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Impact of Plant Geometry and Zinc on Growth and Yield Attributes of Sweet Corn (*Zea mays L.*)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

During Zaid 2021, a field experiment was undertaken at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The experiment was set up using a Randomized Block Design, with nine treatments reproduced three times over the course of a year. The treatments which are T_1: 40cm x 20 cm + 15 kg/ha $ZnSO_4$, T_2: 40cm x 20 cm + 20 kg/ha $ZnSO_4$, T_3: 40cm x 20 cm + 25 kg/ha $ZnSO_4$, T_4: 50cm x 20 cm + 15 kg/ha $ZnSO_4$, T_5: 50cm x 20 cm + 20 kg/ha $ZnSO_4$, T_6: 50cm x 20 cm + 25 kg/ha $ZnSO_4$, T_7: 60cm x 20 cm + 15 kg/ha $ZnSO_4$, T_8: 60cm x 20 cm + 20 kg/ha $ZnSO_4$, T_9: 60cm x 20 cm + 25 kg/ha $ZnSO_4$ used. The results showed that application of 60cm x 20 cm + 25 kg/ha $ZnSO_4$ recorded significantly highest plant height (166.02 cm), Number of leaves/plant (12.25), Dry weight/plant (141.58 g/plant), number of cobs/plant (1.76), length of the cob/plant (16.90 cm), Cob girth (15.46 cm) whereas maximum crop growth rate (48.65 g/m^2/day) was recorded with treatment 40cm x 20 cm + 25 kg/ha $ZnSO_4$ whereas, cob yield (6.45 t/ha) and Green fodder yield (20.55 t/ha) recorded maximum in 40cm x 20 cm + 25 kg/ha $ZnSO_4$..The treatment with 40 x 20 cm spacing and application of 25 kg of zinc is advised for recommendation, as it is recorded maximum cob yield, green fodder yield, and benefit cost ratio in treatment T_3.

Keywords: Plant geometry; zinc; growth; yield; sweet corn.

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1. INTRODUCTION

Maize, a Poaceae family member, is an important cereal food grain crop grown in over 166 countries with tropical, sub-tropical, and temperate climates. Maize is the only cereal on the planet with such a high yield potential, earning it the title of "Queen of Cereals." Sweet corn (Zea mays saccharata) is a vegetable that can be grown successfully. "sweet corn" is frequently used in the food sector. It's a new economic maize cultivar with more sugar content in the green cobs (14-20%).

In plant metabolism, zinc (Zn) affects hydrogenase and carbonic anhydrase activities, as well as the stabilization of ribosomal proteins [1]. Among crops, maize has the highest sensitivity to Zn deficiency. Zinc activates plant enzymes through protecting cellular membrane integrity, protein synthesis, and auxin production regulation via glucose metabolism [2]. Photosynthesis, reactive oxygen species defence, nitrogen metabolism, carbonic anhydrase activity, chlorophyll synthesis, and tolerance to biotic and abiotic stresses are all affected by zinc [3]. Zinc deficiency in maize is known as 'white bud'.

There is an ideal plant population for maximum economic output for all agricultural species, which varies by cultivar and habitat [4]. One of the most significant aspects for higher production is optimal plant population, which allows for optimum use of subsurface resources and maximum solar radiation harvesting, which leads to improved photosynthesis [5]. Plant density increases yield for a corn genotype farmed under specific environmental and management conditions up to a point, then decreases as plant density is increases further [6]. Objectives**-** 1. To study the influence of spacing and different levels of zinc on growth and yield of sweet corn. 2. To workout the economics of different treatment combinations.

2. MATERIALS AND METHODS

S. No	Treatments Combinations
1	40cm x 20 cm + 15 kg/ha $ZnSO_4$
2	40cm x 20 cm + 20 kg/ha $ZnSO_4$
3	40cm x 20 cm + 25 kg/ha $ZnSO_4$
4	50cm x 20 cm + 15 kg/ha $ZnSO_4$
5	50cm x 20 cm + 20 kg/ha $ZnSO_4$
6	50cm x 20 cm + 25 kg/ha $ZnSO_4$
7	60cm x 20 cm + 15 kg/ha $ZnSO_4$
8	60cm x 20 cm + 20 kg/ha $ZnSO_4$
9	60cm x 20 cm + 25 kg/ha $ZnSO_4$

This experimental trial was carried out at the Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), Prayagraj (U. P), which is located at 25^0 39" 42" North latitude, 81^0 67" 56" East longitude, and 98 metres above mean sea level during Zaid 2021. The experiment was set up in a Randomized Block Design with nine different treatments replicated three times to give a total of 27 plots *viz.*

