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Vishal Sharma
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Dr. Biswarup Mehera
Dean, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Vishal Sharma
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Influence of zinc and boron levels on growth parameters and yield of baby corn (*Zea mays* L.)

Vishal Sharma and Dr. Biswarup Mehera

Abstract
A field experiment was conducted at the Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (UP) during the year 2021 *Rabi* season. The experiment comprised of 10 treatments of different combinations of zinc and boron replicated thrice in a Randomized Block Design. The main objective of the experiment was to evaluate the Effect of zinc and boron on growth and yield of baby corn (*Zea mays* L.). The zinc include (Zinc @ 10 kg/ha), (Zinc @ 15 kg/ha) and (Zinc @ 20 kg/ha). Where-as levels of boron include (Boron @ 6 kg/ha), (Boron @ 7 kg/ha) and (Boron @ 8 kg/ha). From the present investigation it may be concluded that the profitable production of baby corn can be secured by Zinc @ 20 kg/ha + Boron 8 kg/ha (Treatment 9).

Keywords: Growth, yield, zinc and boron levels

Introduction

Maize is one of the most important cereal crops next to rice and wheat in world agriculture economy both as food for men and feed for animals. It has high yield potential, there is no crop on earth which has so immense potentiality and that is why it is called queen of cereals. Its botanical name is *Zea mays* L. belonging to the family Gramineae, sub family Poaceae and chromosome number is 20 (2n). Baby corn cultivation can be compared to that of vegetable crops because the sowing period until harvest is short, on average 60 days. In summer, it can be harvested in up to 45 days, depending on the precocity and the cultivar used. Even in winter months, in tropical regions, even using early cultivars, this period can reach 70 days (EMBRAPA, 2008) [6]. Baby corn having unfertilized young cobs harvested 2 or 3 days after silk emergence. Globally, as an immature vegetable, baby corn has attracted an increasing number of peoples‟ preference due to the enhancement of living standards and shift in dietary habit from non-vegetarian to vegetarian; however, production areas are still confined to a few countries, including Thailand, Indonesia, India, and Brazil. Worldwide, Thailand is the leading producer and exporter of baby corn. India is emerging as the potential producer of baby corn due to high demand with less cost of production. The average productivity of baby corn in India is about 7.5-8.7 tonnes / ha (Mohinder *et al.* 2021) [22]. Baby corn has been used by Chinese as vegetable for generations and this practice has spread to other Asian countries. It is used as ingredient in most food preparations. In the soil, Boron (B) is found in the form of boric acid or borate; among all the essential elements, the percolation of boron is in the form of uncharged molecules instead of ions (Miwa and Fujiwara, 2010) [12]. Boron is one of the essential nutrients for the optimum growth, development, yield, and quality of crops (Brown *et al.* 2002) [3]. B is located in the cell walls of leaves (Hu and Brown, 1994) [23]. The enhanced B requirement of young growing tissues proves its critical role primarily in cell division and elongation (Dell and Huang, 1997) [24]. Boron starvation dramatically inhibits root elongation, with deformed flower and fruit formation due to impaired cell division in the meristem tic region, whereas adequate boron supply promotes advantageous root development (Gupta and Solanki, 2013) [8]. Zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes in many important biochemical pathways and these are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Keram and Singh 2014) [10]. Reduced growth hormone production in Zn-deficient plants causes the shorting of internodes and smaller than normal leaves (Tisdale *et al.* 2003) [21].

Materials and Methods

The current study was carried out in the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, during the *Rabi* season 2021-22, (U.P.). The experimental field is located approximately 5 kilometers from Prayagraj city, near the Yamuna River, on the left side of the Prayagraj-Rewa Road. Prayagraj is located in the subtropical zone of Uttar Pradesh, with hot summers and pleasant winters. The area's average temperature is 42.34 °C to 19.34 °C, with temperatures seldom dropping below 8.7 °C or 21.60 °C. The relative humidity levels range from 28.57 % to 95 %. In this location, the average annual rainfall is 1050 mm. The soil chemistry analysis revealed a sandy loam texture with a pH of 7.70, low amounts of organic carbon (0.84 percent) and potassium (160.0 kg/ha), and a low quantity of accessible phosphorus (29.0 kg/ha). The soil was electrically conductive and had a conductivity of 0.22dS / m. For each of the ten treatment combinations, three replications were employed. The therapy details and treatment combinations are shown in Tables 1 and 2, respectively. Zinc and boron were maintained according to the treatment combinations. Plant height (cm) at harvest, dry weight at harvest, number of cobs/plant, weight of cob (g), baby corn yield (t / ha), and green fodder yield (t / ha) were all successfully measured and an economic analysis of each treatment was completed to determine the best treatment combination for baby corn cultivation.

