ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(11): 634-369
www.agriculturaljournals.com
Received: 05-08-2025
Accepted: 07-09-2025

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Effect of foliar nutrient application on growth, economic potential yield and quality of summer cluster bean [*Cyamopsis tetragonoloba*(L.]

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DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i11i.1015

Abstract
The present investigation aimed to find out the "Effect of Foliar Nutrient Application on Growth, Economic Potential Yield and Quality of Summer Cluster Bean [*Cyamopsis tetragonoloba*(L.)]" was carried out at Agriculture Research Farm of Faculty of Agriculture and Veterinary Science, Mewar University, Gangrar, Chittorgarh, Rajasthan. The experiment was laid out in Randomized Block Design. Replicated thrice with 09 treatment combinations, comprising like T_1 Control, T_2 RDF + Foliar spray of soluble NPK at 15 DAS, T_3 RDF + Foliar spray of soluble NPK at 30 DAS, T_4 RDF + Foliar spray of soluble NPK at 45 DAS. T_5 RDF + Foliar spray of soluble NPK at 60 DAS, T_6 RDF + Foliar spray of soluble KNO_3 at 15 DAS, T_7 RDF + Foliar spray of soluble KNO_3 at 0.5% at 30 DAS, T_8 RDF + Foliar + spray of soluble KNO_3 at 45 DAS and T_9 RDF + Foliar spray of soluble KNO_3 at 60 DAS.
The application of Foliar spray of soluble NPK on productivity was found most effective improve success on growth yield, quality and nutrient uptake of cluster bean crops. Plant height measurements taken maximum height of 32.39, 89.12 and 105.3 cm at 30, 60 DAS, number of branches (9.0) at harvest, dry matter accumulation (65.68), plant population at harvest 173.73) maximum chlorophyll content (2.691). The application of a RDF + Foliar spray of soluble NPK at 60 DAS resulted significantly higher number of pods per plan (55.10), higher number (8.63) of seed pod^{-1}, higher test weight (35.28 g) Treatment T_4 (28.67) produced significantly more harvesting index, At straw yield, T_5 had a non-significantly larger straw yield (4619.7) was recorded underT_5 (RDF + Foliar spray of soluble NPK at 60 DAS). T_5 application (RDF + Foliar spray of soluble NPK at 60 DAS) resulted in considerably greater protein content (27.03%) and nutrient content and uptake, highest gross return (₹ 72963 ha^{-1}), highest net return of ₹ 49603 ha^{-1} and highest B:C ratio (3.12) was recorded.

Keywords: Cluster Bean, Foliar Nutrient Application, Growth, Yield, Quality and Economics

Introduction
Cluster bean [*Cyamopsis tetragonoloba* (L.)] is an annual, multipurpose arid legume crop from the Fabaceae family. It is recognised as a drought-tolerant crop, allowing for successful cultivation in arid and semi-arid regions with very low annual rainfall of 200-600 mm, particularly in northwestern India, the southern United States (Texas and Oklahoma), parts of Pakistan, and Sudan (Gresta *et al*., 2013) [5].
The application of fertilizers in solution form directly to the leaves has become a well-established practice for increasing production through improved nutrient uptake and crop quality. In a nutrient-deficient environment, crops suffer from nitrogen deficiencies in the soil as well as limited absorbing capability due to restricted root growth. On the other side, foliar fertilization of nutrients may enhance root absorption of the same or other nutrients, potentially improving root growth and nutrient uptake. For penetration to occur, the solute must adhere and remain on the leaf surface for an extended period of time. Nutrients are transported to the plant's needed regions by diffusion through the cuticle and desorption into phloem vessels. Foliar nutrient treatment to maximise genetic potential and increase development through enhanced nutrient assimilation by the crop may be an economical and efficient technique of nutrient supplementation. Foliar spray may also increase nutrient availability and thus productivity (Iqbal *et al*., 2019) [9].

Materials and Methods

A field experiment entitled "Effect of Foliar Nutrient Application on Growth, Economic Potential Yield and Quality of Summer Cluster Bean [*Cyamopsis tetragonoloba*(L.)]" Was conducted at Research farm of Mewar University, Gangrar Chittorgarh Rajasthan during summer season of 2024, which is situated at South- East part of Rajasthan. It falls under the agro- climatic zone IV A i.e. Sub humid Southern Plain and the Aravalli hills of Rajasthan. Balanced liquid N-P-K fertilizer, suitable for all crops, during all stages of plant growth. Mix liquid fertilizer provides an additional source of nitrogen, phosphorous and potassium during the growing season. The seeds @ 20 kg ha^{-1} were treated with Bavistin @ 3 g kg^{-1} seed followed by *Rhizobium* inoculation using standard method and then sown by hand driven plough with 30 cm row spacing at 5-6 cm depth.

