Original Research article*

Effect of Zinc and Molybdenum on growth and yield of chickpea

Abstract

A field experiment was conducted to find out the Effect of Zinc and Molybdenum on growth and yield of chickpea (var. Pusa 362) with ten treatments in the *rabi* 2022-23, with different levels of Zinc (5, 10, 15 kg $ZnSO_4$/ha) and Molybdenum (1, 1.5, 2 kg/ha) respectively, at Crop Research Farm, Department of Agronomy, Faculty of Agriculture, SHUATS, Prayagraj, Uttar Pradesh. By all these findings, significant and higher plant height (45.75cm), number of nodules/plant (20.78) plant dry weight (44.51g) number of pods/plant (32.65), number of seeds/pod (1.64), seed index (22.95g), seed yield (3.06 t/ha), stover yield (4.16 t/ha) and higher gross returns (INR 2,01,500.00), net returns (INR 1,54,383.00), B:C ratio (3.27) was recorded in treatment with the application of Zinc 15 kg/ha + Molybdenum 2 kg/ha.

***Key words*:** *Chickpea, Zinc, Molybdenum, Growth, Yield and Economics*.

Introduction :

"Chickpea (*Cicer arietinum* L.) Chickpea is an important crop for vegetarians as a primary source of protein, it is the third most important leguminous crop grown in the world after dry beans and peas. These foods are nutritionally and economically essential because they

are consumed by millions of people around the world. Indian vegetarians rely heavily on pulses as a source of protein, and staple grains provide protein, vital amino acids, vitamins and minerals. Legumes are known to reduce numerous non-communicable diseases including colon cancer and cardiovascular disease, in addition to offering significant nutritional and health benefits" **(Jukanti *et al.*, 2012)**.

The production of pulses in India is about 25.72 million tonnes with a cultivated area of about 288.3 lakh hectares and the production of pulses in Uttar Pradesh is 2.62 million tonnes with a cultivated area of about 0.81 lakh hectares **(GOI, 2021)**. In India, chickpea accounted for the lion's share of 49.3% of total pulses production **(ICRISAT, 2021)**, indicating its importance in Indian agricultural production.

"Zinc has important role in formation of chlorophyll and growth hormones and also for plant growth and development. Zn also plays an important role in protein synthesis and nucleic acid and helps in utilization of N and P by plants. Zinc is essential for the formation of carbohydrates and chlorophyll Zn deficiency decreases crop yield and delays crop maturity. Also reduces water use and water use efficiency and also reduces nodulation and N-fixation" **(Ahlawat et al., 2007; Khan et al., 2003)**. Due to the lack of micronutrients in the soil, especially Zn, in many localities it was not possible to achieve normal plant production despite the gentle application of NPK fertilizers. According to **(Ray *et al.*, 2014)**, a 100g serving of chickpeas usually contains 2.2–20 mg of zinc.

"Molybdenum is one of the most well-known nutritional key element necessary for plant development. Legumes require more Molybdenum than other plants because of its crucial role in nitrogen fixation by rhizobium bacteria in the root nodules of legumes" **(Mcbride, 2005)**. "It is a structural component of the nitrogenase and nitrate reductase enzyme, which brings about oxidation-reduction reaction in plant cells" **(Yadav and LYaY 2017)**.

Material and Methods:

The experiment was carried out during *Rabi* 2022-2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) which is located at 25^0 24' 42" N latitude, 81^0 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 physiochemical properties of the soil. The experiment was conducted in Randomized Block Design consisting of 10 treatment combinations which are replicated thrice. Fertilizers were applied as per recommended dosage" [Sri et al. 2021]. The recommended dose of fertilizer is 20:60:20 N: P: K kg / ha. Thinning at seedling stage was carried out in order to maintain spacing of 30 cm x 10 cm. The growth parameters and yield, production was recorded at harvest from randomly selected plants in each plot. The data was computed and analysed by following statistical method of **Gomez and Gomez (1984)**.

Result and Discussion

A. Effect of Zinc and Molybdenum on plant height (cm) of chickpea.

Significantly higher plant height (45.75 cm) was recorded in treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha) at 100 DAS. However, treatment 8 (zinc 15 kg/ha + molybdenum 1.5 kg/ha) (44.82 cm) was found to be statistically at par with treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha). The increase in plant growth treated with zinc (20 kg/ha) may also be due to its effect on the metabolism of growing plants, which can effectively explain the observed response of zinc application on plant height **Masih *et al*. (2020)**. The combined application of zinc and molybdenum had a positive effect on growth. Similar results were reported by **Chakraborty (2009), Rashid *et al*. (2011), Karpagam et al. (2014)**. Furthermore, the plant height was significant and higher when molybdenum was applied, which may be due to its role as a cofactor for the nitrogenase enzyme, which catalyzes the redox reaction of the conversion of atmospheric nitrogen into the ammonium form and helps in nitrogen fixation. Similar results were reported by **Mendel and Hansch (2002)** and **Singh** and **Singh (2006)** in **blackgram**.

