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Effect of sulphur and zinc levels on growth and yield of cluster bean (*Cyamopsis tetragonoloba* L. Taub)

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Abstract
A field experiment was carried out during *kharif* season of 2020 at KVK, Yagantipalli, Kurnool, Andhra Pradesh to study about the effect of Sulphur and zinc levels on growth and yield of Cluster bean (*Cyamopsis tetragonoloba* L. Taub). The experiment was laid out in randomized block design with closing two treatment factors, *i.e.*, Sulphur and zinc levels *i.e.*, S_1- 20 kg/ha, S_2-30 kg/ha and S_3-40 kg/ha and Zn_1-5 kg/ha, Zn_2-10 kg/ha and Zn_3-20 kg/ha. Results revealed that application of sulphur 40 kg/ha + zinc 20 kg/ha recorded significantly highest plant height (124.9 cm), number of branches (25.3), plant dry weight (28.92 g), number of pods/plant (42.1), seed index (3.2 g), number of seeds/pod (8.4), pod yield (4071.20 kg/ha), seed yield (1968 kg/ha) and stover yield (5123.33 kg/ha). However, net returns (39231 INR/ha) and B:C ratio (1.83) were also obtained with the application of Sulphur 40 kg/ha + zinc 20 kg/ha.

Keywords: B:C ratio, cluster bean, net return, sulphur, yield, zinc

Introduction

Cluster bean (*Cyamopsis tetragonoloba* L. Taub.) popularly known as guar, is a drought hardy and deep-rooted legume crop grown for feed, fodder, green manure and vegetable purpose. Guar plant produces a cluster of flowers and pods; therefore, it is also known as cluster bean. It belongs to the family Leguminaceae and is known to improve soil fertility. Being a legume crop, it has the capacity to fix atmospheric nitrogen by its effective root nodules (Kumar *et al.*, 2012). It is generally 50-100 cm tall and bears 4 to 10 branches (branch type). However, non-branch type varieties have main stem only, which is heavily clustered with pods. India leads among the major guar producing countries of the world. According to Aykroyd (1963) [2] the composition of cluster bean is 8.10 g moisture, 10.8 g carbohydrate, 23% protein, 1.4 g fat, 1.4 g minerals, 0.09 mg thiamine, 0.03 mg riboflavin, 47 I.U. vitamin C, 316 I.U, vitamin A (per 100 g of edible portion).

India is one of the main producers of cluster bean accounting 82% of the total production of the world, and the same is grown in the north-western states of India, namely, Rajasthan, Gujarat, Haryana, Punjab and some parts of Uttar Pradesh and Madhya Pradesh. In India, cluster bean is being grown in the area of 4.26 million hectares with a production of 2.42 million tonnes of cluster bean seed. In Andhra Pradesh farmers in Ananthapuram, Guntur, Kurnool, Karimnagar, Nellore, Prakasam and Ranga Reddy districts of undivided Andhra Pradesh have also started the cultivation of clusterbean for seed in more than 1000 ha (NRAA 2014) [2]. Cluster bean is majorly cultivated Ananthapuram district is the second most drought - affected district of India, receives around 500 mm rainfall annually, being located in the scarce rainfall zone of Andhra Pradesh,

Low productivity of cluster bean can be due to many reasons and imbalance or inadequate fertilization. Application of sulphur not only improves plant growth and yield but also improves the quality of cluster bean. Sulphur promotes nodulation in legumes and favours solubilization of organic nitrogen and decrease the quantity of insoluble nitrogen resulting in reduction of sulphur. (Singh and Chauhan, 2015) [16]

Cluster bean is highly responsive to micro nutrients mainly zinc. Zinc is one of such micronutrients, its deficiency in the field crops is the global phenomenon and it has also received maximum attention in our country as compared to other micronutrients. Zinc is required for plant growth, as an activator of several enzymes and is directly involved in the biosynthesis of growth regulators such as auxin which promotes production of more plant cells and biomass that will be stored in the plant organs especially in seeds and their deficiencies may be one of the important reasons of poor yields in light textured soils

(Singh and Raj, 2001) [19].

