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Sri Sai Nikhil Reddy Nellore
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Joy Dawson
Professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj Uttar Pradesh, India

Lipi Rina
Ph.D., Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj Uttar Pradesh, India

Corresponding Author:
Sri Sai Nikhil Reddy Nellore
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of potassium and zinc on growth and yield of chickpea (*Cicer arietinum* L.)

Sri Sai Nikhil Reddy Nellore, Joy Dawson and Lipi Rina

Abstract
A field experiment was conducted to find out the Potassium and Zinc levels on growth and yield of chickpea (var. Pusa 362) with nine treatments in the rabi 2020. With the different levels of Potassium (20,30,40 K_2O kg/ha) and with the application of Zinc (5,10,15 kg $ZnSO_4$/ha) respectively, at Crop Research Farm, Department of Agronomy, Faculty of Agriculture, SHUATS, Prayagraj, Uttar Pradesh. By all these findings maximum plant height was recorded significantly higher *viz.*, 68.72 cm, Number of root nodules recorded (2.73), maximum dry weight was recorded (23.97 g/day), maximum crop growth rate recorded (9.51 g/day/m^2) and maximum relative growth rate recorded (0.02 g/g/day) with the application of treatment combination Potassium 40 kg/ha + Zinc 15 kg/ha. Maximum yield attributes *viz.*, seed yield (2916.67 kg/ha), stover yield (5014.66 kg/ha) and harvest index (36.76) and economics *viz.*, Gross return 102083.45/ha, net return 61600.18/ha and B:C ratio 1.53 was recorded in treatment with the application of Potassium 40 kg/ha + Zinc 15 kg/ha. Therefore, application of Potassium 40 kg/ha + Zinc 15 kg/ha was more productive and economically feasible.

Keywords: Chickpea, potassium, zinc, yield, plant growth

Introduction
Pulses are the edible dry seeds of leguminous plants. They are of special nutritional and economic importance due to their contribution to the diets of millions of people worldwide. The importance of pulses lies primarily in their high protein content besides being a valuable source of energy. In addition, pulses also contain good amount of nutritionally rich essential minerals and vitamins such as calcium, phosphorus, iron and vitamin C.

Pulses are wonderful gift of nature to agriculture. They provide nutrition to human beings and animals. India is one of the major pulses growing country of the world. Pulses occupy a key position in Indian diet and meet about 30% of the daily protein requirement. Among the pulses, chickpea is an important rabi season crop with high acceptability and wider use in nutritional food basket. The essential components of balanced nutritional food are protein, fat, fibre, and mineral nutrients.

Chickpea is the fourth largest grain legume crop in the world, In India with a total production of 11.09 million tons from an area of 14.56 million ha and a productivity of 1.31 t/ha. Major producing countries include India, Pakistan and Iran (FAO, 2019). Chickpea requirement in India is projected to be around 10.18 million tones by the year 2030, which needs a 4.2% increase in the annual growth rate (IIPR, 2016).

Chickpea is widely appreciated as health food. It is a protein rich supplement to cereal based diets, especially to the poor in developing countries, where people are vegetarians or cannot afford animal protein. It offers the most practical means of eradicating protein malnutrition among vegetarian children and nursing mothers. It has a very important role in human diet in India.

Chickpea is one of the important crops of Uttar Pradesh. Though small seeded (Desi) type has been popular, as medium seeded (Desi) type is gaining the farmers interest due to its better consumer preference and high market price. Desi chickpea (*Cicer arietinum* L.) has a good demand for consumption due to high nutritive value and fairly free from anti-nutritional value. The chickpea crop is mainly raised on residual soil moisture and available relative humidity during winter season. The productivity of Desi chickpea is poor, which may be attributed to the limited adoption of improved cultivation techniques and imbalanced nutrition.

Potassium influences the water economy and crop growth through its effects on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation (Nelson, 1980). Although potassium unlike N and P, does not enter into the composition of any product, yet literature on K reveals that it has an important role either direct or indirect, under different environments, in major plant processes such as photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation, growth and yield of plant (Sharma *et al.*, 2006 and Singh and Jagdish, 1997).

