moisture regime and integrated nutrient supply on dose, yield and economics of transplanted rice. *Oryza* **50**(2): 189–191.

Luikham, E., Krishnarajan, J. and Premsekhar, M. 2004. Irrigation and nitrogen application schedules for hybrid 'ADTRH 1' rice (*Oryza sativa*) in Tamil Nadu. *Indian Journal of Agronomy* **49**(1): 37–39.

Nayak, B.R., Pramanik, K., Khanda, C.M., Panigrahy, N., Mohanty, A.K., Mohapatra, S., Samant, P.K., Panda, N. and Swain, S.K. 2015. Influence of irrigation regimes and nitrogen levels on aerobic rice during summer season. *Oryza* **52**(2): 117–122.

Nayak, B.R., Pramanik, K., Khanda, C.M., Panigrahy, N.,Samant, P.K., Mohapatra, S., Mohanty, A.K., Dash, A.K., Panda, N. and Swa2in, S.K. 2016. Response of aerobic rice (*Oryza sativa*) to different irrigation regimes and nitrogen levels in western Odisha. *Indian Journal of Agronomy* **61**(3): 321–325.

Siddiq, A. 1993. Rice production strategy for the 21st century, *Oryza* **30**: 186–196.

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**Research Communication**

# Response of maize (*Zea mays*) to foliar application of Zinc and Boron

HIMANSHU SINGH[1], VIRENDRA SINGH[2], SATYBHAN SINGH[3] AND RICHA KHANNA[4]

*Institute of Foreign trade and Management, IFTM University, Moradabad, Uttar Pradesh 224 102*

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## ABSTRACT

A field experiment was carried out during the summer 2018 at Student Instructional Research Farm of Moradabad, Uttar Pradesh to find out the effect of foliar application of different doses of zinc and boron at different stages of maize (*Zea mays* L.) growth. The foliar application of 1.0% zinc (Zn) and boron (B) at 30,40 and 50 days after sowing of maize significantly influenced the plant height, cob length, cob girth, number of grain rows, grains/ row and seed index. The grain and stover yields of maize also maximum in the same treatment (1% Zn and B spray 3 times).

***Key words***: Zinc, Boron, Foliar application, Maize

Zinc (Zn) is essential for the growth of animals, human beings and plants. It is vital to the crop nutrition as required in various enzymatic reactions, metabolic processes and oxidation-reduction reactions. In addition, Zn is also essential for many enzymes which are needed for nitrogen metabolism, energy transfer and protein synthesis. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation (Pooniya and Shivay, 2011). Zinc plays an important role in increasing the maize yield (Majhi *et. al.* 2018), and can control nitrogen management of this plant. Grzebisz *et al*. (2008) reported that the increase in nitrogen uptake rate by plant canopy at 2 growth stages, i.e. from 7th to 9th leaf stage and from milk to physiological maturity of grain, considered as secondary effect, was induced by Zn application at early stage of maize growth. Foliar application of zinc at 5th leaf stage can increase the partial factor of fertilizer nitrogen productivity (PFPN) as compared to the classical NPK fertilization.

Boron (B) is also an essential micronutrient for plant growth and reproduction. It is important for carbohydrate metabolism and their translocation and also plays an indispensable role in plant cell-wall formation, integrity of plasma membranes, pollen tube growth and increases pollination and seed development. Boron is essential for normal growth and development of all plants (Brown *et al*., 2002). It plays an important role in the growth and development of new cells in the plant meristems because it is closely associated with cell-division in the growing region of the plant that is near the tip of roots and shoots. It is also needed for the growth of the pollen tube during flower pollination and is therefore important for good seed set and fruit development. Suitable B availability augments meristematic growth, cross links cellulose molecules in cell-wall, stimulates enzymes by combining diol comprising groups in cell membrane, movement of sugar into budding parts of plants, pollination and setting of seeds. Tissue of boron-deficient plants often breaks down permanently, causing brown flecks, necrotic spots, cracking and corky areas in fruits and tubers. Soil application of micronutrient is not very effective to recover these deficiencies in calcareous and alkaline soils due to mass flow of micronutrients. Therefore, an experiment was undertaken with foliar applications of different concentration of Zn and B at different growth stages to evaluate the growth and yield of Maize.