B. Effect of Zinc and Molybdenum on number of nodules/plant of chickpea.

Significantly higher number of nodules/plant (20.78) was recorded in treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha) at 100 DAS. Higher number of nodules could be attributed to the application of zinc due to its pivotal role in the regulation of nodulation in pulses. Zn acts as an antioxidant and its application helps in reducing the concentration of lipids for oxidation and the concentration of hydrogen peroxide in the plant and also participates in the functioning of transcriptional regulators responsible for nitrogen fixation. Similar results were obtained by

Upadhyay *et al.* (2016). Furthermore, the number of nodules/plants was significant and higher when molybdenum was applied, due to its vital for the synthesis and activity of molybdo enzymes such as the nitrogen assimilation enzyme-nitrate reductase and the nitrogen-fixing enzyme-nitrogenase, a key regulatory component for the initiation of nodulation and the maintenance of nitrogen fixation in legumes. Similar observations were reported by **Khan *et al.* (2014)**.

C. Effect of Zinc and Molybdenum on plant dry weight of chickpea

At 100 DAS, Significantly higher plant dry weight (44.51 g/plant) was recorded in treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha) at 100 DAS. However, treatment 8 (zinc 15 kg/ha + molybdenum 1.5 kg/ha) (44.39 g/plant) was statistically found to be at the same level as treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha). "The increase in dry matter of plants was with the application of zinc (20 kg/ha), which may be due to zinc's role as an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin, by producing more plant cells and increasing the dry matter". **Chatterjee *et al*. (2017)**. Furthermore, the significant and higher plant dry matter was due to the increase in plant biomass when molybdenum was applied, which was the result of greater molybdenum-induced nitrogen fixation and increased dry matter accumulation. Similar findings were reported by **Datta *et al.* (2009)** in **bengal gram**.

C. Effect of Zinc and Molybdenum on yield attributes and yield of chickpea.

At 100 DAS, significant and higher, number of pods/plant (32.65), number of seeds/pod (1.64), seed index (22.95 g), seed yield (3.06 ta/ha), stover yield (4.16 ta/ha) and harvest index (42.38%) were recorded in treatment 9 (Zinc 15 kg/ha + molybdenum 2 kg/ha). However, treatment 8 (zinc 15 kg/ha + molybdenum 1.5 kg/ha) was found statistically at par with treatment 9 (zinc 15 kg/ha + molybdenum 2 kg/ha). The increase in higher of number of pods per plant due to the application of Zn helped in the translocation of photosynthates to pods and seeds. Other researchers working with different crops have also noted increased yield with Zn application. Application of Molybdenum might have been possible due to increased availability of nitrogen due to nitrogen fixation that induces plant growth to produce huge biomass, pod and grain yield. These results are consistent with the findings of **Rashid *et al.* (2011)** and **Mahesh *et al*. (2021**). Higher harvest index was observed due to improved cell

activities, increased cell proliferation and enlargement, and vigorous growth and yield characteristics of crops, probably due to greater absorption and utilization of available nutrients, resulting in overall improved crop growth, which is reflected in the source-sink relationship, which in turn increased the yield attributes which finally observed greater yield (**Valenciano *et al*., 2010**), (**Kumar and Singh 1980**). "Chickpea seed yield was significantly affected by increasing levels of micronutrients. This is possible due to the combined application of Zn and Mo, which improved the survival and multiplication of microorganisms, improved nitrogen fixation, transport of sugars and better uptake and assimilation of available nutrients by plants during the entire growth period". **Chakraborty *et al.* (2009)** and **Singh *et al.* (2008)**. Further, significant and higher yield attributes and yield were with the application of molybdenum, could be due to increased availability of nitrogen, which helped the plants to produce abundant effective nodules, and subsequently to produce huge biomass, yield of pods and seeds. Similar results are supported by **Reddy *et al.* (2007)** and **Chaudary *et al.* (1996)**.

Table 1. Effect of Zinc and Molybdenum on growth attributes of chickpea.

