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Effect of Phosphorus and Zinc Levels on Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.)

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ABSTRACT: The field experiment was conducted during *Kharif* 2020 at Research Farm, Krishi Vigyan Kendra, Sangaria, Hanumangarh (Rajasthan). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.37), low in organic carbon (0.26 %), available N (210.5 kg/ha), available P(37 kg/ha). The experiment was laid out in Randomized Block Design consists of nine treatment which are replicated thrice and the treatments consisted of phosphorus *viz.*, P_1 (20 kg/ha), P_2 (40 kg/ha) P_3 (60 kg/ha) and Zinc *viz.*, Z_1 (05 kg/ha), Z_2 (10 kg/ha), Z_3 (15 kg/ha). The result revealed that the among nine treatments growth parameters *viz.*, plant height (112.40 cm), Dry weight (15.73 g/ plant), Branches (10.33), Crop growth rate (4.91 g/m^2/day), are found significantly higher in treatment six with the application of 60 kg Phosphorus and 10 kg Zinc and the yield parameter are also recorded significantly higher in the same treatment *viz.*, pods per plant (47.40), seed per pod (6.7), seed yield (1270.00 kg/ ha), Stover yield (3810.30 kg/ ha). A good supply of phosphorous is usually associated to increased root density proliferation, which aids in extensive exploration, supply of nutrients and water to growing plant parts, thus increase growth and yield. Zinc is required for plant growth and it is activator of many enzyme activities.

Keywords: Cluster bean, Phosphorus, Zinc, *Cyamopsis tetragonoloba*.

INTRODUCTION

Cluster bean *Cyamopsis tetragonoloba* (L.) is an annual legume crop mostly grown under resource constrained conditions in arid and semi-arid regions (Kumar, 2005). Cluster bean crop with a chromosome number of 2n=2x=14 which is popularly known as guar, chavli, kayi, guari, khutti. It is a self-pollinated crop. Cluster bean is a deep rooted crop of Leguminosae (Fabaceae) family known for drought and high temperature tolerance (Kumar and Rodge 2012). It is grown for feed, fodder, green manure and vegetable purpose. Being a legume crop, it has the capacity to fix atmospheric nitrogen by its effective root nodules. 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 (Sunil *et al*., 2018). India produces about 80% of the world cluster bean production (Tripathy and Das, 2013). It is a good source of nutrition and its tender green pods are also a cheap source of nutrients. Further cluster bean meal and seed are used as high protein cattle feed (Rai and Dharmatti, 2013). Rajasthan has an area of 46.30 lakh hectare, production of 27.47 million tonnes with a productivity of 593 kg/ha. (Anonymous 2015-16). In the recent years, this crop has assumed great significance in industrial sector due to the presence of good quality of gum in the endosperm of its seed and also having 28 to 33% gum. The natural polysaccharide water-soluble polymer found in the endosperm (Reddy *et al*., 2011).

Zinc plays an outstanding role in synthesis of chlorophyll, protein and also regulates water absorption. Moreover, it also play role in carbohydrates metabolism and activation of various enzymes which help in inducing alkalinity tolerance in crops by enhancing Na/K and Na/Ca ratio (Rohith *et al*., 2020). 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). The improved genotypes of cluster bean are more Zn responsive up to 15-20 kg ha-1 because this nutrient acts as catalytic components of protein and enzymes for normal growth and development as observed by Manivasagaperumal *et al.*, (2011).

Phosphorus plays a good role in evaluation of energy rich phosphate bond like ADP and ATP, nuclear protein

and phospholipid and is essential constitute of nucleic acids (RNA & DNA), nucleoprotein, amino acids, phosphatides, phytin and several coenzymes. Phosphorous also imply in energy conveying metabolic processes and basic reaction of photosynthesis, transformation of sugars, starch and nutrient movements in plants. Phosphorus plays an important role in virtually all main metabolic processes in plant including photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration (Rashmitha *et al*., 2021).

The experiment was conducted to find out best level of Phosphorus and zinc in cluster bean.

MATERIAL AND METHODS

The experiment was conducted during the *Kharif* season 2020, at the Farm, Krishi Vigyan Kendra, Sangaria, Hanumangarh (Rajasthan) which is located at geographical coordinates 29° 51' 39.14" N latitude, 74° 20' 51.96" E longitude and 192.81 m altitude above the mean sea level. Location of KVK is about 26 Kms. From district head quarter on Bhagatpura road in North-West direction and tri junction of Rajasthan, Punjab and Haryana.The experiment was laid out in Randomized block design, replicated thrice. The treatment comprised of three different Phosphorus levels P_1 (20 Kg/ha), P_2 (40 Kg/ha) and P_3 (60 Kg/ha) and three different Zinc levels Z_1 (05 Kg/ha), Z_2 (05 Kg/ha) and Z_3 (05 Kg/ha) through basal application and the possible combination is presented in Table 1. During the growing season, the mean weekly maximum and minimum temperature, relative humidity and rainfall were 40.13°C, 21.00°C, 80.84 %, 53.48 % and 4.72 mm, respectively. The field was uniformly irrigated one day before sowing on each of the treatment combinations. The RDF i.e., Nitrogen (20 kg ha^{-1}) was applied through Urea in basal dose, Observations on growth parameters, yield attributes and yield of Green Gram, was recorded and their significance was tested by the variance ratio and F-value at 5% level of significance (Gomez and Gomez, 1984).