The present field experiment was carried out during *summer*, 2018 at Student Instructional Research Farm of the Institute of Foreign Trade and Management University, Lodhipur-Rajput, Delhi Road, Moradabad, Uttar Pradesh. (28°21′–28°16′ north latitude and 78°4′ to 79° east longitude and 198 m above means sea-level). The field was fairlylevelled and have good drainage with assured irrigation facility. The soil of experimental site was sandy loam and have 7.0 *p*H. The experiment consisted of 10 treatments viz. 3 Zn and B concentration, viz. 0.5, 0.75 and 1%

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[1]**Corresponding author's Email**: virendra.singhed@gmail.com
[1]Research Scholar, [2]Associate Professor, [3,4]A2ssistant Professor, School of Agricultural Sciences and Engineering

and 3 foliar application time at 30, 40 and 50 days after sowing (DAS) with 1 absolute control. The seeds of maize cv. Pioneer ‘P 1866’ (Hybrid) were sown in lines at row-to-row distance of 50 cm and plant-to-plant distance of 20 cm. Nitrogen (N), phosphorus (P) and potassium (K) were applied @ 120, 60 and 40 kg N, $P_2O_5$ and $K_2O$/ha through urea (46% N), diammonium phosphate (18% N, 46% $P_2O_5$) and muriate of potash (60% $K_2O$), respectively. One-third N and whole $P_2O_5$ and $K_2O$ were applied at the time of sowing, and remaining nitrogen was applied in 2 splits-each at knee-high (35 days after sowing) and tasseling stage. The required fertilizer quantity was mixed thoroughly and then placed in open furrows. Zinc sulphate and borax were used for foliar application as per the treatment concentration and time of application. The Zn and B foliar application were done at 30, 40 and 50 days after sowing of maize in 400, 500 and 600 liters water, respectively.

Results indicated that the application of Zn and B significantly affected the growth and yield attributes of maize (Table 1). Application of zinc and boron significantly influenced the plant height, varying from 165.33 cm to 192.49 cm. Maximum plant height was recorded with the application of 1% foliar spray of zinc and boron at 30, 40 and 50 DAS and it was at par with 0.75% of Zn and B foliar application treatment. Plant height increased with the application of zinc may be due to that it is a prosthetic group in a large number of proteins and also involved in the activation of all the 6 groups of enzymes, viz. transferase, oxidoreductase, lysase, hydrolases, isomerases and ligases. Our results confirm the findings of Kumar *et al.* (2019).

Significant effect of zinc and boron was observed on yield attributes of maize. Maximum cob length was recorded with the application of 1% foliar spray of Zn and B at 30, 40 and 50 DAS and it was at par with 0.75% of Zn and B application. Similar results also obtained for cob girth, grains/row, rows/cob and seed index over control treatment (Table 1). Stem girth was recorded maximum in 1% Zn and B foliar spray at 30, 40 and 50 DAS, but it was non-significant with all treatments. Folizr application of Zn and B facilitated augmentation in plant height, stem girth, cob length and seed index over the control, which may be attributed to role of zinc and boron in photosynthesis. Application of zinc and boron might have stimulated enzymes and thereafter improved carbon fixation. Thus, enhanced photosynthesis with zinc and boron nutrition might have encouraged dry-matter accumulation in vegetative parts of the crop. Likewise, zinc and boron incited enrichment in cob girth and 100-grain weight (seed index) recognized the role of zinc and boron in activation of enzymes and photosynthesis. Equally, boron application might encourage radial cell-division and later enhanced stem girth over the control. Moreover, B facilitated radial cell-division was also established from boron intermediated augmentation in cob girth. Our results confirm the findings of Manzeke *et al.* (2014), Shivay and Prasad (2014) and Kumar *et al.* (2019).

