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Growth and yield of sweet corn (*Zea mays* L. saccharata) as influenced by zinc and boron

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Abstract

A field experiment was conducted during Kharif 2018 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.7), low in organic carbon (0.35%), available N (230 kg ha^{-1}), available P (20 kg ha^{-1}) and available K (189 kg ha^{-1}). The experiment consist of 4 levels of Zinc (0, 5, 10, 15 ha^{-1}) and Boron applied as foliar at (0.0%, 0.3%, 0.5% ha^{-1}).There were 12 treatments replicated thrice and lead out in a random block design. Application of 15 kg Zn ha ha^{-1} applied as Basel in combination with Boron at 5% recorded maximum no. of grains cob^{-1} (647.80), test weight (25.14)and green cob yield (5.94 t).Hence gross return (127956.00 INR), net return(71508.00 INR)and B:C ratio (1.26) was also recorded in the aforesaid treatment.

Keywords: Sweet corn, zinc and boron level

Introduction

Maize (*Zea mays*) is a C_4 plant and has high yielding potential. Besides human food and animal feed, this crop has its significance as a source of large number of industrial products like starch and oil. Maize grain contains about 10 % protein, 4 % oil, 70 % carbohydrate, 2.3 % crude fiber, % albuminoids, and 1-4 % ash. It also contains vitamin A, nicotine acid and riboflavin, vitamin E. Maize is important crop in the world grown in more than 150 countries having 600 million ha area with 600 million ton of production. The major maize producing countries are USA, China, Brazil, Mexico, France and India. USA has the largest area and production in the world. Italy having highest productivity in the world 9600 kg ha^{-1} followed by France with 8800 kg ha^{-1}. India stand is 5 positions in total area, fourth in total production and third in yield per hectare after USA China, Brazil and Mexico but with regards to production its rank eleventh. It is a widely grown cereal and is categorized as primary staple food in many developing countries. India contributes merely about 2.5 percent in world maize production. It is third most important cereal crop after rice and wheat and is being grown throughout the year but mainly as *kharif* crop. At present maize is being grown in most of the states of the country with annual grain production of 24.53 million tonnes and productivity 2583 kg ha^{-1}. The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in peri-urban areas. The predominant maize growing states that contributes more than 80 % of the total maize production are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %), Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. Hence, the maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 mt) and productivity (5.26 t ha^{-1}) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA. Whereas Uttar Pradesh contributed 1236 thousand tones in production with 1671 kg ha^{-1} productivity. Contributing nearly 8.0 percent in the nation food basket**.** Directorate of economics and statistics, Department of Agriculture and cooperation, Govt. of India) in Uttar Pradesh. The area, production and productivity of Maize are 0.78 million hectare, 1.19 million tones and 1504 kg ha^{-1}, respectively.

Special corn *viz*., sweet corn, popcorn, baby corn, high-oil corn *etc*. assume tremendous market potential not only in the international market but also in India. These corns with their high market value are perfectly suitable to *peri*-urban agriculture. Thus they promise higher income to maize growers. Out of the various special corns, sweet corn (*Zea mays* L. var. *saccharata*) has a big market potential. It is a hybridized variety of maize specifically bred to increase the sugar content. Sustainability of scientific sweet corn cultivation practices must be ensured to attain the goal of agricultural sustainability. Its consumption at immature stage as roasted and boiled ears is a popular practice as the kernels are sweet (12-20% sugar). After harvest green cobs, the plant of sweet corn are used green fresh or dry fodder and now a day's its cultivation is the first choice of the farmers. Maize is an exhaustive crop and requires high quantities of nitrogen and phosphorus. Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in India. Judicious use of fertilizers play an important role to boost up the productivity of maize, they alone can contribute 40-60 percent of the crop yield (Dayanand, 1998) [1].

Sweet corn is highly exhaustive crop, because of its high nutrient demand (Krishnaveni and Ramaswamy, 1985) [4]. Nitrogen being an important component of leaves in the form of chlorophyll and proteins, it plays a significant role in growth and development of corn plants and hence it required in large quantities (Marschner, 1986) [5]. It favorably influences growth parameters like plant height, leaf area duration and finally the yield. While phosphorous being a component of ATP and ADP it acts as energy currency, providing the energy required during photosynthesis and carbon assimilation. Potassium favors proper grain filling apart from its role in water retention potential.

Planting geometry is one of the major management aspects which are limiting the seed production of sweet corn. Though spacing requirement of common maize has been standardized, the information on influence of spacing on seed yield and seed quality in sweet corn is scanty. Optimum spacing would help in efficient harvesting of solar energy with least competition for growth factors (Olsen and Sander, 1988) [9].

