Original Research Article

Influence of Indole acetic acid (IAA) and Boron on growth and yield of Maize (Zea mays. L)

ABSTRACT

A field experiment was conducted during kharif season of 2022 at Crop Research Farm (CRF), Department of Agronomy, SHUATS, Prayagraj (U.P), to evaluate the influence of IAA and boron on growth and yield of maize. The treatment consisted of 3 levels of IAA (30ppm,60ppm and 90ppm) and Boron (0.5%, 1.0% and 1.5%) both as foliar sprays and a control. The experiment was laid out in a Randomized Block Design with nine treatments and one control each replicated thrice. The results showed that treatment 9 with foliar application of IAA (90ppm) and boron (1.5%) recorded higher growth and yield attribute viz. plant height (185.70 cm), more dry weight (182.15 g), maximum number of cobs per plant (1.49), maximum number of rows per cob (15.97), maximum number of grains per row (22.27), seed index (24.79 g), higher grain yield (4.99 t/ha), higher stover yield (10.20 t/ha), higher harvest index (32.85 %), maximum gross return (1,98,470.00 INR/ha), net return (1,38,620.00 INR/ha) and B:C ratio (2.31).

Keywords: Maize, Indole acetic acid (IAA), Boron, growth, and yield.

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Introduction:

Maize (*Zea mays. L*) is the vital cereal crop around the globe. It is an important staple food apart from being a major ingredient of feed industry. In India, maize is called "Queen of Cereals" due to its higher genetic yield potential. Maize has its significant use for large number of industrial products such as starch industry, corn oil production etc. The word "maize" is from the Spanish connotation "maiz" which is the best way of describing the plant. Various other synonyms like zea, silk maize, makka, barajovar, etc. are used to recognize the plant **(Kumar & Jhariya *et al.* 2013)**. 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 **(Hokmalipour *et al.* 2010).** Maize protein, "Zein" is rich in tryptophan and lysine, the two essential amino acids. Maize produces rich and nutritious green fodder which is a good source of carbohydrates. Maize fodder is a nutritionally rich non-leguminous green fodder, which yields high biomass and is highly palatable. Maize is an essential source of various phytochemicals that play an important role in our health (**Kopsell *et al.* 2009**). USA is the largest maize producing country in the world followed by China, Brazil, and India. Maize for dry grain is annually cultivated on an estimated 197 M ha of land globally, making it the second most widely grown crop in the world. In India, according to advance estimate maize is cultivated in an area of about 9.18 million hectares with production of 27.23 million tones and an average productivity of 2965 kg/ha which is the fifth largest producer in the world contributing three percent of the total global production. In India, the major maize growing states are Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Haryana, Maharashtra, Andhra Pradesh, Himachal Pradesh, West Bengal, Karnataka, and Jammu and Kashmir, jointly

accounting for over 95% of the national maize production (**Milind & Isha *et al.* 2013)**.The global cereal demand shift in favor of maize reflects rising incomes in many developmental countries with consequents growth in meat consumption, which drive demand for maize as feed for poultry and swine. Biotic stresses due to pests are severely constraining production of maize. Similarly, abiotic stresses due to drought, salinity, acid soils and deficiency or toxicity of micronutrients constrains the productivity of maize. To increase the production of maize to meet the increasing demands and to overcome challenges that limits the productivity in our country, improved technologies and cultivation practices needs to be implemented.

Plant hormones play important roles in regulating developmental processes and signaling networks involved in plant responses to a wide range of biotic and abiotic stresses. Plant growth hormones has the potential that could increase agricultural production at an unprecedented rate and help in removing and circumventing many of the barriers imposed by genetics and environment. Indoleacetic acid (IAA) is the most common plant hormone of the auxin class and it regulates various aspects of plant growth and development **(Lüthen *et al.* 1999).** As all auxins, IAA has many different effects, such as inducing cell elongation and cell division with all subsequent results for plant growth and development. On a larger scale, IAA serves as signaling molecule necessary for development of plant organs and coordination of growth. Indoleacetic acid (IAA) is a molecule that is synthesized by plants and a few microbes. In plants, IAA plays a key role in both root and shoot development. A root, for instance, is one of the plant's organs that is, most sensitive to fluctuations in IAA and its response to increasing amounts of exogenous IAA extends from elongation of the primary root, formation of lateral and adventitious roots, **(Finnie and Van Staden et al. 1985)**. It is now generally agreed that IAA increases the ability of cell division in meristematic zones of plant and hence, the ability of plant to absorb nutritive material which finally led to the increase grain yield per area. Some researchers have shown that spraying IAA on the leaves considerably increases the growth rate of the corn **(Ghodrat et al. 2012).**

