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Influence of Potassium and Zinc on Growth, Yield and Economics of Cluster Bean (*Cyamopsis tetragonoloba* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Influence of potassium and zinc on growth, yield and economics of Cluster bean" was conducted during *kharif* season, 2022 at Crop Research Farm in the Department of agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj Uttar Pradesh. The treatment consisted of three levels of K (15, 20 and 25 kg/ha) Zn (10, 15 and 20 kg/ha) and control. The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. Application of K (25 kg/ha) and Zn (20 kg/ha) produces higher plant height (139.20 cm), maximum number branches per plant (5.86), nodules/plant (49.45) and higher dry weight (21.53 g), maximum number of pods/plant (73.13), maximum number of grains/pod (9.13), higher seed yield (1363.56kg/ha), straw yield (3208.91 kg/ha). However, the maximum gross return (77,405.66 INR/ha), maximum net return (54,121.66 INR/ha) and maximum benefit cost ratio (2.32) were obtained with the same treatment- 9 (K 25 kg/ha + $ZnSO_4$ 20 kg/ha).

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1. INTRODUCTION

India is largest pulse-growing country which accounts for nearly one-third of the total world area under pulses and one-fourth of the total world production. Cluster bean (*Cyamopsis tetragonoloba* L.) is a fodder, green manure, seed production and important *Kharif* season legume crop in India, cluster bean are drought tolerant crop in India. It belongs to the sub-family Faboideae under the family Fabaceae (Leguminosae). It is locally known as Guar. The word “guar” represents its derivation from sanskrit word “Gauaahar” which means cow fodder or otherwise fodder of the livestock.

It is vary hard and drought tolerant crop. It is deep penetrating roots enable the plant to utilize available moisture more efficiently and which offer better scope for rain fed cropping. These crop also survives even at moderate salinity and alkalinity conditions. Kherawat et al*.* [1] emphasized that “Cyamopsis is distinct genus in tropical Africa as its probable center of origin. It provides nutritional concentrate and fodder for cattle and adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen. The guar are valueable as a soil builder to increase yield of succeeding crops should not be overlooked when considering guar as an alternative crop”.

“Cluster bean is mainly cultivated for food as vegetables, feed and fodder. Its young pods are used as vegetables which also known for cheap source of energy (16K cal), moisture (8 g), protein (3.2 g), fat (1.4 g), carbohydrate (10.8 g), vitamin-A (65.3 IU), vitamin-C (49 mg), calcium (57 mg) and iron (4.5 mg) for every 100 g of edible portion” [2]. Leaves of guar are eaten of cure night blindness.

“India contributes 80% to the global production of guar grain where it is grown on an area of 3.93 m ha, 1.62 m tonnes with a very low productivity of 413 kg/ha” [3].

“In India is the major exporter of guar-gum to the world. In India an area of cluster bean is 3140.2 m ha, with the production is 1.5 m tonnes and productivity of 484 kg/ha” [4]. In Uttar Pradesh state an area and with the production of this crop is 1979 ha and 1418 tonnes respectively. In Uttar Pradesh state productivity this state is 0.72 tonnes/ha [4].

Indian soil are deficient in potassium due to deficiency of potassium crop are less gum and protein content effect. Cluster bean is main problem of waterlogging the India. Zinc deficiency is a common problem in India and zinc is said to activate several enzymes, play a role in auxin synthesis and increase meristematic activities. Most of the work done on the nutrition of this crop has been related to major elements whereas the significance of micro-nutrients is still ignored.

“Potassium is the third most important essential nutrient after nitrogen and phosphorus in which activates more than 60 enzymes and enzymatic catalyzes the system involved in photosynthesis, metabolism and translocation of carbohydrates and proteins, membrane permeability, stomatal regulation and water utilization. Other benefits ascribed to K include the resistance of plants against pests, disease and stress caused by drought, frost, salinity, sodicity in assuring improved crop quality characteristics” [1]. Application of potassium increases the yield but varies in response from soil to soil and climate condition.

In the plant system, zinc is important for several enzymatic and physiological processes. Additionally, many enzymatic reactions are activated by zinc, which is a key nutrient in the construction of several enzymes like alcohol dehydrogenase, carbonic anhydrase, and superoxide dismutase. Zinc is also necessary for the synthesis of enzymes in plants. Plants enzymes activated by Zn are involved in carbohydrate metabolism, and regulation of auxin synthesis and pollen formation. “Zn seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. As Zn is required for the synthesis of tryptophan which is a precursor of IAA, it also has an active role in the production of an essential growth hormone auxin” [5].

Keeping in the view the above facts, the present experiment was undertaken to find out “Influence of potassium and zinc on growth, yield and economics of clusterbean (*Cyamopsis tetragonoloba* L.)”.