Sweet corn is harvested at the green cob stage, much before the maturity of grain. The requirement of plant density, fertilizer levels and method of planting needs to be rescheduled for this crop. Effects of these factors on seed yield and quality of sweet corn are not known with advent of sweet corn agronomy. It can be a profitable crop for the farmers and seed industry, particularly for those residing in peri-urban areas.

Off late special corn such as baby corn and sweet corn has emerged as an alternative food source, especially for the affluent society. Sweet corn (*Zea mays* var. *rugosa)*, also called sugar corn or simply corn is a variety of maize with high sugar content. Sweet corn is the result of a naturally occurring recessive mutation in the genes which controls conversion of sugar to starch inside the endosperm of the corn kernel. Unlike field corn varieties, where in the cobs are harvested when the kernels are fully mature and dry, sweet corn is picked when it is still immature and consumed as a vegetable, rather than a grain. Sweet corn is gaining popularity both in rural and urban areas, because of its high sugar and low starch content. It has a high market value and great market potential in India and abroad. This promotes potential for sweet corn cultivation in India. Nutritional value per 100 g of sweet corn (seeds) is carbohydrates (19 g), Sugars (3.2 g), dietary fiber (2.7 g), fat (1.2 g), protein (3.2 g), Vitamin A (10 µg), Vitamin B9 (46 µg), vitamin C (7 mg), iron (0.5 mg), magnesium (37 mg) and potassium (270 mg). As regards to health benefits, cooked sweet corn has significant antioxidant activity, which can substantially reduce the chance of heart disease and cancer (USDA nutrient database). In addition to the various factors responsible for lower seed yield and inadequate quality of seeds, lack of balanced nutrition coupled with inadequate spacing and proper method of planting plays a major role in reducing the yields.

Among nutrient elements, Zinc and Boron plays a vital role besides nitrogen in plant nutrient that influences vigour of plant, root growth and improves the quality of crop yield. Boron is an essential factor for cell division because it is a constituent element of nucleoproteins which are involved in the cell reproduction processes. It is also a component of a chemical essential to the reactions of carbohydrate synthesis and degradation. It is important for seed and fruit formation and crop maturation. Zinc and Boron hastens the ripening of fruits thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging. It also affects the quality of the grains and it may increase the plant resistance to diseases.

Since the Zinc and Boron availability is usually low in the soils, the plants have developed special adaptations to acquire the same with the help of multiple high affinity transporters (Raghothama, 1999) [10]. The needs of a sweet corn crop for supplemental nutrient can vary greatly among field's seasons and crop growing conditions. Hence, there is need to evaluate sweet corn varieties under optimum phosphorus fertilization under prevailing agro climatic conditions. Keeping above point in view, the present experiment entitled "Growth and yield of sweet corn (*Zea mays* L. *saccharata)* as influence by Zinc and Boron" was under taken at Crop Research Farm of Naini Agricultural Institute, SHUATS during 2018-2019.

Materials and Methods

The experiment was conducted during the kharif season of 2018 at the Central Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj. The Crop Research Farm is situated at 250 57' N latitude, 870 19' E longitudes and at an altitude of 98 m above mean sea level. The soil of experimental plot was sandy loam in texture, neutral in soil reaction (pH 7.5), low in organic carbon (0.35%), available N (230 kg ha^{-1}), available P (20 kg ha^{-1}) and available K (189 kg ha^{-1}). The treatments comprised of 4 levels of zinc viz. Zn1 (0kg zinc ha^{-1}), Zn2 (5kg zinc ha^{-1}), Zn3 (10kg zinc ha^{-1}) and Zn4 (15kg zinc ha^{-1}) in combination with 3 levels of Boron as foliar B1 (0.0% at 30 DAS) B2(0.3% at 30 DAS) and B3(0.5% at 30DAS). There were 12 treatments each replicated thrice. The experiment was laid out in Randomized Block Design. Pre-harvest observation viz. Plant height, dry weight, Crop Growth Rate and Relative Growth Rate were recorded. Post- harvest observation viz. Cobs $plant^{-1}$, Cob length, Cob weight With husk, Cob weight Without husk, Grains row^{-1}, Grain rows cob^{-1}, Grains cob^{-1} and 100-Grain weight were recorded to find out the best treatment combination.

