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# Influence of Boron and Growth Regulator on Growth and Yield of Maize (*Zea mays* L.) North East Plane Zone

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**ABSTRACT**

To investigate the effect of boron and Gibberellic Acid ($GA_3$) on growth and yield of maize, a field experiment was conducted at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (UP) in *Rabi* season 2022-23. The main objective of the experiment was to evaluate the Influence of boron and growth regulator on growth and yield of maize (*Zea mays* L.) north east Plane Zone. The research field of the treatment consisted of 3 levels of boron Soil application (3, 1.5 kg/ha) and foliar Application (1%, 0.5%) and 3 levels of Gibberellic Acid (50,100,150 ppm) foliar application and a control. The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. Application of soil and foliar application of boron (0.5%+1.5 kg/ha) Along with $GA_3$-150 ppm. produce highest plant height (205.79 cm), plant dry weight (157.74 g), crop growth rate ($g/m^2/day$) (41.39 $g/m^2/day$), more number of cobs per plant (1.67), number of grain row per cob (17.47), number of grain per row (33.63), seed index (25.630 g), higher seed yield (5.40 t/ha), higher Stover yield (9.60 t/ha), highest harvest index (35.97 %).

***Key words:*** *Maize, Boron, Gibberellic Acid, Growth, Yield, and Economic*

## Introduction

Maize (*Zea mays* L.) is an important critical cereal crop in international rating, after rice and wheat rank third. It is a member of family Poaceae (*Gramineae*). Which is of great economic importance, maize is an annual plant that can reach heights of up to 3-4 meters (10-13 feet) and has a distinctive stalk with large, broad leaves. It is cross-pollinated crop, maize is a tall with a fibrous root system, it has a single leaf at each node, and two successive leaves along the stem of maize have an approximately opposite azimuthally orientation (Sleeper and poehlmon, 2006). Today, maize is grown in various parts of the world, including North and South America, Africa, Europe, and Asia. It is known for its versatility and adaptability to different climates and growing conditions. Globally, maize is referred as 'Miracle crop' or 'Queen of the Cereals' because of its excessive productiveness capability in com-

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parison to different Poaceae own circle of relatives members. Maize grain incorporates approximately the nutritional value of maize is high as it contains 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar and 1.7% ash and 2.7% crude protein. (Hokmalipour *et al.,* 2010). Maize is a highly versatile crop with diverse uses. Its primary purpose is as a staple food for humans and livestock. As it's far a potential crop in India, it occupies essential area as meals (25%), fowlfeed (49%) animal feed (12%), business merchandise usually starch (12%) and (1%) every in seeds and brewery, ethanol, oil, alcoholic liquids, meals sweeteners, pharma, cosmetics etc. (Das *et al.,* 2009). Currently nearly 1147.7 million mt of maize is being produced together by over 170 countries from an area of 193.7 million ha with average productivity of 5.75 t/ha (FAOSTATE, 2022). It is the most widely cultivated crop with global pro duction volume just near 1.07 billion tones. In India, this coarse grain is currently being cultivated on 9.22 m ha with 27.82 million tones production.

Boron plays rolein maize by stimulation of root and shoots development, early tassel and silk formation, movement of sugars from leaves to ears, pollen germination capacity, cell wall synthesis, RNA metabolism, IAA metabolism, seed formation, storage of assimilates better water use efficiency and drought tolerance. It also controls the activities of potassium and calcium ratio in plants (Blevins and Lukaszewski, 1998). The lack of B is manifested through the breakdown of plant growing tissue and improper development of organs of reproduction. Insufficient B in plants can lead to deformed flowers, distorted seeds, thick, breakable, Curled leaves or necrotic parts (Brady and Weils, 1999). Gibberellins induce flowering in long-day plants which require chilling. The heading was delayed by addition of gibberellic acid (GA) to the root zone in superdwarf rice (Frantz *et al.,* 2004). Gibberellins are probably one of the growth regulators that have a significant effect on flowering. Dwarfing depends upon gibberellin deficiency and dwarfing gene effects on gibberellin biosynthesis. So, by applying gibberellic acid on dwarf maize mutant, they showed normal growth after hormone treatment. In addition, long stems have more bioactive gibberellin than short stems (Naghashzadeha *et al.,* 2009). Plant growth hormones so far have been emerged as "magic chemicals" that could increase agricultural production at an unprecedented rate and help in removing and circumventing many of the barriers imposed by genetics and environment. Spraying different concentration of gibberellic acid over the plans at 3- 4 leaf growth stage increased seed yield and yield components in soybean (Azizi *et al.,* 2012).