2. MATERIALS AND METHODS

This experiment was laid out during the *Kharif* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of

Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25^0 39” 42” N latitude, 81^0 67” 56” E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in randomized block design and comprised of potassium and zinc with ten treatments and each was replicated thrice *viz*. T_1 - 15kg/ha potassium + 10kg/ha zinc, T_2 - 15 kg/ha potassium + 15 kg/ha zinc, T_3 -15 kg/ha potassium + 20 kg/ha zinc, T_4 – 20 kg/ha potassium + 10 kg/ha zinc, T_5 -20 kg/ha potassium + 15 kg/ha zinc, T_6 – 20 kg/ha potassium + 20 kg/ha zinc, T_7 – 25 kg/ha potassium + 10 kg/ha zinc, T_8 – 25 kg/ha potassium + 15 kg/ha zinc, T_9 -25 kg/ha potassium + 20 kg/ha zinc, T_{10} - Control (RDF 20:40:20).The soil in the experimental area was sandy loam with pH (8.0), organic carbon (0.42%), available N (180.58 kg/ha), available P (15.54 kg/ha), and available K (198.67 kg/ha). Seeds are sown at a spacing of 45×15cm to a seed rate of 15 kg/ha. The recommended dose of nitrogen (20 kg/ha), phosphorus (40 kg/ha) and potassium (20 kg/ha) and potassium and zinc were applied as per the treatments. Data recorded on different aspects of crop, *viz.,* growth, yield attributes were subjected to statistically analysis by analysis of variance method [6]. And economic data analysis mathematical method.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant Height (cm)

The data revealed that a significantly and higher plant height (139.20 cm) was recorded in treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)]. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)], treatment 7 [Potassium (25 kg/ha) + Zinc (10 kg/ha)], treatment 6 [Potassium (20 kg/ha) + Zinc (20 kg/ha)] were found to be statistically at par with treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 1). The significant and higher plant height with application of potassium (25 kg/ha) might be due to increased levels of K function in most of the physiological and metabolic processes resulting in increased growth and development, resulting in higher plant height. A Similar result was also reported by Singh et al*.* [2].

3.1.2 Number of branches/plant

The data revealed that a significant and maximum number of branches/plant (5.86) was recorded with treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)]. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)], treatment 7 [Potassium (25 kg/ha) + Zinc (10 kg/ha)], treatment 6 [Potassium (20 kg/ha) + Zinc (20 kg/ha)] were found to be statistically at par with treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 1).The significant and maximum number of branches/plant was observed with the application of zinc (20 kg/ha) might be due Zn function in the production of Indole acetic acid, a growth hormone and tryptophan, a precursor of auxin. A similar result was also reported by Sharma et al [7]. Kuniya et al*.* [8].

3.1.3 Number of nodules/plant

The data revealed that a significant and maximum number of nodules/plant (49.45) was recorded with treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)]. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)] was found to be statistically at par with treatment 9 [Potassium (25 kg/ha) +Zinc (20 kg/ha)] in (Table 1).The significant and maximum number of nodule/plant observed with the application of Potassium (25 kg/ha) might be due to increased levels of Potassium that activates more than 60 enzyme systems, including the nitrogenous enzyme which is essential for N_2-fixation. Potassium is also essential to generate carbohydrates by photosynthesis which provides the energy needed by bacteria in nodules to fix atmospheric N_2 and contributes to good root growth providing a proper “home” for the nodules in which N is fixed resulting maximum number of nodule/plant. A similar result was also reported by Patil et al*.* [9]. Further increase in number of nodule/plant observed with the application of zinc (20 kg/ha) might be due to Zn function in N fixation through nodule formation and Zn play a major role in leg hemoglobin synthesis. A similar result was also reported by Kuniya et al*.* [8].

3.1.4 Plant dry weight (g)

The data revealed that significant and maximum plant dry weight (21.50g) was recorded in treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)]. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)], treatment 7 [Potassium (25 kg/ha) + Zinc (15 kg/ha)] and treatment 6 [Potassium (20 kg/ha) + Zinc (20 kg/ha)], were statistically at par with treatment 9 [Potassium (25 kg/ha) +Zinc (20 kg/ha)] in (Table 1).The significant and higher plant dry weight (g) observed with the application of Potassium (25 kg/ha) might be due increase levels of K function of protein yield is the result of dry matter yield and protein content because it balances photosynthesis and respiration due to potassium application because of an increase in dry matter yield. Similar results were reported by Tomar et al. [10]. Further increase in dry weight observed with the application of zinc (20 kg/ha) might be due to Zinc application creating a balanced nutritional environment which enhanced metabolic activities and photosynthetic rate, resulting in improvement and ultimately accumulation of plant dry matter. Similar types of results were reported by Meena et al. [11].