The application of zinc results in the enhancement of grain yield and quality. Genetic variability for response to applied zinc has been noticed among different cultivars of pulses. It plays an outstanding role in synthesis of chlorophyll, protein and also regulates water absorption, involved in the synthesis of indole acetic acid, metabolism of gibberellic acid and synthesis of RNA in legumes crops. Because of its preferential binding to sulphydryl group, zinc plays an important role in the stabilization and structural orientation of the membrane proteins. Moreover, it is also concerned with carbohydrate metabolism and activation of various enzymes. Therefore, in the recent years micronutrients are considered as one of the constraints in the optimum production of crops.

Zinc is essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzyme systems, auxin and protein synthesis. Zinc is believed to promote RNA synthesis, which in turn is needed for protein production. At several places normal yield of crops could not be achieved despite judicious use of NPK fertilizers due to deficiency of micronutrients in soil, in general, that of Zn in particular. Chickpea has an average of 2.2–20 mg of Zinc per 100 g edible portion (Ray *et al.*, 2014) [4].

In recent years, Zinc deficiency has been aggravated in Indian soils due to tremendous increase in cropping intensity and adoption of cultivation of high yielding varieties. Zinc is the major component of several enzymes, influencing the synthesis of proteins, auxins and photosynthetic activity. It also increases plant`s resistance to dry and hot weather conditions (Ashok *et al.*, 2005) [1] which are known to affect chickpea productivity.

Materials and Methods

The experiment was carried out during Rabi season of 2019-2020 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) which is located at 250 24' 42" N latitude, 810 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Prayagraj Rewa Road about 5 km away from Allahabad city.The soil samples were collected randomly from 0 to 15 cm depth from 5 spots of the experimental field just before layout of experiment. A representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physico-chemical properties of the soil. The experiment was conducted in Randomized Block Design consisting of 9 treatment combinations with 3 replications and was laid out with the different treatments allocated randomly in each replication. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, single super phosphate (SSP), Murate of potash (MOP) and zinc sulphate to fulfill the requirement of N, P_2O_5, K_2O and $ZnSO_4$/ ha. The recommended dose of 40:20:20 kg N:P:K/ ha and Phosphorus, zinc was applied according to the treatment details. After germination, the gaps were filled up by dibbling of seed at 10 DAS. Seedlings were thinned out in order to maintain spacing of 30 cm x 10 cm. Manual weeding was done with the help of khurpi at 25 days after sowing to minimize the crop weed competition. The field was maintained in a moist condition and for this, two irrigations (Table 3.5) were provided, one as pre sowing and other at grand growth period. In the initial stage of crop growth, the crop was attacked by stem borer; Fluebenzdiamide @ 2 ml L-1 spray was taken up at 40 DAS. The crop was harvested separately from each plot taking 1.0 m^2 area on March 25th 2021, i.e., 120 DAS. Thereafter, the produce from net plot was tied in bundles separately and then tagged. The tagged bundles were allowed for sun drying in field and after drying on the threshing floor, the weight of bundles was recorded for obtaining biological yield. Threshing of chickpea was done manually by beating with stick and then seeds were separated by winnowing.

Results and Discussions

A. Effect of Potassium and Zinc on plant height of Chickpea

Data presented in Table 1, tabulated with parameter plant height (cm) of Chickpea and there was increasing in crop age plant height was progressively increased with the advancement of the experimentation. The plant height was significantly higher in all different growth intervals with the levels of Potassium (K) and Zinc (Zn). At harvest, the maximum plant height (68.72 cm) was recorded with the application of potassium (K) 40 kg ha^{-1}+ Zinc (Zn)15 kg ha^{-1} which was significantly superior over all other treatments. except T2 K 20 kg / ha + Zinc 10 kg / ha (68.57 cm) (68.60 cm), T4 K 30 kg / ha + Zinc 5 kg / ha (68.70 cm) which are statistically at par. The probable reason for increases plant height might due to the potassium in that application plays crucial role in photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation, growth and yield of plant. Similar results observed by Barik *et al.*, (1994) [2]. Zinc plays a pivotal role in cellular growth, differentiation and metabolism which results in vigorous growth of plants and extensive root system leading to increased growth parameters. Similar results reported by Kharol *et al.*, (2014).

