.8	2.9	5.3	210.4	4.1
T ₅	24.4	168	25.0	172	27.0	19.3	2.2	3.7	204.3	3.4
T ₆	24.1	156	25.6	166	25.2	19.7	2.1	3.7	200.1	3.2
T ₇	24.4	173	25.5	181	27.7	22.9	2.2	4.1	206.7	3.4
T ₈	25.7	207	26.7	215	33.2	25.1	2.7	4.5	207.5	3.9
T ₉	24.4	185	26.7	203	29.4	24.5	2.5	4.5	206.7	3.7
T ₁₀	27.2	224	26.7	219	35.8	27.3	2.7	4.9	211.3	3.9
SEm±	0.9	11	0.2	10	1.8	1.9	0.1	0.2		
CD (P=0.05)	2.6	32	NS	30	5.2	5.4	0.3	0.5		

*Treatment details in Table 1

recorded under application of chemical fertilizer @ 50% RDF + *Rhizobium* + PSB, followed by 100% RDF, which were respectively 9.4 and 8.9% higher than the control. Application of chemical fertilizer @ 50, 75 and 100% RDF registered respectively 14.9, 32.7 and 36.2% higher water-use efficiency over the control. Integration of chemical fertilizer @ 50% RDF with *Rhizobium* and PSB recorded respectively 30.1 and 22.6% higher water-use efficiency over the control.

Economics

Total cost of cultivation was highest under 100% RDF (T_4). The maximum net return was realized with integrated use of 50% RDF with inoculation of both biofertilizers (T_{10}) (Table 1). Integration of biofertilizer with chemical fertilizer (T_8 and T_{10}) was more remunerative with higher benefit:cost (B:C) ratio (1.5 and 1.6) than sole application of chemical (1.1 to 1.4) and biofertilizers (1.3 to 1.4).

It can be concluded that integrated nutrient management consisting of chemical fertilizer @ 50% RDF with *Rhizobium* + PSB in clusterbean can be used to achieve higher yield and resource utilization with maximum returns in hot arid region.

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