Table 1: Treatment combination.

Sr. No.	Treatment No.	Treatment Combination
1.	T_1	P_2O_5 20 kg/ha +Zn 05 kg/ha
2.	T_2	P_2O_5 40 kg/ha +Zn 05 kg/ha
3.	T_3	P_2O_5 60 kg/ha +Zn 05 kg/ha
4.	T_4	P_2O_5 20 kg/ha +Zn 10 kg/ha
5.	T_5	P_2O_5 40 kg/ha +Zn 10 kg/ha
6.	T_6	P_2O_5 60 kg/ha +Zn 10 kg/ha
7.	T_7	P_2O_5 20 kg/ha +Zn 15 kg/ha
8.	T_8	P_2O_5 40 kg/ha +Zn 15 kg/ha
9.	T_9	P_2O_5 60 kg/ha +Zn 15 kg/ha

RESULT AND DISCUSSION

Growth parameter: Growth parameters of cluster bean, *viz.* plant height (cm), Dry weight (g), number of branches varied due to different levels of phosphorus and zinc in Table 2.

Table 2: Effect of Phosphorus and Zinc levels on growth and of cluster bean.

Treatment	80DAS			
	Plant Height (cm)	Number of branches	Dry weight (g $plant^{-1}$)	Crop growth rate (g/m^2/day)
T_1: Phosphorus 20 kg/ha + Zinc 05 kg/ha	83.30	4.63	6.20	0.41
T_2: Phosphorus 40 kg/ha + Zinc 05 kg/ha	90.80	5.87	10.07	2.87
T_3: Phosphorus 60 kg/ha + Zinc 05 kg/ha	96.20	8.40	12.67	3.60
T_4: Phosphorus 20 kg/ha + Zinc 10 kg/ha	82.50	5.07	7.47	1.29
T_5: Phosphorus 40 kg/ha + Zinc 10 kg/ha	108.80	9.90	15.10	4.62
T_6: Phosphorus 60 kg/ha + Zinc 10 kg/ha	112.40	10.33	15.73	4.91
T_7: Phosphorus 20 kg/ha + Zinc 15 kg/ha	87.00	5.33	8.60	1.93
T_8: Phosphorus 40 kg/ha + Zinc 15 kg/ha	94.20	6.30	11.40	3.52
T_9: Phosphorus 60 kg/ha + Zinc 15 kg/ha	109.60	10.07	15.40	4.76
S.E.m(+)	1.40	0.16	0.16	0.15
CD.(5%)	4.19	0.47	0.48	0.44

Plant height: The treatment in which Phosphorus 60 kg along with the application of Zinc 10 kg/ha. resulted significantly higher plant height (112.4 cm). However, treatment combination with phosphorus 60 kg + Zinc 15 kg and phosphorus 40 kg + Zinc 10 kg found to be statistically at par for plant height (109.6 cm and 108.8 cm respectively) with highest treatment.

Dry weight: At 80 DAS, treatment combination with phosphorus 60 kg and Zinc 10 kg significantly higher Dry weight (15.73 g) was recorded. However, phosphorus 60 kg + Zinc 15 kg found to be statistically par to higher treatment combination.

Number of branches: At 80 DAS, significantly higher branches (10.33) was recorded with the application of

60 kg phosphorus and 10 kg Zinc. However, treatment combination with phosphorus 60 kg + Zinc 15 kg and phosphorus 40 kg + Zinc 10 kg found to be statistically at par with highest treatment.

Crop Growth Rate (g/m^2/day): At 60-80 DAS, the significantly highest crop growth rate (4.91 g/m^2 /day) was observed in phosphorus 60 kg and Zinc 10 kg. Whereas, phosphorus 60 kg + Zinc 15 kg (4.76 g/m^2 /day) and phosphorus 40 kg + Zinc 10 kg (4.62 g/m^2/day) found to be statistically at par to higher treatment.

The plants attained more vigour with phosphorus as compared to control, due to adequate supply and availability of nitrogen, phosphorus, potassium and spacing in balanced combination, resulting in increased dry weight of the plant. Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants might have also resulted in higher growth of the plant. When P supply is limited, the availability of P and N to chloroplast became limited ultimately affect the photosynthetic processes as well as photosynthates supply to nodules. The effect of P could be related to the finding by that it stimulates root growth and activity and nodule formation (Apáez Barrios *et al.,* 2014). Phosphorus resulted in higher rate of dry matter accumulation which might be due to the increase in vegetative development and reproductive attributes under proper availability of phosphorus and better physical condition of soil. Positive responses in terms of yield attributes due to application of phosphorus (Masih *et al.,* 2020). The improvement in plant growth by Zn nutrient may be assigned to improved nodulation resulting in enhanced N fixation, which in turn might have improved leaf area index and photosynthesis. These results were in conformity with the findings of Meena *et al.,* (2010).

