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Micronutrient (Zn) Role in Stimulating Root Nodules and Yield of Chickpea

Abdur Rashid
Arid Zone Research Institute, Pakistan Agriculture Research Council (PARC), Dera Ismail Khan, Pakistan

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Abstract. In the study of the effect of zinc (Zn) on root nodule stimulation and yield of chickpea under the climatic condition of D.I. Khan, Pakistan, significant effect of application of varying levels of zinc was noted. Plant height was significantly more as compared to the control. The plants receiving 7.5 kg/ha Zn had the highest weight of nodules/plant and produced maximum grain yield of 1185 kg/ha.

Keywords: *Cicer arietinum* L.; zinc application, nodule formation, grain yield, Pakistan

Introduction

In Pakistan, soils are generally poor in micronutrients. Zinc deficiency has particularly been reported in rainfed areas causing substantial yield losses (Rashid and Rafique, 1996). Zinc deficiency restricts RNA development which in turn inhibits protein synthesis and results in stunted growth. Previous research findings revealed that Zn application improved the nitrogen metabolisim, yield and nitrogen fixation in legume crops (Shukla and Yadar, 1982). Similarly, Khanzada and Ahmad (1989) indicated that the application of iron (Fe) and zinc (Zn) significantly increased the grain yield of soybean due to improvement in the yield components and nitrogen metabolism of crop. Muhammad *et al*. (1999) reported that the application of Zn @ 5 kg/ha significantly increased the grain yield of rapeseed but 10 kg/ha of Zn showed depressing effect. In contrast, Sherazi *et al.* (2001) reported that the level of 10 kg/ha Zn significantly increased cotton yield as against other applications in cotton zone of Punjab, Pakistan. Nathan *et al*. (2005) indicated that Zn fertilization increased the paddy yield by 12 to 18% compared to the unfertilized flooded rice. Hussain and Yasin (2004) concluded that the application of 5 kg/ha zinc increased the wheat grain yield by 16% over the control.

Due to high nitrogen concentration in the tissues, pulses contribute considerably towards soil fertility. The soil enriching property of mashbean is of greater value especially to our country, where soils are deficient in organic matter, nitrogen and other soil fertility parameters (Ofori and Stern, 1987). Ibrahim *et al.* (1987) reported that soybean can fix 60-168 kg of atmospheric nitrogen and add to the soil per year. Pal and Sheshu (2001) reported that the transfer of residual N from nodulating soybean, lablab bean, green gram and black gram to the succeeding maize crop was of the order of 18.4-20.9, 19.5-29.9, 12.0-13.7 and 9.3-10.3 kg/ha, respectively.

Chickpea (*Cicer arietinum* L.) pulse group is widely grown, both in rainfed and irrigated regions of Pakistan. During 2003-04, chickpea was grown on an area of 982.3 thousand hectares with a production of 611.1 thousand tons (Qureshi, 2004). Being leguminous in nature, it not only demands less fertilizer but also improves soil fertility by virtue of fixing free atmospheric nitrogen through the root nodules. Being the rich source of protein (17-23%), it is called poor man's meat.

In consideration of the acute shortage of proteins in cereal based diets of mankind and livestock, in general, and in Pakistan, in particular, study on the effect of Zn on the production of chickpea was undertaken in the climatic conditions of D.I. Khan, Pakistan.

Materials and Methods

The field study was conducted to determine the response of Zn manuring on chickpea at Arid Zone Research Institute, PARC, D.I.Khan, Pakistan during Rabi season of 2004-05. The treatments comprised of five Zn levels (0, 2.5, 5.0, 7.5 and 10 kg/ha) applied as zinc sulphate ($ZnSO_4$) at sowing time with a basal dose of 20-50 kg NP/ha to the field. The experiment was laid out in a randomized complete block design (RCB) with three replications. A plot size of 5 x 1.8 m with six (6) rows per plot was maintained, keeping row to row distance of 30 cm. Soil samples collected from experimental site were air dried, grinded, sieved and mixed thoroughly for making accurate physical and chemical analysis (Table 1).