Table 1: Effect of Potassium and Zinc on plant height of Chickpea

		Plant height (cm)					
Treatment Symbols	**Treatment combination**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**
T_1	K 20 kg/ ha+Zinc5 kg/ ha	9.17	13.97	20.07	39.10	67.20	67.53
T_2	K 20 kg/ ha+Zinc10kg / ha	10.10	12.87	21.18	38.93	67.80	68.57
T_3	K 20 kg/ ha+Zinc15kg / ha	9.33	14.17	20.01	38.27	65.17	64.84
T_4	K 30 kg/ ha+Zinc5 kg/ ha	9.07	13.90	21.53	39.97	68.22	68.70
T_5	K 30 kg/ ha+Zinc10kg / ha	10.20	13.20	21.09	39.18	67.23	67.50
T_6	K 30 kg/ ha+Zinc15kg / ha	9.30	13.30	20.00	36.31	64.33	64.23
T_7	K 40 kg/ ha+Zinc5 kg/ ha	8.70	13.47	21.16	38.02	65.60	65.73
T_8	K 40 kg/ ha+Zinc10kg / ha	9.30	13.73	21.37	37.02	65.57	65.70

T_9	K 40 kg/ ha+Zinc15kg / ha	11.10	16.10	22.33	40.30	68.27	68.72
	F-Test	S	S	S	S	S	S
	C.D.at 0.5%	0.98	1.35	0.98	0.51	0.65	0.63
	S.Em(±)	0.33	0.45	0.33	0.17	0.22	0.21

B. Effect of Potassium and Zinc on Number of nodules/plant of Chickpea.

Data presented in Table 2, Observations regarding the response of different levels of Potassium 20, 30, 40 kg/ha and Zinc 5, 10, 15 kg/ha treatments on number of nodules/plant of chickpea are given in Table 2 It was noticed that successive stage there was an incremental trend. At 20, 40, 80, 100 and 120 DAS were significant influence in number of nodules/ plant due to different treatments. At 40 DAS, the highest number of nodules/plant was observed with the T_9 K 40 kg/ha + Zinc 15 kg/ha (28.27) which was significantly higher over rest of the treatments except and T_7 K 40 kg/ha + Zinc 5 kg/ha (24.43) which is statistically on par. The improvement in number of nodules of chickpea with the application of Potassium and zinc could be ascribed to its pivotal role in regulating the nodulation in pulses. Zn acts as antioxidant and its application helps in reducing the lipid per oxidation and hydrogen peroxide concentration in plant and also involved in the functioning of transcriptional regulators responsible for nitrogen fixation (Weisany *et al.*, 2012) [8]**.** Zinc is required for synthesis of tryptophan, which is responsible for formation of indole acetic acid (IAA), which is involved in nodule formation.

Table 2: Effect of Potassium and Zinc on Number of nodules/plant of Chickpea

No. of nodules/plant							
Treatment Symbols	**Treatment combination**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**
T_1	K 20 kg/ha+ Zinc5 kg/ha	6.73	21.20	13.54	4.87	2.37	1.43
T_2	K 20 kg/ha+ Zinc10 kg/ha	6.67	23.03	14.23	5.57	3.20	1.90
T_3	K 20 kg/ha+ Zinc15 kg/ha	5.77	21.27	13.87	5.87	2.07	1.80
T_4	K 30 kg/ha+ Zinc5 kg/ha	7.57	21.80	14.53	5.03	2.36	1.17
T_5	K 30 kg/ha+ Zinc10 kg/ha	7.03	23.07	16.70	5.63	2.27	1.87
T_6	K 30 kg/ha+ Zinc15 kg/ha	6.43	24.93	15.83	4.53	1.64	1.37
T_7	K 40 kg/ha+ Zinc5 kg/ha	7.77	25.43	16.40	4.17	2.23	1.36
T_8	K 40 kg/ha+ Zinc10 kg/ha	6.83	24.20	16.20	5.13	2.14	2.27
T_9	K 40 kg/ha+ Zinc15 kg/ha	8.53	28.27	17.80	6.67	3.63	2.73
	F-Test	S	S	S	S	S	S
	C.D.at 0.5%	0.97	2.34	1.80	0.94	0.86	0.62
	S.Em(±)	0.32	0.78	0.60	0.31	0.29	0.21