Resuslt and Discussion

Effect on growth parameters

It is Table 4.1 displays the results of the analysis of plant height measurements taken maximum height of 32.39, 89.12 and 105.3 cm at 30, 60 DAS, and harvest stage, Treatment T_5 (9.0) produced a non-significantly larger number of branches at harvest. At 75 DAS stage, T_5 had a significantly larger dry matter accumulation (65.68), Treatment T_5 (173.73) produced significantly more plant population at harvest. The treatment (T_7) yielded the fewest plant population (172.65), maximum chlorophyll content (2.691), The growth parameter may be due to an increase in the availability of plant nutrients, or vegetative growth may rise as plant nutrients become more readily available. Foliar application promotes development by increasing the number of green leaves, which enhances photosynthesis due to plant metabolism. It is an established fact as N, P, and K are the most vital nutrients for plant growth and development. P is involved in the early photosynthesis process. In fact, it is regarded an energy currency in plant systems Similar results were reported by Haq and Mallarino (2000) [6], who discovered that foliar N, P, and K spray boosted plant growth and development, resulting in an increase in total dry matter in soybean crops. Using a RDF + Foliar spray of soluble NPK at 60DAS resulted in the most branches, which was consistent with the findings of Shyamrao *et al*. (2016) [18]. It was discovered that foliar application of NPK at various dosages resulted in more vegetative growth in green gram compared to control. Maximum plant height, number of branches per plant, root length, and plant weight in common beans with the foliar application of 20:20:20 ($N:P_2O_5:K_2O$) same result findings of Rahman *et al*. (2014). These findings directly validated the growth enhancement achieved with foliar application of RDF + Foliar spray of soluble NPK at 60 DAS. The flower initiation and pod formation stages, the maximum plant height was reported with a RDF + Foliar spray of soluble NPK at 60 DAS. Dandge *et al*. (2018) [2] observed that foliar application of nutrients RDF+ 15:15:15 (NPK) 2% @ during the pod development stage resulted in the most pods per plant and branches per plant in soybean. The results found were very similar with the findings of Haq and Mallarino (2000) [6], Reddy *et al*. (2018) [5], and Shyamrao *et al.* (2016) [18]. These results were in useful indicate with Gowda *et al*. (2014) [4]. The higher yield attributes of these foliar application treatments compared to control may be due to increased growth and physiological (growth analysis) parameters, as well as biomass per plant, as a result of increased supply of all essential plant nutrients, as well as increased physicochemical and biological activity. All of these favourable conditions may have resulted in enhanced carbohydrate and protein buildup and translocation from source to sink (reproductive organs), resulting in a higher number of pods and other yield-attributing factors. Pavithra *et al*. (2017) [14], Gowda *et al*., (2014) [4], Das and Jana (2015) [3], Kumar *et al*. (2015) [11], and Jadhav and Kulkarni (2016) [10] all found similar results.

Yield Parameters

The application of a RDF + Foliar spray of soluble NPK at 60 DAS resulted significantly higher number of pods per plan (55.10), higher number (8.63) of seed pod^{-1}, higher test weight (35.28 g) Treatment T_4 (28.67) produced significantly more harvesting index, At straw yield, T_5 had a non-significantly larger straw yield (4619.7) Cluster bean seed contains around 25% protein. All foliar nutrient treatments significantly boosted protein and protein yield in cluster bean seed compared to control. The highest protein content was found in T_5 (RDF + Foliar spray of soluble NPK at 60 DAS) when compared to other treatments. According to Imas and Magen (2007) [8], potassium may have aided with photosynthesis, carbohydrate distribution, and starch synthesis in storage organs, hence increasing crop output and quality. Similar findings were reported by Sharma and Singh (2004) [16] and Ibrahim *et al*. (2010) [7]. Foliar fertiliser administration had a considerable influence on cluster bean N and K content, as well as crop absorption. Among the treatments, T_5 (Foliar spray of soluble NPK at 60 DAS) had the highest N and K absorption, followed by T_8 (RDF + Foliar + spray of soluble KNO_3 at 45 DAS). Under these treatments, increasing seed output led to greater nutrient absorption. The crop's nutrition absorption was increased by foliar spraying. These findings are consistent with Mondal *et al*. (2011) [12]. Higher nutrient uptake may be feasible with these treatments because to increased production seed and improved absorption. Naidu *et al*. (2015) [13] and Shurthi and Vishwanath (2013) [17] obtained similar results