Yield attributes: Yield attributes such as number of effective Pods/plants and Seeds/pods exhibited significant variation during the experimental period due to different levels of Phosphorus and zinc.

Number of pods/plant: That phosphorus had significant impact on number of pods per plant. Significantly higher number of pods per plant (47.40) was recorded in phosphorus 60 kg and Zinc 10 kg whereas, phosphorus 60 kg and Zinc 15 kg, phosphorus 40 kg and Zinc 10 kg, phosphorus 60 kg and Zinc 05 kg, phosphorus 40 kg and Zinc 15 kg found to be statistically at par to highest treatments.

Number of Seeds/pod: Treatment combination in which phosphorus 60 kg and Zinc 10 kg recorded higher number of pods per plant (6.7).

Phosphorus is the main constituent of energy rich phosphate molecules viz. ATP and ADP which acts as "energy currency" within plants. Synchronized with the demand of crop for formation of more reproductive structure and thus might have favored the yield attributes viz. number of pod per plant, number of seed per pod and test weight. These results are in agreement to the findings of Meena and Sharma (2001), and Shivran (1996).

Yield: Phosphorus increases yield due to its well-developed root system, increased N fixation and its availability to the plants and favourable environments in the rhizosphere. Seed yield (kg/ha) and Stover yield (kg/ha) varied considerably significant due to different levels of phosphorus and zinc (Table 3).

Table 3: Effect of phosphorus and Zinc levels on the yield and yield attributes of cluster bean.

Treatment	Yield attributes and yield				
	Pods/plant (No.)	Seeds/pod(No.)	Test weight(g)	Seed yield(kg/ha)	Stover yield(kg/ha)
T_1: Phosphorus 20 kg/ha + Zinc 05 kg/ha	32.63	6.3	30.10	870.34	2349.92
T_2: Phosphorus 40 kg/ha + Zinc 05 kg/ha	40.23	6.5	30.27	1020.00	3064.00
T_3: Phosphorus 60 kg/ha + Zinc 05 kg/ha	45.00	6.6	31.03	1180.00	3350.00
T_4: Phosphorus 20 kg/ha + Zinc 10 kg/ha	32.20	6.3	30.50	890.00	2492.56
T_5: Phosphorus 40 kg/ha + Zinc 10 kg/ha	45.97	6.6	31.00	1220.00	3696.26
T_6: Phosphorus 60 kg/ha + Zinc 10 kg/ha	47.40	6.7	31.10	1270.00	3810.30
T_7: Phosphorus 20 kg/ha + Zinc 15 kg/ha	34.77	6.5	31.03	910.00	2548.28
T_8: Phosphorus 40 kg/ha + Zinc 15 kg/ha	42.80	6.5	30.50	1145.00	3104.07
T_9: Phosphorus 60 kg/ha + Zinc 15 kg/ha	46.27	6.6	30.93	1250.00	3759.78
S.E.m(+)	1.82	0.11	0.48	21.89	104.40
CD.(5%)	5.46	-	-	65.61	313.16

Seed yield (kg/ha): At harvest significantly highest Grain yield (1270.00) was recorded with the application of phosphorus 60 kg and Zinc 10 kg. However, phosphorus 60 kg and Zinc 15 kg, phosphorus 40 kg and Zinc 10 kg, phosphorus 60 kg and Zinc 05 kg found statistically at par to phosphorus 60 kg and Zinc 10 kg.

Stover yield (kg/ha): At harvest significantly higher Stover yield (3810.30) was recorded with the application of phosphorus 60 kg and Zinc 10 kg. Whereas, phosphorus 60 kg and Zinc 15 kg, phosphorus 40 kg and Zinc 10 kg, phosphorus 60 kg and Zinc 05 kg

has found statistically at par to highest treatment combination.

The increase in seed yield due to phosphorus application is attributed to source and sink relationship. It appears that greater translocation of photosynthates from source to sink might have increased seed yield. Balai *et al.*, (2017).

CONCLUSION

It is well known that adequate supply of nutrients is essential to provide better growth and development. Hence for better growth and yield of Cluster bean apply different dose of phosphorus and zinc and 60 kg/ha Phosphorus+10 kg/h Zinc has proved to be a better option for getting higher productivity under irrigated condition. All finding is based on the research carried out in single season only it may be validated for another locations and varieties.

FUTURE SCOPE

Further scope for experiment can be carried on the basis of essentiality of phosphorus and zinc to see how phosphorus and zinc affect crop with different doses and sources.

Conflict of Interest. None of the authors of this paper features a financial or personal relation with people or organizations that would inappropriately influence or bias the content of the paper. We assure you that the content of the paper is never been published.

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