C. Effect of Potassium and Zinc on Dry weight of Chickpea.

Data presented in Table 3, Observations regarding the response of different levels of Potassium 20, 30, 40 kg/ha and Zinc 5, 10, 15 kg/ha treatments on dry weight (g)/plant of chickpea are given in Table 3. It was noticed that successive stage there was an incremental trend. At 40, 60, 80, 100 and 120 DAS were significant influence in dry weight (g)/plant due to different treatments. While at 20 DAS the effect of different levels Potassium 20, 30, 40 kg/ha and Zinc 5, 10, 15 kg/ha of the treatments were non-significant. At Harvest, the highest dry weight/plant was observed with the T_9 K 40 kg/ha + Zinc 20 kg/ ha (25.29 g) which was significantly higher over rest of the treatments except T_3 K 20 kg/ha+ Zinc 15 kg/ha (23.01 g) and T_5 K 20 kg/ha + Zinc 15 kg/ha (23.00 g). Dry matter production increased steadily with advancing growth stages and reached the maximum at harvest. The DMP (kg/ha) was found to be more with Potassium and Zinc which could be attributed to higher population and accumulation of nutrients/unitarea. This is in accordance with earlier findings of Vijayakumar *et al.*, (2006) in rice and Sathyamoorthi *et al.*, (2008) [5] in greengram.

Table 3: Effect of Potassium and Zinc on Dry weight/plant of Chickpea

Dry weight (g)/plant							
Treatment Symbols	**Treatment combination**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**
T_1	K 20 kg/ha+ Zinc5 kg/ha	0.28	1.91	7.50	14.09	18.75	21.91
T_2	K 20 kg/ha+ Zinc10 kg/ha	0.35	1.89	8.93	14.16	19.19	21.67
T_3	K 20 kg/ha+ Zinc15 kg/ha	0.27	1.96	7.92	13.44	18.14	23.01
T_4	K 30 kg/ha+ Zinc5 kg/ha	0.30	1.89	8.90	14.40	18.01	22.05
T_5	K 30 kg/ha+ Zinc10 kg/ha	0.24	1.89	8.68	14.14	19.09	23.00
T_6	K 30 kg/ha+ Zinc15 kg/ha	0.28	1.81	7.74	10.96	16.50	21.44
T_7	K 40 kg/ha+ Zinc5 kg/ha	0.28	1.76	8.59	12.51	15.92	21.85
T_8	K 40 kg/ha+ Zinc10 kg/ha	0.25	1.48	7.68	12.42	17.92	21.22
T_9	K 40 kg/ha+ Zinc15 kg/ha	0.45	2.35	9.26	15.41	21.85	23.97
	F-Test	NS	S	S	S	S	S
	C.D.at0.5%	0.19	0.42	0.69	0.73	0.97	1.10
	S.Em(±)	0.06	0.14	0.23	0.24	0.32	0.37

Table 4: Effect of Potassium and Zinc on yield and yield attributes of Chickpea

Yield Yield attributes							
Treatment Symbols	**Treatment combination**	**Pods/plant**	**Seeds/pod**	**Test weight (g)**	**Seed yield (kg/ha)**	**Stover yield (kg/ha)**	**Harvest Index (%)**
T_1	K 20 kg/ha+Zinc5 kg / ha	44.33	1.27	22.50	2550.00	4763.33	34.85
T_2	K 20 kg/ha+Zinc 10 kg / ha	46.67	1.21	22.17	2633.33	4876.67	34.98
T_3	K 20 kg/ha+Zinc 15 kg / ha	50.67	1.23	23.83	2443.33	4808.67	33.54
T_4	K 30 kg/ha+Zinc5 kg/ ha	51.67	1.12	23.10	2636.67	4921.71	35.43
T_5	K 30kg/ha+Zinc10 kg/ ha	53.67	1.63	24.67	2693.33	4756.00	36.16
T_6	K 30 kg/ha+Zinc15 kg/ ha	55.33	1.35	23.97	2353.33	4759.33	33.08
T_7	K 40 kg/ha+Zinc5 kg/ ha	55.67	1.53	24.10	2450.00	4808.34	33.73
T_8	K 40 kg/ha+Zinc10 kg/ ha	51.33	1.60	23.97	2346.67	4773.33	32.95
T_9	K 40 kg/ha+Zinc15 kg/ ha	56.67	1.83	26.17	2916.67	5014.66	36.76
	F-Test	S	S	S	S	S	S
	C.D.at 0.5%	1.72	0.32	1.51	240.19	115.09	2.29
	S.Em(±)	0.57	0.11	0.50	80.12	38.39	0.76

