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Effect of zinc and gibberellic acid on growth and yield of cluster bean

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Abstract
A field experiment was conducted during *kharif* season of 2023 at Crop Research Farm, Department of Agronomy. The treatments consisted of 3 levels of Zinc (15 kg/ha, 20 kg/ha and25 kg/ha) and GA3 (30, 40 and 50 ppm) along with recommended doses of nitrogen, phosphorus and potash and a control (20-40- 25 kg N-P-K/ha). The results showed that application of 25 kg/ha zinc along with foliar spray GA3 50 ppm (Treatment 9) recorded highest plant height (110.41 cm), highest number of nodules per plant (22.12), highest dry weight (33.90 g), pods per plant (50.13), seeds per pod (8.13), test weight (28.53 g), seed yield (1314.10 kg/ha) and stover yield (3215.90 kg/ha). The aforesaid treatment also recorded maximum gross return (75214.00 INR/ha), net return (50054.16 INR/ha) and B:C ratio (1.99).

Keywords: Cluster bean, zinc, gibberellic acid, productivity and economics

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 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 very hard and drought tolerant crop. Its deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rain fed cropping. The crop also survives even at moderate salinity and alkalinity conditions. In the 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 value of guar 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 (16 Kcal), 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. Leaves of guar are eaten to 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 (GOI, 2022) [3]. In India is the major exporter of guar-gum to the world. In India area of cluster bean is 3140.2 m ha, production is 1.5 m tonnes and productivity of 484 kg/ha. In Uttar Pradesh state area and production of this crop is 1979 ha and 1418 tonnes respectively. In Uttar Pradesh state productivity this state is 0.72 tonnes/ha (GOI, 2022) [3].

Low productivity of cluster bean may be ascribed to many reasons but inadequate and imbalanced fertilization is the major factor. In most of the cluster bean growing areas, poor soil fertility is one of the severe constraints limiting expression of its potentialproductivity. Cluster bean is main problem of waterlogging in India.

In the plant system, zinc is important for a number of 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.

The use of plant growth regulators (PGRs) to enhance yield by improving either source strength or sink strength is a key strategy for increasing productivity in Cluster bean. Insufficient levels of Gibberellic acid (GA3) in plants can lead to reduced seed germination, hindered endosperm mobilization, limited stem elongation, slower leaf expansion, prolonged maturation, and reduced flower and fruit formation and quality. GA3 delays aging, enhances growth and chloroplast development, and boosts photosynthetic efficiency, potentially resulting in higher yields. GA3 is particularly effective in stimulating cell elongation and is crucial for achieving optimal seed production. It is widely recognized for inducing flowering in various crops, influencing the formation of flowers in both long-day and short-day plants by regulating endogenous gibberellin levels. Application of GA3 to Cluster bean has shown significant increases in plant height (cm), total branch number, leaf area, plant dry weight, leaf chlorophyll content, stomatal conductance, and photosynthesis rate compared to untreated plants.

Applying zinc and Gibberellic acid via foliar spray during the flowering stage has been observed to reduce the percentage of flower drop in Cluster bean. Growth regulators can enhance physiological efficiency by improving photosynthetic capabilities and promoting effective distribution of accumulated substances between sources and sinks in the field. This improvement in physiological efficiency may significantly contribute to increasing crop productivity.

Material and Methods

The experiment was conducted during *Kharif* season 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.). The soil of the experimental field was sandy loamin texture, with soil pH 7.8, low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha), K (240.7 kg/ha) and zinc (2.32 mg/kg). The treatment consists of three levels of zinc along with the combination of three levels of gibberellic acid. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T_1 - Zinc - 15 kg/ha + GA3 - 30 ppm, T_2 - Zinc - 15 kg/ha + GA3 - 40 ppm, T_3 - Zinc - 15 kg/ha + GA3 - 50 ppm, T_4 - Zinc - 20 kg/ha + GA3 - 30 ppm, T_5 - Zinc - 20 kg/ha + GA3 - 40 ppm, T_6 - Zinc - 20 kg/ha + GA3 - 50 ppm, T_7 - Zinc - 25 kg/ha + GA3 - 30 ppm, T_8 - Zinc - 25 kg/ha + GA3 - 40 ppm, T_9 - Zinc - 25 kg/ha + GA3 - 50 ppm and T_{10} -Control (RDF). Data recorded on different aspects of crop, *viz*., growth, yield attributes and yield were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez (1976) [4].