3.1.5 Number of pods/ plant

The data revealed that Treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] recorded a significant and the maximum number of pods/ plant (73.13) which was superior over all other treatments. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)] and treatment 7 [Potassium (25 kg/ha) + Zinc (10 kg/ha)] were found to be statistically at par with the treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 2).The significant and maximum number of pods/plant observed with the application of zinc (20 kg/ha) might be due increase levels of Zn application to crops on nutrient metabolism, biological activity and growth parameters and hence which applied zinc results in taller and higher enzyme activity in pods/ plant. Similar results were reported by Yashona et al. [12].

3.1.6 Number of seeds/pod

The data revealed that Treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] was recorded a significant and the maximum number of seeds/pod (9.13) which was superior over all other treatments. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha) (8.53)] was found to be statistically at par with treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 2). The significant and maximum number of seed/pod observed with the application of K (25 kg/ha) might be due increased levels of K application and increased transportation of photosynthates; protein synthesis from source to sink might be the main reason for the increase in a number of seeds. Similar results were reported by Hussain et al. [13]. Further increase in dry weight observed with the application of zinc (20 kg/ha) might be due increase levels of Zn application of appropriate fertilizers increased assimilate production and photosynthesis efficiency of the seed filling. Similar types of results were reported by Ali et al. [14] and Yashona, [12].

3.1.7 Test weight (g):

The data revealed highest test weight (29.53 g) was recorded in Treatment 9 [Potassium (25kg/ha) + Zinc (20kg/ha)], thought there was non-significant difference among the treatment.

3.1.8 Seed yield (kg/ha)

The data revealed that Treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] recorded a significantly maximum Seed yield (1363.56 kg/ha) which was superior over all other treatments. However, treatment 8 [Potassium (25 kg/ha) + Zinc (15 kg/ha)] and treatment 7 [Potassium (25 kg/ha) + Zinc (10 kg/ha)] were found to be statistically at par with the treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 2).The significant and maximum seed yield observed with the application of Potassium (25 kg/ha) might be due increase levels of K application may be attributed to strong exchange mechanisms in soil, greater cell division and elongation, efficient nodulation and CO_2 assimilation. The higher photosynthetic surface for longer duration in crops receiving K might have resulted in enhanced photosynthetic activity and thus more metabolites are directed for the development of crop increase in seed yield. Similar results were reported by Begadkar et al. [15]. Further increase in dry weight observed with the application of zinc (20 kg/ha) might be due to Zinc application role in the biosynthesis of Indole acetic acid which is responsible for the initiation of primordial for reproductive parts and partitioning of photosynthesis toward them which results in the better grain yield. Similar results were reported by Ram et al. [16] and Sunil et al. [17].

3.1.9 Stover yield (kg/ha)

The data revealed that Treatment 9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] recorded a significantly maximum Stover yield (3208.91 kg/ha) which was superior over all other treatments. However, the treatment-8 [Potassium (25kg/ha) + Zinc (15 kg/ha)] was found to be statistically at par with treatment-9 [Potassium (25 kg/ha) + Zinc (20 kg/ha)] in (Table 2). The significant and maximum straw yield observed

Table 1. Effect of potassium and zinc on growth of cluster bean

S.No.	Treatment combinations	At 80 DAS			
		Plant height (cm)	**Number of branches/plant**	**Number of nodules/plant**	**Dry weight (g/plant)**
1.	Potassium (15kg/ha) + Zinc (10kg/ha)	118.26	4.40	39.63	17.76
2.	Potassium (15kg/ha) + Zinc (15kg/ha)	124.06	4.80	40.13	18.26
3.	Potassium (15kg/ha) + Zinc (20kg/ha)	124.10	4.83	40.66	18.30
4.	Potassium (20kg/ha) + Zinc (10kg/ha)	127.33	4.90	41.33	18.60
5.	Potassium (20kg/ha) + Zinc (15kg/ha)	127.20	4.93	42.20	18.40
6.	Potassium (20kg/ha) + Zinc (20kg/ha)	128.80	5.03	43.08	19.60
7.	Potassium (25kg/ha) + Zinc (10kg/ha)	131.40	5.33	43.13	19.61
8.	Potassium (25kg/ha) + Zinc (15kg/ha)	136.73	5.53	46.33	21.00
9.	Potassium (25kg/ha) + Zinc (20kg/ha)	139.20	5.86	49.45	21.53
10.	Control (N:P:K 20:40:20 kg/ha)	109.53	3.80	39.46	17.43
	F test	S	S	S	S
	SEm(±)	3.90	0.29	1.65	0.90
	CD (p=0.05)	11.60	0.86	4.90	2.67