## Materials and Methods

### Experimental site

The experiment took place in the Crop Research farm of the department of Agronomy, Naini Agricultural Institute, (Research Farm is situated at 25.750 N latitude, 87.190 E longitudes and at an altitude of 98 m above mean sea level) during the growth *Rabi* season of 2022-23. The experiment employed a Randomized Block Design consisting of ten treatments with three boron levels, the treatment boron soil application (3, 1.5 kg/ha) and foliar application (1%, 0.5%) i.e., along with three levels of Gibberellic Acid (50,100,150 ppm) foliar application 40, 70 DAS. The soil of the experimental field was sandy loam in texture with pH 7.6, low in organic carbon 0.230 %, available nitrogen 278.93 kg/ha, available phosphorus 19.03 kg/ha and available potassium 238.10 kg/ha. Maize variety "DKC-9081" was shown on 20th December 2022. Foliar Application in boron on tasseling and slicking stage. In growth parameters plant height (cm), dry weight (g/plant), crop growth rate (g/m$^2$/day) and yield parameters were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez and Gomez, 1984).

## Results and Discussion

### Growth parameters of maize

Significantly highest plant height (205.79 cm), Plant dry weight (157.47 g/plant), Crop growth rate (g/m$^2$/day) (41.39 g/m$^2$/day) was recorded in the treatment $T_9$ with Soil application 1.5 kg/ha + Foliar (0.5%) along with Gibberellic Acid 150 ppm over all the other treatments. However, the treatments with application Foliar Application + Soil Application of Boron (0.5 % + 1.5 kg/ha) along with $GA_3$ 50 ppm. Which were found to be at par with treatment $T_9$ as compared to all the treatments. With the increase in levels of boron and change in methods of application of boron from soil application and foliar application, the plant height gradually increased, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to boron fertilization resulting into better vegetative growth. As boron generally influences cell division and nitrogen absorption from the soil might enhance plant growth which reflects in terms of plant dry weight. These findings are in harmony with those obtained by Tahir *et al.* (2012) and Singh *et al.* (2015). Gibberellic acid have a regulatory function are produce the shoot apex primary in the leaf primordial and root system stimulates stem growth dramatically and also stimulates cell division, cell elongation and enzyme secretion, which eventually increased the plant height. The improvement in plant height was due to interaction of both boron and $GA_3$ application to Maize crop. Similar results were reported by Keykha *et al.* (2014) $GA_3$ promotes cell proliferation in plant developmental stages due to their own metabolism regulation and promotes the development of cells by increasing turgor pressure and it also activates different enzymes and has a positive effect on plant growth and dry matter accumulation. The results were found in accordance with Islam *et al.* (2014). The dry matter yield increase in the boron suggests that it was one of the limiting nutrients in the soils. This indicates that, at this level, the soil boron was further improved with better boron nutrition leading to high dry matter production which in turn increases CGR.