Quality Parameters

T_5 application (RDF + Foliar spray of soluble NPK at 60 DAS) resulted in considerably greater protein content (27.03%), comparable to T_8 (26.16%), T_7 (26.11%), and T_6 (26.08%), Treatment T_5 (RDF + Foliar spray of soluble NPK at 60 DAS) resulted in a non-significantly greater phosphorus% in the plant, namely 0.21%. However, it was shown to be comparable to T_7 (0.19%), T_6 (0.18%), T_4 (0.18%), and T_3 (0.18%). The control has the lowest P% in the plant (0.15 percent). T_5 (RDF + Foliar spray of soluble NPK at 60 DAS) and T_8 (RDF + Foliar + spray of soluble KNO_3 at 45 DAS) resulted in considerably greater potassium (0.94) levels in the plant. However, it was determined to be comparable to T_6 (0.92%) and T_3 (0.91%). Control T_1 has the lowest K% (0.74%) in the facility.

Economics

Treatment T_5 (RDF + Foliar spray of soluble at 60 DAS) yielded the highest gross return (₹ 72963 ha^{-1}), highest net return of ₹ 49603 ha^{-1} and highest B:C ratio (3.12) followed by T_4 (RDF + Foliar spray of soluble NPK at 45DAS)

(3.09), T_3 (FRDF + Foliar spray of soluble NPK at 30 DAS) (2.83), and T_6 (F RDF + Foliar spray of soluble KNO_3 at 15 DAS) (2.61), while T_8 had the lowest B:C ratio (2.40). RDF + Foliar spray of soluble NPK at 60 DAS (T_5) resulted in highest net revenue up to 49603 ha^{-1} with a B: C ratio of 3.12. This was followed by the application of treatments T_4 (RDF + Foliar spray of soluble NPK at 45 DAS) (net income 43572 ha^{-1} with B: C ratio 3.09) and T_6 (RDF + Foliar spray of soluble KNO_3 at 15 DAS) (net income 38102 ha^{-1} with B: C ratio 2.61). These findings were consistent with prior studies by Shyamrao *et al*. (2016) [18], Zambre *et al*. (2016) [19], Pavithra *et al*. (2017) [14], and Banasode and Math (2018) [1].

Table 1: Effect of foliar application of nutrients on plant height

Treatments	Treatments combination	Plant height (cm)		
		At 30 DAS	At 60 DAS	At Harvest
T_1	Control	27.31	75.18	84.18
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	27.24	77.32	89.01
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	30.27	86.71	97.23
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	32.39	83.23	95.08
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	32.31	89.12	105.3
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	29.47	86.24	97.22
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	29.41	81.17	94.01
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	29.03	87.09	102.23
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	29.88	83.58	95.25
	S.E.(m)±	0.71	1.82	2.17
	C.D. (at 5%)	2.12	5.42	6.45
	CV%	8.12	9.32	9.22

Table 2: Effect of foliar application of nutrients on number of branches per plant

Treatments	Treatments combination	Number of branches/plant		
		At 45 DAS	At 60 DAS	At Harvest
T_1	Control	3.43	5.02	7.1
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	3.56	5.54	7.2
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	5.3	6.27	8.42
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	4.69	6.18	8
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	5.47	7.52	9
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	4.98	6.43	8.42
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	5.03	6.17	7.79
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	4.68	7.39	8.79
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	4.25	6.3	8.08
	S.E.(m)±	0.71	0.81	0.67
	C.D. (at 5%)	2.12	2.42	1.99
	CV%	8.32	8.51	9.25

Table 3: Effect of foliar application of nutrients dry matter accumulation

Treatments	Treatments combination	Dry matter accumulation		
		45 DAS	60 DAS	75 DAS
T_1	Control	10.14	39.24	43.4267
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	11.8133	42.4533	55.42
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	11.9733	38.8667	57.8133
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	11.9533	44.72	63.4333
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	12.68	47.47	65.6867
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	12.5267	43.22	61.2667
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	11.2067	41.66	55.4467
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	11.54	42.1733	62.9067
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	11.82	37.45	48.10
	S.E.(m)±	0.99	2.16	2.76
	C.D. (at 5%)	2.95	6.41	8.2
	CV%	9.65	8.68	8.36

Table 4: Effect of foliar application of nutrients plant population.