Results and Discussion

The result of the experiment entitled "Performance of sweet corn (*Zea mays* L. *saccharata*) under varying Zinc and Boron levels" was carried out during the *Kharif* season of 2018 at the Central Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences Prayagraj, to study the performance of sweet corn under varying levels of Zinc and Boron. The results of the investigation regarding the Growth and yield of sweet corn as influence by different levels of Zinc and Boron on growth and yield of sweet corn have been presented in tables and figures, wherever required. Maximum plant height (215.87cm), maximum Dry weight(84.57g), maximum CGR (4.088), maximum RGR (0.013), cob length(25.81cm), cob weight with husk (369.93g), cob weight without husk (270.27g), Average grains row^{-1} (16), Average grain cob^{-1} (647..80), 100-Grain weight (25.14), green cob yield (5.94 t) and grwwn fodder yield (13.73 t) was recorded in treatment no. 12 (15kg zinc ha^{-1}+boron 0.5%).

Under present investigation the better performance of Sweet Corn seems to be on account of higher uptake of Zinc and Boron and its reallocation in grain and plant. The higher availability of Zinc and Boron seems to have promoted development of morphological structure by virtue of multiplication of cell division which is well reflected through increased crop growth rate (Kumar, 2008) [2].

Table 1: Effect of different of Zinc and Boron levels on growth attributes of Sweet corn

	At 60	**DAS**	**At 40-**	**60 DAS**
Treatment	**Plant Height (cm)**	**Dry weight (g plant^{-1})**	**CGR (g m^{-2} day^{-1})**	**RGR (g g^{-1} day^{-1})**
1. 0kg zinc ha^{-1} +boron0.0% at 30 DAS	168.07	30.80	1.173	0.031
2. 5kg zinc ha^{-1} +boron 0.0% at 30 DAS	174.60	31.90	0.789	0.018
3. 10kg zinc ha^{-1} +boron0.0% at 30 DAS	177.40	37.67	1.021	0.020
4. 15 kg zinc ha^{-1} +boron0.0% at 30 DAS	182.47	43.13	1.252	0.022
5. 0kg zinc ha^{-1} +boron 0.3% at 30 DAS	185.60	51.13	1.714	0.027
6. 5kg zinc ha^{-1} +boron 0.3% at 30 DAS	188.27	53.33	1.762	0.025
7. 10kg zinc ha^{-1} +boron0.3% at 30 DAS	191.00	57.33	1.898	0.026
8. 15 kg zinc ha^{-1} +boron 0.3% at 30 DAS	193.60	64.03	2.212	0.028
9. 0kg zinc ha^{-1} +boron 0.5% at 30 DAS	199.13	67.47	2.4	0.023
10. 5kg zinc ha^{-1} +boron 0.5% at 30 DS	207.97	69.90	2.098	0.018
11. 10kg zinc ha^{-1} +boron 0.5% at 30DAS	209.93	76.80	3.136	0.018
12. 15kg zinc ha^{-1} +boron 0.5% at 30DAS	215.87	84.57	4.088	0.017
S.E.m$\pm$	2.71	4.82	-----	-----
CD.(p=0.05)	7.96	9.44	-----	-----

Table 2: Effect of different zinc and Boron levels on Yield Attributes of Sweet corn

Treatment	**Number of cobs plant^{-1} (no.)**	**Cob length (cm)**	**Cob Weight With Husk (g plant^{-1})**	**Cob Weight Without Husk (g plant^{-1})**
1. 0kg zinc ha^{-1} +boron0.0% at 30 DAS	1.00	19.22	213.57	156.37
2. 5kg zinc ha^{-1} +boron 0.0% at 30 DAS	1.00	20.50	220.90	161.70
3. 10kg zinc ha^{-1} +boron0.0% at 30 DAS	1.00	20.50	228.47	166.13
4. 15 kg zinc ha^{-1} +boron0.0% at 30 DAS	1.00	20.92	233.03	172.07
5. 0kg zinc ha^{-1} +boron 0.3% at 30 DAS	1.00	21.35	250.93	181.03
6. 5kg zinc ha^{-1} +boron 0.3% at 30 DAS	1.00	21.53	255.03	191.47
7. 10kg zinc ha^{-1} +boron0.3% at 30 DAS	1.00	22.12	266.50	197.13
8. 15 kg zinc ha^{-1} +boron 0.3% at 30 DAS	1.00	22.57	281.37	210.93
9. 0kg zinc ha^{-1} +boron 0.5% at 30 DAS	1.00	22.91	298.43	218.47
10. 5kg zinc ha^{-1} +boron 0.5% at 30 DS	1.00	23.28	321.33	234.37
11. 10kg zinc ha^{-1} +boron 0.5% at 30DAS	1.00	24.79	350.27	256.27
12. 15kg zinc ha^{-1} +boron 0.5% at 30DAS	1.00	25.81	369.93	270.27
S.E.m$\pm$	0.10	0.39	6.94	5.23
CD.(p=0.05)	0.28	1.16	20.35	15.33
F-test	NS	S	S	S