Study on mean values for grain yield was conveyed to have significant changes among the treatment means that wide-ranging from 2.78 to 5.12 t/ha (Table 2). The maximum grain yield was recorded in 1% foliar spray of Zn and B at 30, 40 and 50 DAS (5.12 t/ha), followed by 0.75% foliar spray of Zn and B at 30, 40 and 50 DAS (4.92 t/ha), 1% foliar spray of Zn and B at 30 and 40 DAS (4.89 t/ha), while the least grain yield was recorded in the control (2.78 t/ha). Stover and biological yields of maize were also significantly influenced by the application of Zn and B. Maximum stover and biological yields were recorded with the application of 1% foliar spray of Zn and B at 30, 40 and 50 DAS being 25.74 and 30.85 t/ha, respectively. This might be owing fact that to the foliar-applied Zn and B increased

**Table 1.** Effect of zinc and boron foliar application on **p**lant growth and yield attributes of maize

| Treatment | Plant height (cm) | Stem girth (cm) | Cob length (cm) | Cob girth (cm) | Grains/ row | Grain rows/cob | Seed index (g) |
|---|---|---|---|---|---|---|---|
| Control | 165.3 | 7.1 | 13.6 | 12.1 | 28.0 | 15.3 | 17.3 |
| Zn and B spray 0.5% at 30 DAS | 175.1 | 7.3 | 14.4 | 12.5 | 28.4 | 15.7 | 19.0 |
| Zn and B spray 0.5% at 30, 40 DAS | 184.4 | 7.4 | 15.3 | 12.6 | 29.3 | 16.7 | 19.0 |
| Zn and B spray 0.5% at 30, 40, 50 DAS | 186.3 | 7.5 | 16.2 | 13.6 | 30.3 | 17.1 | 20.7 |
| Zn and B spray 0.75% at 30 DAS | 179.4 | 7.4 | 16.3 | 12.6 | 28.8 | 16.5 | 19.0 |
| Zn and B spray 0.75% at 30, 40 DAS | 188.9 | 7.6 | 16.3 | 13.6 | 30.9 | 17.3 | 21.7 |
| Zn and B spray 0.75% at 30,40,50 DAS | 191.4 | 7.7 | 16.7 | 13.9 | 32.7 | 17.9 | 21.9 |
| Zn and B spray 1% at 30 DAS | 185.2 | 7.5 | 15.9 | 13.1 | 30.0 | 16.7 | 19.3 |
| Zn and B spray 1% at 30, 40 DAS | 190.3 | 7.7 | 16.6 | 13.9 | 32.1 | 17.4 | 22.0 |
| Zn and B spray 1% at 30, 40, 50 DAS | 192.5 | 7.7 | 17.4 | 14.0 | 33.2 | 18.6 | 22.3 |
| SEm± | 4.376 | 0.157 | 0.550 | 0.386 | 1.037 | 0.495 | 0.629 |
| CD (P=0.0 5) | 13.104 | N.S. | 1.646 | 1.157 | 3.105 | 1.483 | 1.882 |

DAS, Days after sowing

**Table 2.** Yield (t/ha) and harvest index of maize as influenced by zinc and boron foliar application

| Treatment | Grain yield (t/ha) | Stover yield (t/ha) | Biological yield (t/ha) | Harvest index |
|---|---|---|---|---|
| Control | 2.78 | 19.37 | 22.15 | 14.3 |
| Zn and B spray 0.5% at 30 DAS | 3.24 | 20.34 | 23.58 | 16.0 |
| Zn and B spray 0.5% at 30, 40 DAS | 3.51 | 21.47 | 24.98 | 16.3 |
| Zn and B spray 0.5% at 30, 40, 50 DAS | 4.43 | 23.43 | 27.85 | 18.9 |
| Zn and B spray 0.75% at 30 DAS | 3.39 | 21.34 | 24.73 | 15.9 |
| Zn and B spray 0.75% at 30, 40 DAS | 4.59 | 23.77 | 28.35 | 19.3 |
| Zn and B spray 0.75% at 30,40,50 DAS | 4.92 | 24.32 | 29.24 | 20.2 |
| Zn and B spray 1% at 30 DAS | 3.52 | 21.89 | 25.41 | 16.1 |
| Zn and B spray 1% at 30, 40 DAS | 4.89 | 24.07 | 28.96 | 20.3 |
| Zn and B spray 1% at 30, 40, 50 DAS | 5.12 | 25.74 | 30.85 | 19.9 |
| SEm± | 0.108 | 0.350 | 0.335 | 0.382 |
| CD (P=0.0 5) | 0.322 | 1.049 | 1.003 | 1.143 |