Treatments	Treatments combination	Plant population	
		20 DAS	At harvest
T_1	Control	101.45	154.77
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	126.53	171.61
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	108.71	159.97
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	109.53	170.81
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	129.63	173.71
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	121.59	151.7

T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	128.91	172.65
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	113.63	161.95
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	125.52	159.67
	S.E.(m)±	2.24	2.23
	C.D. (at 5%)	6.67	6.63
	CV%	9.32	8.96

Table 5: Effect of foliar application of nutrients on chlorophyll content 40 DAS

Treatments	Treatments combination	Chlorophyll content 40 DAS
T_1	Control	2.243
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	2.381
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	2.451
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	2.633
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	2.691
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	2.645
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	2.522
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	2.537
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	2.602
	S.E.(m)±	0.13
	C.D. (at 5%)	0.39
	CV%	9.36

Table 6: Effect of foliar application of nutrients on number of pod per plant

Treatments	Treatments combination	Number of pods/plant
T_1	Control	37.00
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	38.1
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	50.24
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	48.03
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	55.10
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	47.01
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	44.99
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	53.07
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	46.93
	S.E.(m)±	0.63
	C.D. (at 5%)	1.88
	CV%	9.32

Table 7: Effect of foliar application of nutrients on number of seed per pod and test weight (g)

Treatments	Treatments combination	Number of seed/pod	Test weight (g)
T_1	Control	6.8	28.27
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	6.86	29.02
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	7.73	32.14
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	7.94	35.19
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	8.63	35.28
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	8.37	32.18
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	7.82	33.14
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	8.8	33.1
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	7.6875	32.029
	S.E.(m)±	0.76	0.71
	C.D. (at 5%)	2.27	2.12
	CV%	9.33	8.58

Table 8: Effect of foliar application of nutrients on harvesting index (%), straw yield (kg/ha) and biological yield (kg/ha)

Treatments	Treatments combination	Biological yield (kg/ha)	Harvesting index (%)	straw yield (kg/ha)
T_1	Control	5640.2	21.27	3611.5
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	6409.0	23.65	4331.2
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	6791.6	25.24	3815.5
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	6538.1	24.51	3732.2
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	7040.1	28.67	4619.7
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	6051.3	22.43	4225.8
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	6768.3	26.13	4388.7
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	5691.1	27.79	3995.9
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	6483.2	23.59	3834.1
	S.E.(m)±	546.15	1.4	293.55
	C.D. (at 5%)	1622.7	4.17	872.17
	CV%	8.69	8.56	9.78

Table 9: Effect of foliar application of nutrients on Protein content (%)

Treatments	Treatments combination	Protein content (%)
T_1	Control	24.59
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	25.99
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	25.51
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	25.87
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	27.03
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	26.08
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	26.11
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	26.16
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	25.75
	S.E.(m)±	0.63
	C.D. (at 5%)	1.86
	CV%	9.36

Table 10: Effect of foliar application of nutrients on N, P and K content in plant

Treatments	Treatments combination	N content in plant (%)	P content in plant (%)	K content in plant (%)
T_1	Control	1.49	0.15	0.74
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	1.85	0.17	0.81
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	2.39	0.18	0.91
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	2.43	0.18	0.89
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	2.83	0.21	0.94
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	2.34	0.18	0.92
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	2.28	0.19	0.88
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	2.61	0.19	0.94
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	2.32	0.17	0.78
	S.E.(m)±	0.19	0.02	0.03
	C.D. (at 5%)	0.56	0.07	0.1
	CV%	8.31	9.33	8.66

Table 11: Economics of the various treatments

Treatments	Treatments combination	Total cost (₹/ha)	Gross returns (/ ₹/ha)	Net returns (₹/ha)	B:C Ratio
T_1	Control	20060	50930	30870	2.53
T_2	RDF + Foliar spray of soluble NPK at 15 DAS	21200	54182	32982	2.55
T_3	RDF + Foliar spray of soluble NPK at 30 DAS	21680	61421	39741	2.83
T_4	RDF + Foliar spray of soluble NPK at 45 DAS	21680	65252	43572	3.09
T_5	RDF + Foliar spray of soluble NPK at 60 DAS	23360	72963	49603	3.12
T_6	RDF + Foliar spray of soluble KNO_3 at 15 DAS	23642	61774	38102	2.61
T_7	RDF + Foliar spray of soluble KNO_3 at 30 DAS	23642	60598	36956	2.56
T_8	RDF + Foliar + spray of soluble KNO_3 at 45 DAS	27256	65599	38343	2.40
T_9	RDF + Foliar spray of soluble KNO_3 at 60 DAS	22810	61587.8	38766.2	2.72

Conclusion

Based on our findings, we infer that diverse treatments improve cluster bean growth and yield. RDF + Foliar spray of soluble NPK at 60 DAS (T_5) resulted in substantially greater seed production, highest net return (₹49603 ha^{-1}) and B: C ratio (3.12) compared to treatment (T_4), RDF + Foliar spray of soluble NPK at 45 DAS. The net return and B: C ratio ₹49603 ha^{-1}, and 3.12, respectively. As a result, it is established that treatment (T_5) produced considerably better production, net return, and B: C ratio, as well as being more cost effective than other cluster bean treatments.

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