Table 1: Treatment Details

Zinc application (Zn): 3 (Three) levels	Zn_1	Zinc @ 10kg / ha
	Zn_2	Zinc @ 15kg / ha
	Zn_3	Zinc @ 20kg / ha
Boron fertilizer (B):3 (Three) levels	B_1	Boron @ 6 kg / ha
	B_2	Boron @ 7kg / ha
	B_3	Boron @ 8 kg / ha

Table 2: Treatment Combinations

Treatment symbol	Treatment combinations Symbol	Treatment combinations
T_1	Zn_1B_1	Zinc @ 10 kg / ha + Boron 6 kg / ha
T_2	Zn_1B_2	Zinc @ 10 kg / ha + Boron 7 kg / ha
T_3	Zn_1B_3	Zinc @ 10 kg / ha + Boron 8 kg / ha
T_4	Zn_2B_1	Zinc @ 15 kg / ha + Boron 6 kg / ha
T_5	Zn_2B_2	Zinc @ 15 kg / ha + Boron 7 kg / ha
T_6	Zn_2B_3	Zinc @ 15 kg / ha + Boron 8 kg / ha
T_7	Zn_3B_1	Zinc @ 20 kg / ha + Boron 6 kg/ ha
T_8	Zn_3B_2	Zinc @ 20 kg / ha + Boron 7 kg / ha
T_9	Zn_3B_3	Zinc @ 20 kg / ha + Boron 8 kg / ha
T_{10}	Fe_0B_0	Control

Results and Discussion

Growth parameters at maturity

Plant height (cm) at harvest

Table 3 shows zinc and boron fertilizer on plant height at harvest. The Data indicated that spacing had significant impact on plant height at harvest during the crop growth period. At harvest, maximum plant height (140.62 cm) was recorded with application of Zinc @ 20 kg/ha + Boron 8 kg / ha. Whereas the minimum plant height (123.39 cm) was recorded with Control. There was no-significant difference between different treatment combinations. However, Zinc @ 20 kg/ha + Boron 6 kg/ha, Zinc @ 20 kg/ha + Boron 7 kg/ha, Zinc @ 10 kg/ha + Boron 8 kg/ha and Zinc @ 15 kg/ha + Boron 6 kg/ha are found statistically at par to Zinc @ 20 kg/ha + Boron 8 kg/ha. Application of zinc gave significant increase in growth parameters such as plant height and leaf area index in maize. Zinc have played a vital role in the vegetative growth especially under low temperature ambient and Rhizosphere regime and adequate availability of zinc to young and developing plants resulting in sufficient growth and development (Singh *et al.*, 2012) [20]. Boron application methods also improved plant height in rice, which is due to active involvement of B in meristematic growth of plant (Bohnsack and Albert, 1977) [2].

Dry weight per plant At Harvest

Table 3 shows zinc and boron fertilizer on dry weight per plant at harvest. The Data indicated that at harvest, maximum plant dry weight (g / plant) (120.71) was recorded with application of Zinc @ 20 kg/ha + Boron 8 kg ha. Whereas the minimum Plant dry weight (g / plant) (91.15) was recorded with Control. There was no significant difference between different treatment combinations. Continuous and balanced supply of nutrients right from the early stage of growth result in vigorous plant growth which eventually may have resulted in increased dry-matter accumulation **(**Pooniya and Shivay, 2011; Shukla and Warsi, 2000) [15, 19].

Table 3: Effect of zinc and boron levels on growth parameters at maturity of baby corn

Treatment details		Growth Parameters	
		Plant height (cm)	Plant dry weight (g / plant)
1	Zinc @ 10 kg / ha + Boron 6 kg / ha	129.03	115.75
2	Zinc @ 10 kg / ha + Boron 7 kg / ha	135.19	114.29
3	Zinc @ 10 kg / ha + Boron 8 kg / ha	138.17	114.02
4	Zinc @ 15 kg / ha + Boron 6 kg / ha	136.29	109.36
5	Zinc @ 15 kg / ha + Boron 7 kg / ha	133.07	108.70
6	Zinc @ 15 kg / ha + Boron 8 kg / ha	135.07	106.15
7	Zinc @ 20 kg / ha + Boron 6 kg / ha	137.59	117.40
8	Zinc @ 20 kg / ha + Boron 7 kg / ha	139.57	118.52
9	Zinc @ 20 kg / ha + Boron 8 kg / ha	140.62	120.71

10	Control	123.39	91.15
	F Test	S	S
	S.E.D. (±)	1.441	1.085
	CD (p = 0.05)	3.025	2.280

Yield parameters

Number of cobs per plant

Observations regarding the response of different levels of zinc and boron fertilizer on yield and yield attributes of baby corn are given in table 4 the results revealed that there was ear from the data that among different treatments, The highest No. of cobs/plant (2.86) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest test weight (1.22) was found in treatment Control. There was significant difference between different treatment combinations. Application of zinc and boron fertilizer combination along with foliar application of zinc and boron fertilizer ultimately accrued huge quantity of biomass and partitioned a large fraction of assimilates to the sink, resulting in enhanced yield structures (cobs) as displayed by all the yield attributes. The finding of Nagavani *et al*. (2010) [25] confirmed these results.