Materials and Methods

A field experiment was conducted during *Kharif* season of 2020 at Krishi Vigyan Kendra, Yagantipalli, Kurnool, Andhra Pradesh, the farm situated at 15^0 32' N latitude, $78^0$18' E longitude during *Kharif* season 2020 on sandy loam soil, having soil reaction (pH 7.1), organic carbon (0.112), available nitrogen (278.93 kg/ha), available phosphorus (10.8 kg/ha) and available potassium (206.4 kg/ha). The climate of the region is subtropical. Treatments comprised of T_1 – 20 kg/ha S + 5 kg/ha Zn, T_2 – 20 kg/ha S + 10 kg/ha Zn, T_3 – 20 kg/ha S + 20 kg/ha Zn, T_4 – 30 kg/ha S + 5 kg/ha Zn, T_5 – 30 kg/ha S + 10 kg/ha Zn, T_6 – 30 kg/ha S + 20 kg/ha Zn, T_7 – 40 kg/ha S + 5 kg/ha Zn, T_8 – 40 kg/ha S + 10 kg/ha Zn, T_9 – 40 kg/ha S + 20 kg/ha Zn and T_{10} – Control (20:40:20 kg/ha N, P, K). These were replicated thrice in Randomized Block Design. The recommended dose of fertilizer is 60-30-30 kg/ha NPK. Recommended dose of fertilizer was applied at the time of sowing in the form of Urea, DAP and MOP.

Chemical analysis of soil

Composite soil samples were collected before layout of the experiment to determine the initial soil properties. The soil samples were collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analysed for organic carbon by rapid titration method by Nelson (1975) [11]. Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956) [21], available phosphorus by Olsen's method as outlined by Jackson (1967), available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) [6] and available $ZnSO_4$ was estimated by Atomic Absorption Spectrophotometer method as outlined by Lindsay and Norvell (1978).

Statistical analysis

The data recorded where different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (2010). Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

Results and Discussion

Growth Attributes

Plant height

Plant height was increased with increase in age of crop, and was recorded in all the different growth intervals with the levels of sulphur and zinc. At harvest, maximum plant height (124.9 cm) was recorded with application of Sulphur 40 kg/ha + Zinc 20 kg/ha which was significantly superior over all other treatments except treatment of application of Sulphur 40 kg/ha + Zinc 10 kg/ha (123.5 cm), Sulphur 40 kg/ha + Zinc 5 kg/ha (122.6 cm) which were found statistically on par with application of Sulphur 40 kg/ha + Zinc 20 kg/ha. The probable reason for increasing plant height might due to presence of sulphur in the application plays pivotal role in several physiological and biochemical processes which are of vital importance for growth and development of plant. Similar results were earlier reported by Raiger *et al.* (2017) [14]. 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 Ali *et al.* (2013) [1].

Plant dry weight

Observations regarding the plant dry weight of cluster bean are given in Table 1 and there was progressive increase in dry weight with advancement of crop during the crop growth At harvest, maximum plant dry weight (28.92 g) was recorded with application of Sulphur 40 kg/ha + Zinc 20 kg/ha which was significantly superior over all other treatments except treatment of application of Sulphur 40 kg/ha + Zinc 10 kg/ha (28.24 g), Sulphur 40 kg/ha + Zinc 5 kg/ha (27.41 g) which were statistically on par with application of Sulphur 40 kg/ha + Zinc 20 kg/ha. Zn and S application 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 types of results were reported by Meena *et al*. (2006) [10], Ramawtar *et al*. (2013) [13].

Number of branches/plant

At harvest, maximum number of branches (25.3) were recorded with application of Sulphur 40 kg/ha + Zinc 20 kg/ha which was significantly superior over all other treatments except treatment with application of Sulphur 40 kg/ha + Zinc 10 kg/ha (24.7) and Sulphur 40 kg/ha + Zinc 5 kg/ha (223.8) which are statistically on par with application of Sulphur 40 kg/ha + Zinc 20 kg/ha. Maximum number of branches were observed with application of sulphur 40 kg/ha + zinc 20 kg/ha due to availability of zinc might have stimulated the metabolic and enzymic activity and there by increases the plant growth attributes which increases the number of branches/plant similar results have also reported by Kasturi krishna and Ahlawat (2000) [7].