Results and Discussion

Plant height (cm): At 80 DAS, significant and higher plant height (110.41 cm) was shown in the treatment 9 [Zinc (25 kg/ha) +GA3 (50 ppm)]. However, treatment 3 [Zinc (15 kg/ha) + GA3 (50 ppm)], treatment 5 [Zinc (20 kg/ha) + GA3 (40 ppm)] and treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] were found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and higher plant height was with the application of zinc (25 kg/ha) may be due to application of zinc increase in plant height might be due to its role in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial for promoting of photosynthesis which resulted in better plant growth and yield. Similar results were reported by Ali *et al*. (2013) [15]. Further, significant and higher plant height was with application of GA3 (50 ppm) possibly due to the beneficial effects of GA3, on cell elongation and cell division of cluster bean. Similar finding was also reported by Dawar *et al*. (2020) [2].

Number of nodules/plant: At 80 DAS, significant and maximum number of nodules/plant (22.12) was observed in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)], treatment 7 [Zinc (25 kg/ha) + GA3 (30 ppm)] and treatment 8 [Zinc (25 kg/ha) + GA3 (40 ppm)] were found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. The significant and maximum number of nodules/plant was with the application of zinc (25 kg/ha) might be due to zinc have stimulated the metabolic and enzymic activity and there by increases the plant growth attributes which increases the number of nodules/plant. Similar result was also reported by Patel *et al*. (2023) [16]. Further, significant and higher root nodules/plant was observed with GA3 (50 ppm), the efficient nutrient application enhanced the root growth there by colonizing the more rhizobacteria that helped for better root development and nodulation, resulted in increasing number of nodules/plant. Similar results was also reported by Revanth *et al*. (2021) [17].

Plant dry weight (g): At 80 DAS, significant and higher plant dry weight (33.90 g) was observed in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 3 [Zinc (15 kg/ha) + GA3 (50 ppm)] and treatment 6 [Zinc (50 kg/ha) + GA3 (50 ppm)] were found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and higher plant dry weight was with the application of zinc (25 kg/ha) maybe due to application of Zinc created a balanced nutritional environment which enhanced metabolic activities and photosynthetic rate, resulting in improvement in plant height and ultimately increases plant dry weight. Similar results also found by Reddy *et al.* (2021) [18]. Further, significant and higher plant height was with application of GA3 (50 ppm) which might be due to beneficial effects of GA3 on increasing the photosynthetic activity and better food accumulation resulting in higher dry weight of plant. Similar results were obtained by Navya *et al*. (2021) [19].

Number of pods/plant: Significant and maximum number of pods/plant (50.1) was observed in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] was found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and maximum number of pods/plant was with the application of zinc (25 kg/ha) role in synthesis of sulphur having amino acids, proteins and developed photosynthetic activity of plant with better chlorophyll synthesis which may have increased the number of pods/plants. Similar result was also reported by Banothu and Mehera, (2023) [20]. Further, significant and higher

number of pods/plant was with application of GA3 (50 ppm) may be due to the foliar application of GA3 at flowering stage (30 DAS) may have improved the reproductive development of the crop and supported efficient translocation of photosynthates from source to sink, this might have significantly increased the number of pods/ plant. Similar result was also reported by Dawar *et al*. (2020) [2].

Number of seeds/pod: Significant and maximum number of seeds/pods (8.13) was observed in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] was found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and maximum number of seeds/pod was with the application of zinc (25 kg/ha) might be due to application of Zn encouraged greater root growth and sink size development, which ultimately led to increased seeds/pod and seed yield. Similar result was also reported by Singh *et al*. (2018) [21]. Further, significant and higher number of seeds/pod was with application of GA3 (50 ppm) might be due to increased nodulation, an extensive root system, enhanced metabolite synthesis, and greater translocation to different sinks, especially the fruiting structures (pods and seeds), each plant may have produced more pods in proportion to its overall development. Similar results were also reported by Charles and Dawson, (2023) [1]

Seed yield (kg/ha): Significant and higher seed yield (1314.10 kg/ha) was recorded in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 3 [Zinc (15 kg/ha) + GA3 (50 ppm)], treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] and treatment 7 [Zinc (25 kg/ha) + GA3 (50 ppm)] were found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and higher seed yield was with zinc (25 kg/ha) might be due to role of Zn in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial for partitioning of photosynthates towards them which resulted in better yield which in turn led to increase in seed yield. Similar result was reported by Singh *et al*. (2016) [22]. Further, significantly higher seed yield of cluster bean was increased due to cumulative effect of yield attributing characters, enhanced photosynthetic efficiency and improvement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the foliar application of GA3. Similar results were observed by Dawar *et al*. (2020) [2].