S No	Treatments	Plant height (cm)	Number of nodules/ plant	Plant dry weight (g/plant)
1.	Zinc 5 kg/ha + Molybdenum 1 kg/ha	43.12	37.18	36.59
2.	Zinc 5 kg/ha + Molybdenum 1.5 kg/ha	43.21	38.89	39.32
3.	Zinc 5 kg/ha + Molybdenum 2 kg/ha	43.54	40.92	41.02
4.	Zinc 10 kg/ha +Molybdenum 1 kg/ha	43.76	41.84	42.08
5.	Zinc 10 kg/ha + Molybdenum 1.5 kg/ha	43.98	42.87	42.72
6.	Zinc 10 kg/ha + Molybdenum 2 kg/ha	44.24	43.68	43.48
7.	Zinc 15 kg/ha + Molybdenum 1 kg /ha	44.56	43.88	44.00
8.	Zinc 15 kg/ha + Molybdenum 1.5 kg /ha	44.82	44.74	44.39
9.	Zinc 15 kg/ha + Molybdenum 2 kg/ha	45.75	44.81	44.51
10.	Control (RDF-20:60:20 NPK kg/ha)	42.94	37.25	33.56
	F-test	**S**	S	S
	Sem±	0.60	0.47	0.54
	CD at 5%	1.55	0.97	1.27

Table 2. Effect of Zinc and Molybdenum on yield attributes and yield of chickpea.

S.No.	Treatments	No of pods/plant	No of seeds/pod	Seed index	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1	Zinc 5 kg/ha + Molybdenum 1 kg/ha	25.57	1.22	19.45	2.24	3.21	41.10
2	Zinc 5 kg/ha + Molybdenum 1.5 kg/ha	26.67	1.25	19.52	2.36	3.38	41.11
3	Zinc 5 kg/ha + Molybdenum 2 kg/ha	26.85	1.28	20.67	2.47	3.43	41.86
4	Zinc 10 kg/ha +Molybdenum 1 kg/ha	27.39	1.31	20.73	2.54	3.55	41.70
5	Zinc 10 kg/ha + Molybdenum 1.5 kg/ha	28.45	1.35	21.61	2.66	3.64	42.22
6	Zinc 10 kg/ha + Molybdenum 2 kg/ha	29.72	1.41	21.86	2.75	3.75	42.30
7	Zinc 15 kg/ha + Molybdenum 1 kg /ha	30.70	1.49	22.73	2.86	3.88	42.45
8	Zinc 15 kg/ha + Molybdenum 1.5 kg /ha	31.90	1.57	22.85	3.00	3.94	43.25
9	Zinc 15 kg/ha + Molybdenum 2 kg/ha	32.65	1.64	22.95	3.06	4.16	42.38
10	Control (RDF-20:60:20 NPK kg/ha)	25.70	1.18	18.25	2.08	3.17	39.59
	F test	S	S	NS	S	S	NS
	SEm±	0.06	5.16	0.14	8.35	6.81	0.47
	CD (P = 0.05)	0.19	15.34	--	0.02	0.11	--

Table 3. Effect of Zinc and Molybdenum on economics of chickpea.

S.No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR)	Net return (INR/ha)	B:C ratio
1	Zinc 5 kg/ha + Molybdenum 1 kg/ha	44,417	1,45,600	1,01,183	2.27
2	Zinc 5 kg/ha + Molybdenum 1.5 kg/ha	45,417	1,53,400	1,07,983	2.37
3	Zinc 5 kg/ha + Molybdenum 2 kg/ha	46,417	1,60,550	1,14,133	2.45
4	Zinc 10 kg/ha +Molybdenum 1 kg/ha	44,767	1,65,100	1,20,333	2.68
5	Zinc 10 kg/ha + Molybdenum 1.5 kg/ha	45,767	1,72,900	1,27,133	2.77
6	Zinc 10 kg/ha + Molybdenum 2 kg/ha	46,767	1,78,750	1,31,983	2.82
7	Zinc 15 kg/ha + Molybdenum 1 kg /ha	45,117	1,85,900	1,40,783	3.12
8	Zinc 15 kg/ha + Molybdenum 1.5 kg /ha	46,117	1,95,000	1,48,883	3.22
9	Zinc 15 kg/ha + Molybdenum 2 kg/ha	47,117	2,01,500	1,54,383	3.27
10	Control (RDF-20:60:20 NPK kg/ha)	42,067	1,35,200	93,133	2.21

CONCLUSION

From the results it is revealed that in chickpea with the application of zinc 15 kg/ha + molybdenum 2 kg/ha in treatment 9 recorded higher growth, yield and benefit cost ratio which is beneficial to the farmers. Since the findings are based on one season, additional routes are needed to confirm the results

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REFERENCES :

Ahlawat, I.P.S. and Gangaiah, B. 2010. Effect of land configuration and irrigation on sole and linseed (*Linum us itatissimum*) intercropped chickpea (*Cicer arientinum* L.). Indian Journal of Agricultural Sciences **80**(3): 250- 253.

Chakraborty, A. (2009). Growth and yield of lentil (*Lens culinaris* L.) as affected by boron and molybdenum application in lateritic soil. *Journal of Crop and Weed* **5**(1): 88-91.