An improved variety of chickpea "NIFA-88" was sown in a well prepared seed bed using seed rate of 70 kg/ha. Recommended cultural practices and plant protection measures were adopted till harvest of the crop. The agro-meteorological data recorded during the growing period of crop is depicted in Fig. 1.

At complete flowering and pod formation stage, ten (10) plants from each treatment were uprooted at random. Roots of

Table 1. Physicochemical soil properties of the experimental field

Parameter	Value
pH	8.20
ECe (ds/m)	2.75
Organic matter (%)	0.76
Total nitrogen (%)	0.37
Olsen P(mg/kg)	6.91
DTPA-Zn (mg/kg)	0.52
Clay (%)	51.0
Silt (%)	37.5
Sand (%)	11.5
Textural class	clayey

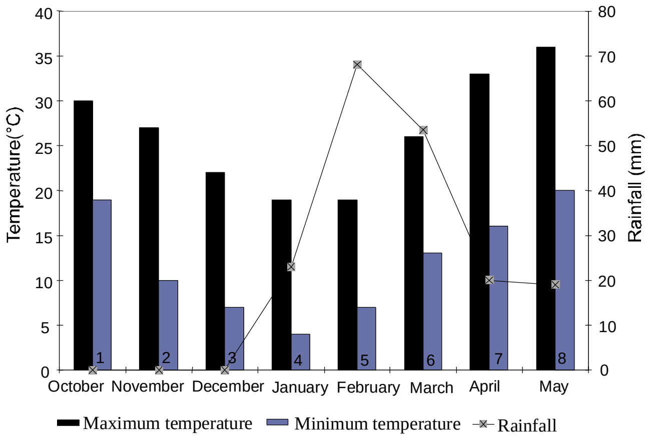

Fig. 1. Mean monthly rainfall and temperature during 2004-2005.

individual plant were carefully washed in buckets to collect and count nodules of each plant separately. Then the nodules of 10 plants were mixed and averaged for the number of nodules/plant of each treatment. The nodules of each treatment were weighed on electrical balance and computed to record the weight of nodules per plant. The crop was harvested at physiological maturity and the sun-dried samples were threshed manually to record grain yield data. On weighing, grain moisture content was 12%. The data recorded on different parameters of plant growth and development was subjected to statistical analysis of variance. The LSD at 5 percent level of probability was used for comparison of the treatment means (Steel *et al.,* 1997).

Results and Discussion

Plant height. The height of plant is an important growth character directly linked with the productive potential of the plant in terms of fodder and grain yield. The recorded data (Table 2) showed that all the levels of Zn significantly produced taller plants relative to the plants grown as control. A maximum of 111.7 cm plant height was recorded in the plots fertilized with 10 kg/ha Zn, while the minimum plant height of 105.1 cm was recorded for the control. Analysis of variance for plant height of chickpea as affected by different treatments of Zn also indicated a significant difference (P=0.05) between different means of Zn treatments. The maximum plant height produced with 10 kg/ha Zn was statistically at par with the plant heights produced by the application of 5.0 and 7.5 kg/ha Zn. This increase in the plant height might be attributed to the effect of Zn on vegetative growth of chickpea particularly plant height. Similar increase in plant height of wheat by 3.2%, effective tillers by 11.6% and per grain panicle by 11% over control was reported by Jana *et al.* (2005).

Table 2. Effect of different levels of zinc on growth parameters and yield of chickpea

Zn levels (kg/ha)	Plant height (cm)	No. of nodules/ plant	Nodule weight/ plant (mg)	1000 seed weight (g)	Grain yield (kg/ha)	Increase over control (%)
0	105.1^{c}	14.3^{d}	338.0^{d}	160.3^{d}	821^{c}	-
2.5	109.0^{b}	16.0^{bc}	393.0^{c}	165.6^{c}	953^{d}	16
5.0	111.2^{a}	17.0^{bc}	435.0^{b}	170.3^{b}	1989^{c}	32
7.5	111.5^{a}	17.3^{a}	459.3^{a}	173.3^{a}	1185^{a}	44
10.0	111.7^{a}	17.3^{a}	455.0^{a}	173.1^{a}	1142^{b}	39
LSD	1.009	0.901	13.39	1.595	22.85	-