Table 3: Effect of different zinc and Boron levels on Yield Attributes of Sweet corn

Treatment	**Grains row cob^{-1}(No.)**	**Grains cob^{-1} (No.)**	**100- Grain weight (g)**	**Green cob yield (t / ha^{-1})**	**Green fodder Yield (t/ha)**
1. 0kg zinc ha^{-1} +boron0.0% at 30 DAS	14.89	556.17	21.20	5.21	12.02
2. 5kg zinc ha^{-1} +boron 0.0% at 30 DAS	15.22	573.83	21.93	5.27	12.12
3. 10kg zinc ha^{-1} +boron0.0% at 30 DAS	15.33	582.83	22.47	5.38	12.29
4. 15 kg zinc ha^{-1} +boron0.0% at 30 DAS	15.44	588.80	22.67	5.47	12.46
5. 0kg zinc ha^{-1} +boron 0.3% at 30 DAS	15.56	601.50	23.20	5.57	12.55
6. 5kg zinc ha^{-1} +boron 0.3% at 30 DAS	15.56	612.37	23.41	5.67	12.68
7. 10kg zinc ha^{-1} +boron0.3% at 30 DAS	15.78	621.00	23.62	5.74	12.84
8. 15 kg zinc ha^{-1} +boron 0.3% at 30 DAS	16	627.13	23.77	5.84	13.06
9. 0kg zinc ha^{-1} +boron 0.5% at 30 DAS	16	631.37	23.93	58.6	13.18
10. 5kg zinc ha^{-1} +boron 0.5% at 30 DS	16	635.00	24.06	5.86	13.37
11. 10kg zinc ha^{-1} +boron 0.5% at 30DAS	16	639.47	24.89	5.89	13.67
12. 15kg zinc ha^{-1} +boron 0.5% at 30DAS	16	647.80	25.14	5.94	13.73
S.E.m$\pm$	0.09	3.30	0.19	0.17	0.22
CD.(p=0.05)	0.25	9.68	0.57	0.48	0.65
F-test	S	S	S	S	S

Table 4: Effect of different levels of zinc and boron on economics of sweet corn

Treatment	Cost of cultivation (INR)	Gross Return (INR)	Net Return (INR)	B : C Ratio
1. 0kg zinc ha^{-1} +boron0.0% at 30 DAS	53935.00	116100.00	62165.00	1.15
2. 5kg zinc ha^{-1} +boron 0.0% at 30 DAS	54310.00	116566.00	62256.00	1.14
3. 10kg zinc ha^{-1} +boron0.0% at 30 DAS	54680.00	117394.00	62714.00	1.14
4. 15 kg zinc ha^{-1} +boron0.0% at 30 DAS	55060.00	118582.00	63522.00	1.15
5. 0kg zinc ha^{-1} +boron 0.3% at 30 DAS	54768.00	119684.00	64916.00	1.18
6. 5kg zinc ha^{-1} +boron 0.3% at 30 DAS	55143.00	120533.00	65930.00	1.19
7. 10kg zinc ha^{-1} +boron0.3% at 30 DAS	55518.00	122374.00	66856.00	1.20
8. 15 kg zinc ha^{-1} +boron 0.3% at 30 DAS	55893.00	123384.00	67491.00	1.20
9. 0kg zinc ha^{-1} +boron 0.5% at 30 DAS	55323.00	124184.00	68861.00	1.24
10. 5kg zinc ha^{-1} +boron 0.5% at 30 DS	55698.00	125190.00	69492.00	1.24
11. 10kg zinc ha^{-1} +boron 0.5% at 30DAS	56073.00	127032.00	70959.00	1.25
12. 15kg zinc ha^{-1} +boron 0.5% at 30DAS	56448.00	127956.00	71508.00	1.26

Summary and Conclusion

Summary

- Application of 15kg ha^{-1} Zinc as basel in combination with Boron at 0.5% at 30DAS recorded maximum plant dry weight, higher crop growth rate and relative crop growth rate in sweet corn. Also, maximum cob length, cob weight, more no. of cobs/plant, seed index, green cob yield and green fodder yield was also recorded in the aforesaid treatment.
- The same treatment also recorded highest gross return, net return and benefit cost ratio.

Conclusion

Application of 15kg ha^{-1} Zinc as Basel in combination with Boron at 0.5% at 30DAS recorded maximum growth in plant, higher yield attributes namely more no. of grains/cob (647.8), maximum seed index (25.14), higher cob yield (5.94t) and also maximum B:C ratio (1.26).

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