Boron plays a key role in flowering, pollen development and viability, and the pollination process. Most boron is accumulated in the maize plant just prior to pollination to support reproductive growth in tassels and ears. It is mobile in the soil, boron can leach from the soil profile, especially during wet conditions, which can negatively affect plant uptake and yield potential. If boron is not available, plants produce pollen without the starch required for growth once the pollen lands on a silk. A severe boron deficiency may result in a completely barren plant where an ear shoot may not even develop. Boron is one of the essential nutrients for the optimum growth, development, yield, and quality of crops **(Brown *et al.* 2002).** The enhanced B requirement of young growing tissues proves its critical role primarily in cell division and elongation **(Dell and Huang *et al.* 1997).** Boron is an important trace element required for the physiological functions of higher plants. Boron plays a pivotal role in nitrogen (N) metabolism and development (**Hajiboland *et al.* 2013**).

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Keeping in view the environment and human health, the present study entitled "Influence of Indole Acetic Acid (IAA) and Boron on growth and yield of Maize *(Zea mays L.)"* was conducted at the Crop Research Farm of the Department of Agronomy, SHUATS, Allahabad during the *kharif* season of 2022.

MATERIALS AND METHODS:

The field experiment was conducted during kharif season 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), organic carbon level in medium condition (0.87%), medium available N (225 Kg/ha), high in available P (41.8 kg/ha) and medium available K (261.2 kg/ha). The treatment consists of three levels of Indole acetic acid (IAA) *viz.*30ppm, 60ppm and 90ppm and three levels of Boron *viz.*0.5%, 1.0% and 1.5%. The experiment was laid out in Randomized Block Design with 10 treatments each replicated thrice. The treatment combination are T_1- IAA (30ppm) + Boron (0.5%), T_2- IAA (30ppm) + Boron (1.0%), T_3- IAA (30ppm) + Boron (1.5%), T_4 – IAA (60ppm) + Boron (0.1%), T_5- IAA (60ppm) + Boron (1.0%), T_6- IAA (60ppm) + Boron (1.5%), T_7- IAA (90ppm) + Boron (0.1%), T_8- IAA (90ppm) + Boron (1.0%), T_9- IAA (90ppm) + Boron (1.5%) , T_{10}- Control N:P:K (120:60:40 kg/ha). All agronomic practices are followed in order in the crop period. Experimental data regarding growth and yield attributes was recorded during the field experiment collected and was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level.

RESULT AND DISCUSSIONS:

Growth attributes

Plant height (cm)

At harvest, highest plant height (185.70 cm) was observed again in treatment 9 with foliar application of IAA at 90 ppm + Boron at 1.5%. However, plant height in treatment 8 with IAA at 60 ppm + Boron at 1.0% (185.48 cm) was found to be statistically at par with treatment 9. With the increase in levels of boron and methods of application of boron as 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. IAA has many different effects, such as inducing cell elongation and cell division with all subsequent results for plant growth and development, which eventually increased the plant height. The improvement in plant height was due to the interaction of both boron and IAA application to maize crop. Similar results were reported by **Tahir et al. (2012) and Haana et al. (2019).**

Dry weight (g/plant)

At 100 DAS, treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5% was recorded with significantly maximum dry weight (182.15 g/plant) over all the treatments. However,

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treatment 8 with foliar application of IAA at 90 ppm + Boron 1.0% (181.45 g/plant) was found to be statistically at par with treatment 9. Dry weight was increased significantly with increasing levels of Boron. 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 **Singh et al. (2015).** Enhancement in dry weight might be due to role of boron and IAA in increasing the nitrogen and phosphorus usage by plants. Under IAA has a key role in plant. The foliar application of IAA to the salinized plants resulted in significant increases in chlorophyll content in maize plants. And at the same time increases plant dry matter. Similar results were obtained with **Kaya et al. (2007)** and **Tuna et al. (2013).**