### Yield and yield attributes of Maize

Significantly Maximum number of Cobs/plant (1.67), Grain/row (33.63), Grain Row/cob (17.476), Seed index (g) (25.630 g), Seed yield (t/ha) (5.40 t/ha), Stover yield (t/ha) (9.60 t/ha), Harvest index (35.97%) was recorded with the treatment $T_9$ of application of soil application 1.5 kg/ha and foliar (0.5%) along with ($GA_3$) 150ppm over all the treatments. However, the treatments foliar application and soil Application of boron (0.5 % +1.5 kg/ha) and $GA_3$-50 ppm. Which were found to be statistically at par with treatment $T_9$ Soil application 1.5 kg/ha and Foliar (0.5%) along with $GA_3$ 150 ppm. The increase in number of cobs/plant, grain/row due to the soil

**Table 1.** Quantity and used formula in fertilizers

| Sr. No. | Treatments | Source | Fertilizer formula | Quantity of fertilizer |
|---|---|---|---|---|
| 1 | $B_1$: B applied (1%) | Boric acid 20% | Nutrient (kg/ha)/Nutrient in fertilizer (%) *100 | 1 kg |
| 2 | $B_2$: B applied (3 kg/ha.). | Boric acid 20% | Nutrient (kg/ha)/Nutrient in fertilizer (%)*100 | 3 kg |
| 3 | $B_3$: B applied (0.5 % + 1.5 kg/ha). | Boric acid 20% | Nutrient (kg/ha)/Nutrient in fertilizer (%)*100 | 2 kg |
| 4 | $G_1$: 50 ppm | $GA_3$ | Nutrient (ppm)* Nutrient in (%)/ 1000 | 50 ppm |
| 5 | $G_2$: 100 ppm | $GA_3$ | Nutrient (ppm)* Nutrient in (%)/ 1000 | 100 ppm |
| 6 | $G_3$: 150 ppm | $GA_3$ | Nutrient (ppm)* Nutrient in (%)/ 1000 | 150 ppm |

**Table 2.** Effect of Boron application and Plant growth regulators on growth parameters of Maize.

| S. No. | Treatments | Plant height (cm) | Plant dry weight (g) | Crop growth rate (g/m²/ day) |
|---|---|---|---|---|
| 1. | Foliar Application of Boron (1%) + $GA_3$- 50 ppm. | 172.88 | 132.97 | 29.64 |
| 2. | Foliar Application of Boron (1%) + $GA_3$- 100 ppm. | 175.18 | 135.53 | 30.90 |
| 3. | Foliar Application of Boron (1%) + $GA_3$- 150 ppm. | 178.73 | 138.13 | 31.77 |
| 4. | Soil Application of Boron (3 kg/ha.) +$GA_3$-50 ppm. | 183.69 | 140.87 | 34.31 |
| 5. | Soil Application of Boron (3 kg/ha.) + $GA_3$-100 ppm. | 189.61 | 130.80 | 27.88 |
| 6. | Soil Application of Boron (3 kg/ha.) + $GA_3$-150 ppm. | 193.90 | 146.00 | 36.61 |
| 7. | Foliar Application + Soil Application of Boron (0.5 % + 1.5 kg/ha) + $GA_3$-50 ppm. | 201.28 | 151.47 | 39.86 |
| 8. | Foliar Application + Soil Application of Boron (0.5 % + 1.5 kg/ha) + GA3-100 ppm. | 194.56 | 149.60 | 38.87 |
| 9. | Foliar Application + Soil Application of Boron (0.5 % +1.5 kg/ha) + $GA_3$-150 ppm. | 205.79 | 157.47 | 41.39 |
| 10. | Control (Farmer Practice) 120-60-40 NPK kg/ha. | 170.91 | 118.03 | 28.60 |
| | SEm(±) | 6.67 | 4.55 | 1.24 |
| | CD (P= 0.05) | 19.83 | 13.54 | 4.16 |

and foliar application of boron and positive effect of boron may be due to key role in plant metabolism and in the synthesis of nucleic acid by Tahir *et al.* (2012). Application of boron to maize crop generally improves cob growth by synthesizing tryptophan and axon. The enhancement effect on seeds/pod and pods/plant attributed to the favorable influence of the boron application to crops on nutrient metabolism, biological activity and growth parameters and hence, applied boron resulted in taller and