Yield attributes and yield

At harvest, maximum no. of pods/plant (42.1) were recorded with application of Sulphur 40 kg/ha + Zinc 20 kg/ha which was significantly superior over all other treatments except treatment with application of Sulphur 40 kg/ha + Zinc 5 kg/ha (41.3) which were statistically on par with application of Sulphur 40 kg/ha + Zinc 20 kg/ha. Application of sulphur 40 kg/ha and zinc 20 kg/ha recorded significantly highest number of seeds/pod (8.4). Application of sulphur 40 kg/ha and zinc 10 kg/ha (7.9) and sulphur 40 kg/ha and zinc 5 kg/ha (7.6) were found to be statistically on par with sulphur 40 kg/ha and zinc 20 kg/ha. Application of sulphur 40 kg/ha and zinc 20 kg/ha recorded significantly highest seed index (3.2 g). Application of sulphur 40 kg/ha and zinc 10 kg/ha (3.1 g) and sulphur 40 kg/ha and zinc 5 kg/ha (3.1 g) were statistically on par with sulphur 40 kg/ha and zinc 20 kg/ha. Successive increases in sulphur 40 kg/ha and zinc 20 kg/ha intended to increase in yield attributes like number of pods/plants, number of seeds/pod and test weight. The favourable effects thus led to increased translocation of photosynthates towards seeds resulting in formation of bold seeds. Cumulative effect of improvement of growth parameters through efficient metabolic activity and increased rate of photosynthesis led to maximum expression of yield. With increasing supply of sulphur, the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have increased, resulting in more flowers and pods. In cluster bean sink lies in pods and seed. When supply of sulphur is optimum, greater translocation of photosynthate occur from leaves to the sink site *i.e.*, pods and seeds, resulting in robust pods and better seeds. The sum total effect will be higher seed yield. Increase in straw yield can be ascribed due to overall improvement in plant organs associated with faster and uniform vegetative growth of the crop under the effect of sulphur over control. Results of present study corroborate with the findings of Karche *et al*. (2012) [8] and Ramawtar *et al*. (2013) [13]. Application of sulphur 40 kg/ha and zinc 20 kg/ha was recorded significantly highest seed yield (1968.66 kg/ha). Application of sulphur 40 kg/ha and zinc 10 kg/ha (1906.33 kg/ha) and sulphur 40 kg/ha and zinc 5 kg/ha (1835.33 kg/ha) were statistically on par with sulphur 40 kg/ha and zinc 20 kg/ha. Application of sulphur 40 kg/ha and zinc 20 kg/ha was recorded significantly highest stover yield (5123.33 kg/ha). Application of sulphur 40 kg/ha and zinc 10 kg/ha (4931.33 kg/ha) and sulphur 40 kg/ha and zinc 5 kg/ha (4802.66 kg/ha) were recorded statistically on par with sulphur 40 kg/ha and zinc 20 kg/ha. Harvest index (%) was obtained maximum with application of sulphur 40 kg/ha and zinc 10 kg/ha (27.89%) which was significantly superior over all other treatments except with application of sulphur 40 kg/ha and zinc 20 kg/ha (27.69%), sulphur 40 kg/ha and zinc 5 kg/ha (27.63%) and sulphur 30 kg/ha and zinc 20 kg/ha (26.0%). Successive increase in sulphur 40 kg/ha and zinc 20 kg/ha significantly improved yield and yield attributes *viz*., no. of pods/plant, no. of grains/pod, test weight; and grain, straw and biological yields of cluster bean. The improvement in nutritional environment ultimately resulted in better plant metabolism and photosynthetic activity improved yield components. The grain yield being the function of cumulative effect of yield attributes, increased significantly due to addition of S. Among the various S levels, application of 40 kg/ha produced higher grain yield (1968.66 kg/ha) over control. Sulphur of chloroplast protein resulted in greater photosynthetic efficiency which in turn translated in terms of increase in yield Karche *et al.* (2012) [8]. Similar results were also reported by Singh *et al*. (2006), Singh and Mann (2007) [18] and Baviskar *et al.* (2010) [3]. Zinc plays an important role in biosynthesis of indole acetic acid which is responsible for initiation of primordial for reproductive parts and partitioning of photosynthesis towards them which resulted in better yield (Krishna, 1995, Srivastava *et al.,* 2006, Ram and Katiyar, 2013) [9, 20, 15].

Economics

Maximum Net returns (39,231.00 INR /ha) and B:C ratio (1.83) was obtained with application of sulphur 40 kg/ha and zinc 20 kg/ha which was significantly superior over rest of the treatments.

Table 1: Effect of sulphur and zinc on Growth Attributes of cluster bean.