DAS, Days after sowing

the photosynthesis and chlorophyll production that ultimately increased the dry weight and yield (Tariq *et al*., 2014). Grain yield is the mutual outcome of different characters of the crop. Rise in grain yield under foliar-applied Zn and B combination might be ascribed to distinguished increase in complete yield-related traits. Equally, it might be owing to advanced translocation of carbohydrates to grains (Rajaie and Ziaeyan, 2009), which in the end give rise to higher grain yield under foliar application of micronutrients. Minimum stover and grain yield were recorded in the control treatment (Table 2). Application of Zn and B also affected harvest index significantly. Maximum harvest index was recorded with the application of 1% foliar spray of Zn and B at 30 and 40 DAS (20.31%), being at par with 1% foliar spray of Zn and B at 30, 40 and 50 DAS (20.23%) and 0.75% foliar spray of Zn and B at 30, 40 and 50 DAS (19.89%). The minimum harvest index was recorded in the control. Application of boron increased the pollen-tube germination, seed setting and synthesis of proteins carbohydrates (Moeinian *et al.,* 2011), which improved the seed yield owing to application of B and other micronutrients. Foliar application of Zn and B increased the biological yield and harvest index, might be to owing increased chlorophyll contents and grain yield. It might be because of to activation of different physiological processes like stomatal regulation, chlorophyll formation, enzyme activation and biochemical processes through application of micronutrients (Cakmak, 2008) which resulted in high dry matter and yield. Kumar *et al.* (2019) also reported similar results.

It can be concluded that the results of the present study show that foliar application of zinc and boron at different growth stages of maize had roles on the vegetative growth and yield. Application of zinc and boron @ 1% foliar spray at 30, 40 and 50 days after sowing may be recommended for getting high yield of maize.

## REFERENCES

Brown, P.H., Bellaloui, N., Wimmer, M.A., Bassil, E.S., Ruiz, J., Hu H., Pfeffer, H., Dannel, F. and Romheld, V. 2002. Boron in plant biology. *Plant Biology* **4**: 205–223.

Cakmak, I. 2008. Enrichment of cereal grains with zinc: agronomic or genetic biofortification. *Plant Soil* **302**: 1–17.

Grzebisz, W., Wronska, M., Diatta, J.B. and Dullin, P. 2008. Effect of zinc foliar application at early stage of maize growth on patterns of nutrients and dry-matter accumulation by the canopy. Part I. Zinc uptake patterns and its redistribution among maize organs. *Journal of Elementology* **13**: 17–28.

Kumar, Monu, Singh, Satybhan, Singh, Virendra, Singh, Kamal and Khanna, Richa. 2019. Effect of zinc and boron on growth and yield of maize (*Zea mays* L.). *Progressive Research-An International Journal* **14**(3): 215–221.

Majhi, S., Thakur, R., Pal, S.K., Upasani, R.R., Puran, A.N. and Kujur, A.N. 2018. Long-term influence of nutrient managementon productivity and profitability of maize (Zea mays)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **63**(1): 14–20.

Manzeke, G.M., Mtambanengwe, F., Nezomba, H. and Mapfumo, P. 2014. Zinc fertilization influence on maize productivity and grain nutritional quality under integrated soil fertility management in Zimbabwe. *Field Crops Research* **166**: 128–136.

Moeinian, M. R., Zargari, K. and Hasanpour, J. 2011. Effect of boron foliar spraying application on quality characteristics and growth parameters of wheat grain under drought stress. *European Journal of Agricultural Environmental Science***10**: 593–599.

Pooniya, V. and Shivay, Y.S. 2011. Effect of green manuring and zinc fertilization on productivity and nutrient uptake in Basmati rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **56**(1): 28–34.

Rajaie, M., Ziaeyan, A.H. 2009. Combined effect of zinc and boron on yield and nutrients accumulation in corn. *International Journal of Plant Production* **3**: 435–440.

Shivay, Y.S. and Prasad, Rajendra. 2014. Effect of source and methods of zinc application on corn productivity, nitrogen and zinc concentrations and uptake by high quality protein corn