Table 2. Effect of potassium and zinc on yield and yield attributes of cluster bean

S.No.	Treatment combination	Number of pods /Plants	Number of seeds/pod	Test weight (g)	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Harvest Index (%)
1.	Potassium (15kg/ha) + Zinc (10kg/ha)	53.80	7.53	26.13	1093.96	2662.02	29.12
2.	Potassium (15kg/ha) + Zinc (15kg/ha)	56.60	7.60	26.70	1127.85	2670.36	29.88
3.	Potassium (15kg/ha) + Zinc (20kg/ha)	58.20	7.66	26.96	1150.56	2766.89	29.36
4.	Potassium (20kg/ha) + Zinc (10kg/ha)	59.20	7.73	26.93	1164.42	2840.29	29.07
5.	Potassium (20kg/ha) + Zinc (15kg/ha)	61.73	7.86	27.33	1170.02	2910.09	28.66
6.	Potassium (20kg/ha) + Zinc (20kg/ha)	62.93	7.93	27.46	1196.44	2937.19	28.92
7.	Potassium (25kg/ha) + Zinc (10kg/ha)	69.20	8.20	27.50	1261.89	2988.80	28.92
8.	Potassium (25kg/ha) + Zinc (15kg/ha)	72.00	8.53	28.83	1266.69	3005.02	29.64
9.	Potassium (25kg/ha) + Zinc (20kg/ha)	73.13	9.13	29.53	1363.56	3208.91	29.84
10.	Control (N:P:K 20:40:20 kg/ha)	49.66	7.40	25.86	1036.69	2576.74	28.70
	F test	S	S	NS	S	S	NS
	SEm(±)	2.62	0.25	0.90	34.95	82.28	0.98
	CD (p=0.05)	7.77	0.75	-	103.83	244.42	-

Table 3. Effect of potassium and zinc of economics on cluster bean

S.No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	Potassium (15kg/ha) + Zinc (10kg/ha)	22080.00	62538.33	40458.33	1.83
2.	Potassium (15kg/ha) + Zinc (15kg/ha)	22580.00	64105.05	41525.05	1.84
3.	Potassium (15kg/ha) + Zinc (20kg/ha)	23080.00	65609.66	42529.66	1.84
4.	Potassium (20kg/ha) + Zinc (10kg/ha)	22176.00	66600.66	44424.66	2.00
5.	Potassium (20kg/ha) + Zinc (15kg/ha)	22676.00	67201.66	44525.66	1.96
6.	Potassium (20kg/ha) + Zinc (20kg/ha)	23176.00	68525.78	45349.78	1.95
7.	Potassium (25kg/ha) + Zinc (10kg/ha)	22284.00	717729.23	49445.23	2.21
8.	Potassium (25kg/ha) + Zinc (15kg/ha)	22784.00	72026.33	49242.33	2.16
9.	Potassium (25kg/ha) + Zinc (20kg/ha)	23284.00	77405.66	54118.66	2.32
10.	Control (N:P:K 20:40:20 kg/ha)	21176.00	59534.93	38385.93	1.81

with the application of Potassium (25 kg/ha) might be due increase levels of K application may be either direct or indirect, under different environments, in major plant processes such as photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation straw yield of plant. Similar results were reported by Nellore et al*.* [18]. Further increase in dry weight observed with the application of zinc (20 kg/ha) might be due to Zinc application role decreases the pH of the soil and increasing root absorption of minerals and improving biosynthesis of plant growth regulator IAA, carbohydrate and N metabolism which leads of straw yield. Similar results were reported by Ali et al. [14] and Yashona et al*.* [12].

3.1.10 Harvest index (%)

The data revealed highest harvest index (29.88%) was recorded in Treatment 2 [Potassium (20kg/ha) + Zinc (15kg/ha)], thought there was non-significant difference among the treatment.

3.1.11 Economic

The result showed that maximum gross return (INR 77,405.66/ha), net return (INR 54,121.66/ha) and B:C ratio (2.32) were also recorded in treatment 9 (Potassium 25 kg/ha + Zinc 20 kg/ha) in (Table 3). Higher gross returns, net returns, and benefit-cost ratio were recorded with the application of zinc (20 kg/ha) might be due to maximum recovery from the application of zinc with less expenditure and higher seed yield and strow yield obtained from these treatments. These results conform with those observed by Sunil et al*.* [17].

4. CONCLUSION

Based on the above findings it can be concluded that Cluster bean with the application of Potassium 25 kg/ha along with the application of Zinc 20 kg/ha (Treatment 9) was observed highest seed yield and benefit- cost ratio [19].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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