Chatterjee, R. and Bandyopadhyay, S. (2017). Effect of boron, molybdenum and biofertilizers on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) in acid soil of eastern Himalayan region. *Journal of the Saudi Society of Agricultural Sciences* **16**: 332-336.

Chaudhary, H.P. and Das, S.K. (1996). Effect of P, S and Mo application on yield of rainfed black gram and their residual effect on safflower and soil and water conservation in an eroded soil. Journal of Indian Society of Soil Science, **44**: 741-45.

Gomez, K. A. and Gomez, A. A. (1976). Three or more factor experiment. (In:) *Statistical Procedures for Agricultural Research* 2nd ed., pp.139-141.

ICRISAT-2021 International Crop Research Institute for Semi-Arid Tropics.

Jukanti AK, Gaur PM. Gowda CLL and Chibbar RN. (2012). Nutritional quality and health 108, $11-$26benefits of chickpea (*Cicer unetinum L)* a review, *Brish Journal of Nutrition.*

Karpagam, J. and Chander, G. 2014. Molybdenum application for enhancing growth, yield and soil health on green gram (*Vigna radiata* L.). *International Journal of Scientific Research* **3**(12): 2277-8179.

Khan, N., Tariq, M., Ullah, K., Rahatullah, D. M. I. K. K., Ahmed, N. and Ahmed, S. (2014). The effect of molybdenum and iron on nodulation, nitrogen fixation and yield of chickpea genotypes (*Cicer arietinum* L.). *IOSR Journal of Agriculture and Veterinary Science* **7**(1):63-79.

Khan, M. A., Ali. A. and Tanveer, A. (2003) Effect of seed inoculation and different levels of phosphorus on the yield and yield components of chickpea. *Pakistan Journal of Life and Social Sciences* **1**: 10608.

Kumar, V., & Singh, M. (1980). Interactions of sulphur, phosphorusand molybdenum in relation to uptake and utilization of phosphorus by Soybean. *Soil Science*, **130**(1): 26-31.

Mahesh kumbam., Umesha, C., Lalit Kumar Sanodiya and Makani Sarath Chandra Kumar. (2021). Impact of Phosphorus Levels and Application of Molybdenum of Black gram (*Vigna mungo* L.) on Growth and Yield Attributes. Biological Forum **13**(3): 12-15.

Masih, A., Dawson, I and Singh, R. E. (2020) Effect of Levels of Phosphors and Zinc on growth and yield of Greengram (*Vigna radiata L.*).*International Journal ofCurrent Microbiology and Applied Sciences.* **9** (10); 3106-3112.

Mendel RR, Hänsch R 2002: Molybdoenzymes and molybdenum cofactor in plants. *Journal of Experimental Botany* **53**, 1689–1698. doi:10.1093/jxb/erf038.

McBride, M.B. (2005). Molybdenum and copper forage grasses and legumes grown on a metal contaminated sludge site. *Common Soil Science Plant Act*, **36**:2489-2501.

Rashid, M.H., Quddus, M.A., Rahman, M.T., Naser, H.M. and Shil, N.C. (2011). Response of chickpea to zinc and boron fertilization. *Bangladesh Journal of Agriculture,* **36**(2): 11- 16.

Reddy, M., Padmaja, B., Malathi,S and JalapathiRao,L. 2007. Effects of micronutrients on growth and yield of pigeon pea. *Journal of SAT Agricultural Research* **5** (1): 334-336

Singh, J.P. and Singh, H. (2006). Effect of micronutrient and FYMon yield and nutrients uptake by urdbean. *Annals of Plant Soil Research*, **8**(1):100-101.

Singh, R.P., Singh, Bisen, Yadav, Jay, Singh, P.K., Singh, S.N., Singh, R.K. and Singh, J. (2008). Integrated use of sulphur and molybdenum on growth, yield and quality of black gram (*Vigna mungo* L.) *Legume Research* **31**: 214-217

Upadhyay, R.G. and Anita Singh. (2016), Effect of nitrogen and zinc on nodulation, growth and yield of cowpea (*Vigna unguiculata*). *Legume Research*, **39**(1): 149-151.

Valenciano, J.B., Boto, J.A. and Marcelo, V. (2010). Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot condition. *Spanish Journal of Agricultural Research* **8**(3): 797-807.

Yadav, A. & LYaY, S. (2017). Effect of molybdenum nodulation,total nutrient uptake and protein content of cluster bean. *International Journal of Microbiological Applied Sciences,* **6** (5): 1939-1944.

Sri Sai Nikhil Reddy Nellore, Joy Dawson and Lipi Rina. Effect of potassium and zinc on growth and yield of chickpea (Cicer arietinum L.). The Pharma Innovation Journal 2021; 10(10): 1547-1551