**Fig.** (A) 30 DAS of field view,

**Fig.** (B) Taslling and Silking stage of crop

**Fig.** (C) Plant protection

**Fig.** (D) Maturity stage of maize

**Table 3.** Effect of Boron application and Plant growth regulators on Yield attributes and Yield of Maize

| S. No. | Treatments | Yield attributes | | | | Yield | | |
|---|---|---|---|---|---|---|---|---|
| | | Number of cob/ plant | Number of grain/ row | Number of grain row/cob | Seed index (g) | Seed yield (t/ha) | Stover yield (t/ha) | Harvest index (%) |
| 1. | Foliar Application of Boron (1 %) + $GA_3$- 50 ppm. | 1.45 | 25.47 | 13.55 | 23.487 | 4.02 | 8.50 | 32.14 |
| 2. | Foliar Application of Boron (1%) + $GA_3$- 100 ppm. | 1.40 | 23.88 | 13.66 | 23.860 | 4.13 | 8.52 | 32.67 |
| 3. | Foliar Application of Boron (1%) + $GA_3$- 150 ppm. | 1.23 | 25.69 | 12.88 | 22.893 | 4.22 | 8.67 | 32.82 |
| 4. | Soil Application of Boron (3 kg/ha.) + $GA_3$-50 ppm. | 1.27 | 25.36 | 14.88 | 23.713 | 4.42 | 8.63 | 33.62 |
| 5. | Soil Application of Boron (3 kg/ha.) + $GA_3$-100 ppm. | 1.43 | 20.81 | 14.77 | 24.360 | 4.70 | 8.73 | 31.90 |
| 6. | Soil Application of Boron (3 kg/ha.) + $GA_3$-150 ppm. | 1.46 | 26.22 | 15.02 | 24.907 | 4.87 | 8.95 | 34.44 |
| 7. | Foliar Application + Soil Application of Boron (0.5% + 1.5 kg/ha) + $GA_3$ 50 ppm. | 1.50 | 31.92 | 16.30 | 25.447 | 5.20 | 9.45 | 35.38 |
| 8. | Foliar Application + Soil Application of Boron (0.5%+ 1.5 kg/ha) + $GA_3$ 100 ppm | 1.47 | 27.80 | 15.10 | 24.823 | 4.90 | 9.10 | 34.95 |
| 9. | Foliar Application + Soil Application of Boron (0.5% + 1.5 kg/ha) + $GA_3$-150 ppm. | 1.67 | 33.63 | 17.47 | 25.630 | 5.40 | 9.60 | 35.97 |
| 10. | Control (Farmer Practice) 120-60-40 NPK kg/ha. | 1.20 | 24.70 | 12.44 | 21.887 | 3.99 | 7.00 | 27.35 |
| | SEm (±) | 0.08 | 1.08 | 0.55 | 0.71 | 0.31 | 0.43 | 0.96 |
| | CD (P= 0.05) | 1.45 | 3.22 | 1.653 | 2.11 | 0.93 | 1.28 | 2.87 |

higher enzyme activity which in turn encourage more seeds/row and cobs/plant. The application of $GA_3$ along with boron helped in increase the number of seeds per row of cob. Similar findings have been reported earlier by Anjum *et al.* (2017) and Thuc *et al.* (2021). Boron and $GA_3$, play a vital role in increasing yield attribute because $GA_3$ and boron takes place in many physiological process of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhances yield. Boron is a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops.

## Conclusion

It study recommended to the farmer maize crop we can application of soil and foliar application of boron 1.5 kg/ha + 0.5% along with combination of ($GA_3$) 150 ppm (Treatment 9), have highest growth metrics and yield characteristics while also being economically viable. However, additional tests are required to corroborate the findings because they are based only on one season.

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