Treatments	Plant height (cm)				Plant dry weight (g/plant)				No of branches/plant			
	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest
Sulphur 20 Kg + Zinc 5 Kg	44.5	92.9	112.7	116.5	4.7	14.58	21.38	25.95	11.9	18.5	19.9	21.7
Sulphur 20 Kg + Zinc 10 Kg	44.9	92.0	111.5	117.3	4.5	14.25	21.32	26.09	12.1	16.8	20.4	22.0
Sulphur 20 Kg + Zinc 20 Kg	43.4	91.5	112.7	116.5	4.5	14.09	21.98	25.29	11.8	17.0	20.6	22.3
Sulphur 30 Kg + Zinc 5 Kg	44.3	92.0	115.0	117.6	4.6	15.62	22.41	25.69	12.3	17.1	20.1	22.1
Sulphur 30 Kg + Zinc 10 Kg	45.5	93.7	114.6	118.2	4.4	14.87	23.52	26.68	12.5	18.8	20.9	21.7
Sulphur 30 Kg + Zinc 20 Kg	45.9	93.2	117.6	121.5	4.6	16.15	22.67	26.93	12.6	18.3	20.0	22.1
Sulphur 40 Kg + Zinc 5 Kg	48.7	94.3	118.3	122.6	4.7	17.22	23.37	27.41	13.1	19.1	22.6	23.8
Sulphur 40 Kg + Zinc 10 Kg	49.4	95.6	118.8	123.5	4.8	18.13	24.22	28.24	13.6	19.7	22.8	24.7
Sulphur 40 Kg +Zinc 20 Kg	50.3	96.8	119.2	124.9	4.9	18.83	25.13	28.92	13.9	20.0	23.5	25.3
Control plot (RDF 20:40:20 NPK kg/ha)	41.9	90.9	109.2	113.3	4.1	14.07	20.99	23.45	11.9	16.3	19.8	21.8
S.Em (±)	0.71	0.83	1.21	0.99	0.13	0.70	0.76	0.59	0.46	0.76	0.69	0.54
CD (0.05%)	2.11	2.49	3.60	2.95	0.40	2.10	2.28	1.75	1.40	2.27	2.05	1.62

Table 2: Effect of sulphur and zinc on Yield Attributes and Yield of cluster bean

Treatments	No of pods/plant	No of seeds/pod	Test weight(g)	Pod yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Sulphur 20 Kg + Zinc 5 Kg	34.2	6.4	2.8	3227.70	1383.33	4179.33	24.91
Sulphur 20 Kg + Zinc 10 Kg	34.0	6.7	2.8	3106.36	1331.33	3786.66	26.30
Sulphur 20 Kg + Zinc 20 Kg	35.1	7.1	2.8	3162.94	1375.33	4294.00	24.22
Sulphur 30 Kg + Zinc 5 Kg	35.4	7.3	2.8	3166.36	1362.66	4510.66	23.18
Sulphur 30 Kg + Zinc 10 Kg	35.8	6.8	2.9	3361.32	1494.00	4708.66	24.07
Sulphur 30 Kg + Zinc 20 Kg	37.3	7.5	3.0	3444.36	1562.66	4448.66	26.00
Sulphur 40 Kg + Zinc 5 Kg	41.3	7.6	3.1	3913.73	1835.33	4802.66	27.63
Sulphur 40 Kg + Zinc 10 Kg	40.1	7.9	3.1	4046.44	1906.33	4931.33	27.89
Sulphur 40 Kg +Zinc 20 Kg	42.1	8.4	3.2	4071.20	1968.66	5123.33	27.67
Control plot (RDF 20:40:20 NPK kg/ha)	34.2	6.2	2.7	3094.58	1332.00	4111.00	24.45
S.Em (±)	0.52	0.24	0.06	105.14	58.53	132.52	1.12
CD (0.05%)	1.56	0.74	0.19	312.39	173.91	393.74	3.62

Table 3: Effect of sulphur and zinc on Economics of cluster bean

Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C Ratio
Sulphur 20 Kg + Zinc 5 Kg	44787	61619	16832	1.37
Sulphur 20 Kg + Zinc 10 Kg	45078	58932	13854	1.30
Sulphur 20 Kg + Zinc 20 Kg	45770	61454	15684	1.34

Sulphur 30 Kg + Zinc 5 Kg	45502	61271	15769	1.34
Sulphur 30 Kg + Zinc 10 Kg	45793	66822	21029	1.44
Sulphur 30 Kg + Zinc 20 Kg	46485	69179	22694	1.47
Sulphur 40 Kg + Zinc 5 Kg	46217	80616	34399	1.74
Sulphur 40 Kg + Zinc 10 Kg	46573	83649	37076	1.79
Sulphur 40 Kg +Zinc 20 Kg	47200	86431	39231	1.83
Control plot (RDF 20:40:20 NPK kg/ha)	43021	59446	16425	1.38

Conclusion
It can be concluded that application of sulphur 40 kg/ha and zinc 20 kg/ha soil application in Cluster bean was recorded significantly higher seed yield (1968.66 kg/ha), Gross returns (86,431 INR/ha), Net returns (39,231 INR/ha) and Benefit Cost ratio (1.83).

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