D. Effect of Potassium and Zinc on yield and yield attributes of Chickpea

Observations regarding the response of different levels of Potassium 20, 30, 40 kg/ha Zinc 5, 10, 1 5 kg/ha on yield and yield attributes of chickpea are given in Table 4. The observation showed that at yield and yield attributes there was significant difference between treatments. Significantly higher number of pods/plant was observed with the T_9 K 40 kg/ha + Zinc15 kg/ha (56.67) which was significantly higher over rest of the treatments except T_6 K 30 kg/ha+ Zinc 15 kg/ha (55.33) and T_7 K 20 kg/ha + Zinc 5 kg/ha (55.67) which are statistically on par. The highest Number of seeds/pod was observed with the T_9 K 40 kg/ha + Zinc 15 kg/ha (1.83) which was significantly higher over rest of the treatments except T_5 K 30 kg/ha + Zinc 10 kg/ha (1.63), T_7 K 20 kg/ha + Zinc 5 kg/ha(1.53), K 40 kg/ha + Zinc 10 kg/ha(1.60) which are statistically on par. The highest Seed yield was observed with the T_9 K 40 kg/ha + Zinc 15 kg/ha (2916.67 kg/ha) which was significantly higher over rest of the treatments except T_5 K 30 kg/ha + Zinc 10 kg/ha (2693.33 kg/ha) which is statistically on par.The highest Stover yield was observed with the T_9 K 40 kg/ha + Zinc 15 kg/ha (5014.66 kg/ha) which was significantly higher over rest of the treatments except T_4 K 30 kg/ha + Zinc 5kg/ha (4921.71 kg/ha) which is statistically on par. The highest Harvest index was observed with the T_9 K 40 kg/ha + Zinc 15 kg/ha (36.76%) which was significantly higher over rest of the treatments except T_1 K 20 kg/ha + Zinc 5 kg/ha(34.85), T_2 K 20 kg/ha + Zinc 10 kg/ha (34.98), T_5 K 30 kg/ha + Zinc 10 kg/ha(35.43), T_6 K 30 kg/ha + Zinc 15 kg/ha (36.16) which are statistically on par.

The yield of crop is the cumulative effect of yield attributing characters such as pods per plant and seed index. The increase in haulm yield due to increased plant height, dry matter production and number of branches per plant i.e. growth parameters. This is due to the increased supply of available Potassium and zinc to plants through its addition to the soil.Potassium influences the water economy and crop growth through its effects on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation (**Nelson**, 1980). Although potassium unlike N and P, does not enter into the composition of any product, yet literature on K reveals that it has an important role either direct or indirect, under different environments, in major plant processes such as photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation, growth and yield of plant (Sharma *et al.* 2006 and Singh and Jagdish, 1997).

Conclusion

Study suggests that to achieve maximum plant height was recorded significantly higher *viz*., 68.72 cm, Number of root nodules recorded (2.73), maximum dry weight was recorded (23.97 g/day), maximum crop growth rate recorded (9.51 g/day/m^2) and maximum relative growth rate recorded (0.02 g/g/day) with the application of treatment combination Potassium 40 kg/ha + Zinc 15 kg/ha. Maximum yield attributes *viz*., seed yield (2916.67 kg/ha), stover yield (5014.66 kg/ha) and harvest index (36.76) and economics *viz*., Gross return 102083.45/ha, net return 61600.18/ha and B:C ratio 1.53 was recorded in treatment with the application of Potassium 40 kg/ha + Zinc 15 kg/ha.

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