Table 4: Effect of zinc and boron levels on yield parameters at maturity of baby corn

	Treatment details	Yield Parameters					
		Cobs / plant (No.)	Cob weight (g without husk)	Cob weight (t / ha with husk)	Cob yield without husk (t / ha)	Cob yield with husk (t / ha)	Green fodder yield (t / ha)
1	Zinc @ 10 kg / ha + Boron 6 kg / ha	2.08	8.52	48.33	1.83	12.44	27.08
2	Zinc @ 10 kg / ha + Boron 7 kg / ha	2.12	8.41	46.13	1.66	12.43	27.53
3	Zinc @ 10 kg / ha + Boron 8 kg / ha	2.35	8.43	47.13	1.58	15.39	25.86
4	Zinc @ 15 kg / ha + Boron 6 kg / ha	2.53	8.40	47.05	1.59	12.74	27.09
5	Zinc @ 15 kg / ha + Boron 7 kg / ha	2.49	8.61	46.73	1.72	13.01	24.57
6	Zinc @ 15 kg / ha + Boron 8 kg / ha	2.54	8.70	46.14	1.70	13.77	26.83
7	Zinc @ 20 kg / ha + Boron 6 kg / ha	2.37	9.87	51.74	2.16	13.91	29.86
8	Zinc @ 20 kg / ha + Boron 7 kg / ha	2.52	10.05	53.41	2.36	14.05	30.54
9	Zinc @ 20 kg / ha + Boron 8 kg / ha	2.86	10.32	55.78	2.56	14.32	32.30
10	Control	1.22	5.55	41.95	1.27	10.48	20.12
	F Test	S	S	S	S	S	S
	S.E.D. (±)	0.100	0.118	1.121	0.104	0.099	1.265
	CD (p = 0.05)	0.210	0.248	2.356	0.219	0.208	2.658

Weight of cob (without husk) (g)

Table 4 shows zinc and boron fertilizer on weight of cob (without husk). The data revealed that various treatments of the highest cob weight (g) without husk (10.32) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest Zinc @ 20 kg/ha + Boron 8 kg/ha (5.55) was found in treatment control. There was significant difference between different treatment combinations.

Weight of cob (with husk) (g)

Table 4 shows zinc and boron fertilizer on weight of cob (with husk). The data revealed that various treatments of the highest the highest cob weight (g) with husk (55.78) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest control (41.78) was found in treatment control. There was significant difference between different treatment combinations. From this study, it was inferred that combination of zinc and boron gives higher yield as they play major role in assimilation rate and metabolic activities in plant. The cob weight is primarily raised by a balanced supply of nutrients from fertilizers including zinc and boron throughout the time of grain filling and development Salomone and Dobereiner (2004) [16].

Cob yield without husk (t / ha)

The data on cob yield without husk (t / ha) as influenced by different zinc and boron fertilizer is tabulated in table 4. It is evident from this data the cob yield was significantly influenced by different zinc and boron fertilizers. The highest Cob yield (t / ha) without husk (2.56) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest Control (1.27) was found in treatment control. There was significant difference between different treatment combinations. Similar results were found with Shanmugam and Veeraputhran (2000) [18].

Cob yield with husk (t / ha)

The data on cob yield with husk (t / ha) as influenced by different zinc and boron fertilizer is tabulated in table 4. It is evident from this data the cob yield was significantly influenced by different zinc and boron fertilizers. The highest Cob yield (t / ha) with husk (14.32) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest Control (10.48) was found in treatment control. There was significant difference between different treatment combinations. This might be due to Zinc fertilization had significant effect on the grain yield of rice and highest grain yield was recorded with the application of zinc. Due to its favorable effect on metabolic pathways involved in cell division and elongation, B improves the growth properties (Hatwar *et al.*, 2003; Fageria *et al.*, 2004) [9, 26]. This may be because the production of straw rises when zinc sulphates is sprayed to the soil and taken up by plants (Cihatak *et al.*, 2005, Ullah *et al.*, 2001) [14, 27]. Higher zinc applications were closely associated to the crops vegetative and reproductive development stages. Similar results were obtained by Sarjamei *et al.* (2014) [17]; Bairagi *et al.* (2015) [1]; Dutta *et al.* (2015) [5].

Green fodder yield

The data on green fodder (t / ha) as influenced by different zinc and boron fertilizer istabulatedintable4.The highest green fodder yield of baby corn (32.30 t / ha) was observed in treatment Zinc @ 20 kg/ha + Boron 8 kg/ha, whereas the lowest Control (20.12) was found in treatment control. Similar results were found in Patil *et al*. (2018) [14] and Kumar *et al. (*2018) [11].

Conclusion

It has been determined that applying Zinc @ 20 kg/ha + Boron @ 8 kg/ha throughout the *rabi* season would result in the best yield of baby corn (Treatment 9) highest plant height (cm), plant dry weight (g / plant), crop growth rate (g / m^2 / day), relative growth rate (g / g / day), number of corn cobs per plant, cob weight (g) without husk, cob weight (g) with husk, cob yield (t / ha) without husk, cob yield (t / ha) with husk, and green fodder yield (t / ha) were all recorded. Additionally, the greatest gross return, net return, and benefit cost ratio have been documented. These techniques might be taught to farmers to help them increase their yields in this agro climatic region.

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