Means followed by same letter do not differ significantly

Number of nodules on roots. The data pertaining to the number of nodules per plant of chickpea (Table 2) indicated that the application of Zn, significantly increased the development of nodules on the roots of the plants. The data evinced that all the levels of zinc produced significantly more number of nodules per plant relative to the control. The number of nodules per plant linearly increased from 14.3 to 17.3 with increasing level of Zn but beyond the level of 7.5 kg/ha of Zn evinced declining trend in the development of nodules on the roots. The difference between the number of nodules per plant due to the treatment of 5.0, 7.5 and 10.0 kg/ha Zn was non-significant, whereas, the lowest number of 14.3 nodules per plant was produced by the control. These results suggested that the application of Zn might have stimulated the native rhizobia population to increase nodule production on the root system of chickpea.

Weight of nodules. The data (Table 2) indicated that the treatments of Zn also affected the weight of nodules per plant of chickpea. The maximum weight of 459.3 mg of nodules was obtained by the treatment of 7.5 kg/ha Zn, whereas, minimum weight of 338 mg was recorded in the control. The difference between the treatments of different levels of zinc was also significant except for application of 7.5 and 10 kg/ha Zn levels. Low levels of zinc gave low weight of nodules/plant as compared to higher levels. This confirmed the synergistic effect of Zn in the development of nodules which ultimately improved the efficiency of atmospheric nitrogen fixation by legumes as reported by Shukla and Yadar (1982) that the application of phosphorus and zinc improved the metabolic activities relating to nitrogen fixation and grain yield of chickpea.

Grain weight. The magnitude of grain development is indicated by the 1000 grain weight of crop. The data in this respect, depicted in Table 2, indicate that 1000 grain weight of chickpea was significantly affected by the application of Zn. Different levels of Zn significantly increased 1000 grain weight relative to control. Maximum of 173.3 g of 1000 grain weight was obtained by the treatment of 7.5 kg/ha Zn followed by 173.1 g obtained by that of 10 kg/ha showing non-significant difference between the two. Minimum 1000 grains weight of 160.3 g was recorded in the control. The data revealed that 1000 grain weight showed positive relationship with plant height and number of nodule per plant of the crop. This increase in 1000 grain weight of chickpea due to Zn application might be attributed to vigorous vegetative growth which ultimately produced well developed seeds. These results are in harmony with the findings of Ammanullah and Hatam (2000), who observed positive relationship of 1000 seed weight of soybean with plant height and other parameters.

Grain yield. Data concerning grain yield of chickpea is presented in Table 2. Statistical analysis of the data showed that different levels of Zn had significant ($P=0.05$) effect on grain yield of chickpea. It can be inferred from the data that maximum grain yield of 1185 kg/ha was produced by Zn treatment at the rate of 7.5 kg/ha followed by the yield of 1142 kg/ha obtained by application of 10 kg/ha Zn; the minimum grain yield of 821 kg/ha was produced by control. These results are in line with the findings of Hussain *et al.* (2007), Iqbal *et al.* (2002) and Khanzada and Ahmad (1989), who observed similar increase in grain yield of different crops with application of micronutrients. The data further revealed that the difference between the treatment means of different levels of Zn was also significant. The percentage increase in grain yield of chickpea with different levels of Zn ranged from 16 to 44% over control. The maximum increase was recorded by the treatment of 7.5 kg/ha Zn as compared to the low and the high level of Zn. Beyond this level, grain yield of chickpea declined with higher level of treatment. These results are in conformity with the work of Muhammad *et al.* (1999) who observed similar decrease in yield of rapeseed with 10 kg/ha of Zn as compared to the lower level. Similarly, Sharma *et al.* (2000) reported that wheat responded only to 5 kg Zn/ha and resulted in 13.62 and 6.14% higher grain yield as compared to the control and application of 10 kg Zn/ha, respectively.