Yield attributes:

Cobs/plant

The data revealed that significantly maximum Cobs/plant (1.49) was recorded in treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (1.47) was found to be statistically at par with treatment 9 [Table 2]. The increase in number of cobs/plant due to the soil 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. And it was observed that the most promising effect IAA in promoting growth of maize plants under saline regime was recorded Highest kernel yield, cob yield, test weight and dry weight was recorded when IAA is applied as foliar. These findings were in accordance with **Tahir et al. (2012)** and **Tuna et al. (2013).**

Grains/row

Significantly maximum grains/row (22.27) was recorded in treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (22.12) was found to be statistically at par with treatment 9 [Table 2]. Application of boron to maize crop generally improves cob growth by synthesizing tryptophan and auxin. 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 higher enzyme activity which in turn encourage more seeds/row and cobs/plant. And the foliar application of IAA at the beginning of grain growth with may be because increasing of grain weight and then seed vigor. These results are in confirmatory with the work of **Saeidi et al. (2014).**

Grain rows/plant

Data shows that the maximum number of Rows/cob (15.97) was observed in treatment 9 foliar application of IAA at 90ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (15.60) which was found to be statistically at par with treatment 9 [Table 2].

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Seed index (g)

Significantly highest seed index (24.79 g) was recorded in the treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (24.40 g) was found to be statistically at par with treatment 9 [Table 2]. Increase in this attribute by foliar spray might be due the involvement of the spray of boron in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhance accumulation of assimilate in the grains resulting in heavier grains. Applications accelerated the plant growth long with cell division and contributed to the increase of dry matter per unit area and accordingly increased seed weight. These results agree with the findings of **Asif *et al.* (2013)** and **Tahir *et al.* (2012).**

Grain yield (t/ha)

Data shows that the maximum grain yield (4.99 t/ha), was observed in treatment 9 with application of IAA at 90 ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (4.67 t/ha) was found to be statistically at par with treatment 9 [Table 2]. Boron and IAA play a vital role in increasing grain yield because IAA and boron takes place in many physiological processes of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhances seed yield. Boron is required for many physiological processes and plant growth; also, adequate nutrition is critical for increased yields and quality of crops. These results are in confirmatory with the work of **Kaya *et al.* (2010)** and **Wasaya *et al.* (2017).**

Stover yield (t/ha)

Data shows that the maximum stover yield (10.20 t/ha), was observed in treatment 9 with application of IAA at 90ppm + Boron at 1.5%. However, treatment 8 with foliar application of IAA at 90ppm + Boron at 1.0% (9.85 t/ha) was found to be statistically at par with treatment 9[Table 2]. The improvement in biomass yield of maize may be attributed to the complementary role of boron in the reproduction and vegetative stage of plants. Effect of boron was observed to be positively significant with respect to grain and stover yield. These findings are in accordance with **Ao et al. (2020).**

Harvest index (%)

Significantly highest harvest index (32.85 %) was recorded in treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5 %. However, treatment 8 with application of IAA at 90ppm + Boron at 1.0 %. (32. 16 %) and treatment 5 with foliar application of IAA at 60ppm + Boron at 1.0% (29.60 %) was found to be statistically at par with treatment 9 [Table 2]. Adequate B availability enhances meristematic growth, cross links cellulose molecules in cell wall and activates enzymes by incorporating diol containing groups in cell membrane. It is also an essential micro nutrient which helps in more grain yield and hence increase harvest index. These findings are in accordance with **Anjum *et al.* (2017).**

Economics:

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The result showed [Table 3] that maximum gross return (INR 1,98,470/ha), net return (INR 1,38,620/ha) and B:C ratio (2.31) was recorded in treatment 9 with foliar application of IAA at 90ppm + Boron at 1.5 %.

Conclusion:

Based on the above results, it may be concluded that foliar application of IAA at 90ppm and Boron at 1.5% (treatment 9) performed better in terms of growth and yield attributes as compared to other treatments. Maximum net returns, gross returns and benefit cost ratio was also observed in treatment 9. These findings are based on one season therefore further trials may be required for further confirmation.