Stover yield (kg/ha): Significant and higher stover yield (3215.90 kg/ha) was recorded in the treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. However, treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)], treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] and treatment 6 [Zinc (20 kg/ha) + GA3 (50 ppm)] were found to be statistically at par with treatment 9 [Zinc (25 kg/ha) + GA3 (50 ppm)]. Significant and higher stover yield was with zinc (25 kg/ha) which might be due to increased plant height. Similar result was reported by Nellore *et al*. (2021) [23]. Further, significant and higher stover yield was with application of GA3 - 50 ppm might be due to GA3 have distinct impact on the distribution of assimilators between vegetative and reproductive organs, which may have helped in the building up of photo assimilates and their separation into the storage parts of the plant. Similar results were observed by Pasarla *et al*. (2021) [9].

Table 1: Influence of Zinc and Gibberellic acid on growth attributes of Cluster bean

S. No.	Treatments	Plant height (cm)	Number of nodules/plant	Dry Weight (g)
1.	Zinc 15 kg/ha + GA3 30 ppm	93.48	16.63	27.00
2.	Zinc 15 kg/ha + GA3 40 ppm	96.19	15.39	29.83
3.	Zinc 15 kg/ha + GA3 50 ppm	102.20	17.00	31.00
4.	Zinc 20 kg/ha + GA3 30 ppm	99.11	16.71	30.60
5.	Zinc 20 kg/ha + GA3 40 ppm	104.86	15.66	30.13
6.	Zinc 20 kg/ha + GA3 50 ppm	108.30	20.66	31.33
7.	Zinc 25 kg/ha + GA3 30 ppm	95.67	18.41	27.67
8.	Zinc 25 kg/ha + GA3 40 ppm	98.80	18.16	28.80
9.	Zinc 25 kg/ha + GA3 50 ppm	110.41	22.12	33.90
10.	Control (RDF)	93.48	15.62	27.03
	F - test	S	S	S
	S Em (±)	3.79	1.41	1.07
	CD (p=0.05)	11.26	4.20	3.17

Table 1: Influence of Zinc and Gibberellic acid on yield attributes and yield of Cluster bean

S. No.	Treatments	Number of Pods/plant	Number of Seeds /Pod	Seed yield (kg/ha)	Stover yield (kg/ha)
	Zinc 15 kg/ha + GA3 30 ppm	35.07	6.89	1022.63	2652.02
2.	Zinc 15 kg/ha + GA3 40 ppm	37.32	6.66	1140.56	2664.89
3.	Zinc 15 kg/ha + GA3 50 ppm	46.20	7.20	1202.57	2978.80
4.	Zinc 20 kg/ha + GA3 30 ppm	35.60	6.60	1117.88	2660.26
5.	Zinc 20 kg/ha + GA3 40 ppm	38.10	6.73	1121.09	2740.19
6.	Zinc 20 kg/ha + GA3 50 ppm	49.66	7.53	1204.46	3004.01
7.	Zinc 25 kg/ha + GA3 30 ppm	41.93	6.93	1186.41	2927.19
8.	Zinc 25 kg/ha + GA3 40 ppm	40.62	6.86	1120.07	2901.00
9.	Zinc 25 kg/ha + GA3 50 ppm	50.13	8.13	1314.10	3215.90
10.	Control (RDF)	34.56	6.91	1017.67	2143.19
	F - test	S	S	S	S
	S Em (±)	1.77	0.21	51.06	105.45
	CD (p=0.05)	5.25	0.62	151.72	313.29

Table 3: Influence of Zinc and Gibberellic acid on economics of Cluster bean

S. No.	Treatments	Total cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1.	Zinc 15 kg/ha + GA3 30 ppm	23919.84	59278.45	35358.61	1.48
2.	Zinc 15 kg/ha + GA3 40 ppm	24024.84	64649.65	40624.81	1.69
3.	Zinc 15 kg/ha + GA3 50 ppm	24159.84	69009.65	44849.81	1.86
4.	Zinc 20 kg/ha + GA3 30 ppm	24419.84	63605.9	39186.06	1.60
5.	Zinc 20 kg/ha + GA3 40 ppm	24524.84	64150	39625.16	1.62
6.	Zinc 20 kg/ha + GA3 50 ppm	24659.84	69220.75	44560.91	1.81
7.	Zinc 25 kg/ha + GA3 30 ppm	24919.84	68024.4	43104.56	1.73
8.	Zinc 25 kg/ha + GA3 40 ppm	25024.84	64908.15	39883.31	1.59
9.	Zinc 25 kg/ha + GA3 50 ppm	25159.84	75214.00	50054.16	1.99
10.	Control (RDF)	22284.84	56511.1	34226.26	1.54

Conclusion

It is concluded that in Cluster bean (Treatment 9) with the combination of zinc (25 kg/ha) along with the GA3 (50 ppm) was observed highest grain yield and benefit cost ratio.

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