Conclusion

The findings of this study suggest that soils, poor in micronutrients may be supplied with the respective micronutrient fertilizer, so as to overcome the deficiency. The data showed considerable increase in the development of root nodules that might improve the soil fertility through the symbiotic nitrogen fixation. Increase in grain yield of chickpea with zinc (Zn) supply also suggests application of micronutrients for improvement of yield and nitrogen fixing capability of the leguminous crops.

However, for sustainable productivity, further research is recommended for studying the multiple effects of micronutrients with reference to the mobilization/stimulation of the root system and the yield of pulses.

References

Ammanullah., Hatam, M. 2000. Performance and nodulation efficiency of soybean cultivars. *Pakistan Journal of Biosciences* **3:** 1822-1823.

Hussain, F., Yasin, M. 2004. Soil fertility monitoring and management in rice-wheat system. *Annual Report LRRP, NARC*, pp. 1-33, Islamabad, Pakistan.

Hussain, R., Rashid, M., Akram, M., Hussain, K., Jami, A.R. 2007. Wheat response to Zn and K application under rainfed condition. *Soil and Environment* **26:** 134-138.

Ibrahim, M., Dogar, A.M.S., Chaudry, M.A. 1987. Phali Dar Faslein (Urdu). *Zarat Nama* **26:** 1-17.

Iqbal, J., Gill, K.H., Sherazi, S.J.A., Sheikh, A.A., Ramzan, M., Shaheen, M.K. 2002. Wheat response to zinc application in various zones of the Punjab. *Pakistan Journal of Soil Science* **21:** 38-43.

Jana, P.K., Ghattak, R., Sounda, G., Ghosh, R.K. 2005. Response of wheat to levels of zinc sulfate at farmer's field in red and laterite soils. *Environment and Ecology* **23:** 36-361.

Khanzada., Ahmad, S. 1989. Micronutrients nutrition of inoculated soybean in relation to yield and yield components. *Pakistan Journal of Agricultural Research* **10:** 132-137.

Muhammad, W., Shah S.M., Nawaz, H., Iqbal, M.M. 1999. Interactive effect of nitrogen, zinc and boron on yield and nutrient uptake by rapeseed. *Pakistan Journal of Soil Science* **16:** 111-114.

Nathan, A.S., Norman, R. J., Wilson, C.E. 2005. Effect of zinc source and application time on zinc uptake and grain yield of flood irrigated rice. *Agronomy Journal* **97:** 272-278.

Ofori, F., Stern, W. R. 1987. Cereal legumes intercropping system. *Advance Agronomy* **41:** 41-90.

Pal, U. R., Sheshu, Y. 2001. Direct and residual contribution of symbiotic nitrogen fixation by legumes to the yield and nitrogen uptake of maize in the Nigerian Savannah. *Journal of Agronomy and Crop Science* **187:** 53-58.

Qureshi, M.I. 2004. *Agriculture Statistic of Pakistan,* pp. 44-45, Ministry of Food, Agriculture and Livestock, Islamabad, Pakistan.

Rashid, A., Rafique, E. 1996. Micronutrients in Pakistan agriculture: significance and use. *Technical Brochure,* Pakistan Agriculture Research Council, Islamabad, Pakistan.

Sharma, P.K., Yadav, G.L., Sharma, B.L., Sudesh, K. 2000. Response of wheat to nitrogen and zinc fertilization. *Indian Journal of Agronomy* **45:**124-127.

Sherazi, S.J.A., Iqbal, J., Gill, K.H., Ramzan, M., Shaheen, M.K., Hameed, Z. 2001. Cotton response to Zn and B application in cotton in central zone of the Punjab, *Pakistan Journal of Soil Science* **20:** 65-72.

Shukla, G.C., Yadar, O.P. 1982. Effect of phosphorus and Zn as nodulation and nitrogen fixation of chickpea. *Plant and Soil* **65:** 239-248.

Steel, R.G.D., Torrie, J.H., Dicky, D.A. 1997. *Principle and Procedures of Statistics- A Biometrical Approach,* pp. 204-227, 3rd edition, McGraw-Hill Book International Co., Singapore.