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Table 1. Effect of IAA and boron on growth attributes of Maize

Treatments	At 100 DAS	
	Plant height (cm)	Dry weight (g)
1. Foliar application of IAA at 30ppm + Boron at 0.5%	181.57	164.28
2. Foliar application of IAA at 30ppm + Boron at 1.0%	182.02	165.21
3. Foliar application of IAA at 30ppm + Boron at 1.5%	182.54	168.94
4. Foliar application of IAA at 60ppm + Boron at 0.5%	183.04	173.74
5. Foliar application of IAA at 60ppm + Boron at 1.0%	183.84	175.68
6. Foliar application of IAA at 60ppm + Boron at 1.5%	184.45	176.55
7. Foliar application of IAA at 90ppm + Boron at 0.5%	184.82	176.97
8. Foliar application of IAA at 90ppm + Boron at 1.0%	185.48	181.45
9. Foliar application of IAA at 90ppm + Boron at 1.5%	185.70	182.15
10. Control (120-60-40 kg/ha)	180.24	161.59
F- test	S	S
SE(m)±	0.22	0.52
CD (p = 0.05)	0.47	1.56

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Table 2. Effect of IAA and boron on yield attributes of maize

Treatments	Cobs/plant	Grains/row	Grain rows/cob	Seed index (g)	Grain yield (t/ha)	Stover Yield (t/ha)	Harvest index
1. Foliar application of IAA at 30ppm + Boron at 0.5%	1.18	18.42	12.27	19.23	2.40	6.84	25.97
2. Foliar application of IAA at 30ppm + Boron at 1.0%	1.21	18.88	12.93	20.98	2.85	7.22	28.30
3. Foliar application of IAA at 30ppm + Boron at 1.5%	1.24	19.21	13.33	21.84	3.10	7.58	29.24
4. Foliar application of IAA at 60ppm + Boron at 0.5%	1.30	19.86	13.47	21.25	3.27	8.03	28.93
5. Foliar application of IAA at 60ppm + Boron at 1.0%	1.32	20.37	14.67	22.08	3.65	8.68	29.60
6. Foliar application of IAA at 60ppm + Boron at 1.5%	1.35	20.60	14.53	22.14	3.73	8.97	29.34
7. Foliar application of IAA at 90ppm + Boron at 0.5%	1.41	21.45	15.07	22.41	4.01	9.11	29.04
8. Foliar application of IAA at 90ppm + Boron at 1.0%	1.47	22.12	15.60	24.40	4.67	9.85	32.16

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9. Foliar application of IAA at 90ppm + Boron at 1.5%	1.49	22.27	15.97	24.79	4.99	10.20	32.85
10. Control	1.11	18.14	11.87	18.81	2.24	6.57	24.54
F- test	S	S	S	S	S	S	S
SE(m)±	0.026	0.24	0.22	0.78	0.12	0.49	1.14
CD (p= 0.05)	0.052	0.71	0.46	2.33	0.37	1.04	3.40

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Tables 3. Effect of IAA and boron on economics of Maize

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio (B:C)
1. Foliar application of IAA at 30 ppm + Boron at 0.5%	57,775.00	1,23,200.00	65,425.00	1.13
2. Foliar application of IAA at 30 ppm + Boron at 1.0%	57,950.00	1,31,500.00	73,550.00	1.26
3. Foliar application of IAA at 30 ppm + Boron at 1.5%	58,125.00	1,43,980.00	85,855.00	1.47
4. Foliar application of IAA at 60 ppm + Boron at 0.5%	58,525.00	1,49,130.00	90,605.00	1.54
5. Foliar application of IAA at 60 ppm + Boron at 1.0%	58,700.00	1,58,030.00	99,330.00	1.69
6. Foliar application of IAA at 60 ppm + Boron at 1.5%	58,875.00	1,64,560.00	1,05,685.00	1.79
7. Foliar application of IAA at 90 ppm + Boron at 0.5%	59,275.00	1,79,170.00	1,19,875.00	2.02
8. Foliar application of IAA at 90 ppm + Boron at 1.0%	59,450.00	1,94,740.00	1,35,290.00	2.27
9. Foliar application of IAA at 90 ppm + Boron at 1.5%	59,850.00	1,98,470.00	1,38,620.00	2.31
10. Control (120-60-40 kg/ha)	56,850.00	1,03,180.00	57,730.00	1.01

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