To determine the impact of plant geometry and zinc on growth and yield attributes of sweet corn. The trial plot's soil was sandy loam in texture, pH (7.1), low in organic carbon (0.72 percent), available N (278.48 kg/ha), and medium in available P and K (27.80 kg/ha and 233.24 kg/ha, respectively). The research plot used urea, DAP, and MOP as nutrient sources to meet the nitrogen, phosphorous, and potassium requirements.120 kg N, 60 kg P2O5, and 40 kg K2O/ha is the recommended dose. Zinc was given in the form of $ZnSO_4$ and according to the treatment protocol. Many plant growth variables were recorded at equal intervals from germination until harvest, and yield metrics like cobs/plant, cob length/plant (cm), the girth of cob (cm), cob yield (t/ha), and green fodder yield (t/ha) were recorded after harvest. Plant height (cm), the number of leaves/plant, and dry weight (g/plant) were measured as growth parameters. In contrast, yield parameters like cobs/plant, cob length/plant (cm), the girth of cob (cm), cob yield (t/ha), and green fodder yield (t/ha) were measured and statistically analysed using analysis of variance (ANOVA) as applied to Randomized Block Design (Gomez, K. A. and Gomez, A. A. 1984). RBD Anova software is used to analyze the results.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters of Sweet Corn

3.1.1 Plant height

Significantly higher plant height (166.02 cm) was observed in the treatment with 60cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the other treatments. However, the treatments with application of 50cm x 20 cm + 25 kg/ha $ZnSO_4$ (164.47 cm) and 60cm x 20 cm + 20 kg/ha $ZnSO_4$ (165.11 cm) which were found to be at par with treatment 60cm x 20 cm + 25 kg/ha $ZnSO_4$ as compared to all the treatments.

Table 1. Impact of Plant geometry and Zinc on Growth parameters of Sweet corn

	Treatment	Plant height (cm)	Number of leaves/plant	Dry weight (g/plant)
1	40cm x 20 cm + 15 kg/ha $ZnSO_4$	159.60	11.63	136.83
2	40cm x 20 cm + 20 kg/ha $ZnSO_4$	160.38	11.72	137.31
3	40cm x 20 cm + 25 kg/ha $ZnSO_4$	162.60	11.85	138.38
4	50cm x 20 cm + 15 kg/ha $ZnSO_4$	161.45	11.79	137.77
5	50cm x 20 cm + 20 kg/ha $ZnSO_4$	163.30	11.98	139.11
6	50cm x 20 cm + 25 kg/ha $ZnSO_4$	164.47	12.07	140.20
7	60cm x 20 cm + 15 kg/ha $ZnSO_4$	162.85	11.91	138.92
8	60cm x 20 cm + 20 kg/ha $ZnSO_4$	165.11	12.14	141.00
9	60cm x 20 cm + 25 kg/ha $ZnSO_4$	166.02	12.25	141.58
S. Em (±)		0.53	0.09	0.54
CD (p=0.05)		1.62	0.27	1.56

Table 2. Impact of Plant geometry and Zinc on Yield parameters and Yield of Sweet corn

Treatments		No. of Cobs/Plant	Cob Length/Plant (cm)	Cob Girth/ Plant (Cm)	Cob yield(t/ha)	Green fodder yield (t/ha)
1.	40cm x 20 cm + 15 kg/ha $ZnSO_4$	1.31	15.37	14.48	5.54	20.02
2.	40cm x 20 cm + 20 kg/ha $ZnSO_4$	1.40	15.60	14.65	6.26	20.49
3.	40cm x 20 cm + 25 kg/ha $ZnSO_4$	1.51	16.00	14.83	6.45	20.55
4.	50cm x 20 cm + 15 kg/ha $ZnSO_4$	1.45	15.83	14.75	4.76	19.77
5.	50cm x 20 cm + 20 kg/ha $ZnSO_4$	1.61	16.30	15.00	5.83	20.26
6.	50cm x 20 cm + 25 kg/ha $ZnSO_4$	1.68	16.57	15.16	6.07	20.35
7.	60cm x 20 cm + 15 kg/ha $ZnSO_4$	1.55	16.13	14.94	4.16	19.57
8.	60cm x 20 cm + 20 kg/ha $ZnSO_4$	1.73	16.73	15.27	4.53	19.68
9.	60cm x 20 cm + 25 kg/ha $ZnSO_4$	1.76	16.90	15.46	5.22	19.94
S. Em (±)		0.03	0.15	0.11	0.13	0.07
CD (P = 0.05)		0.10	0.45	0.32	0.40	0.22

Plant height was reduced when row spacing was reduced from 60 cm to 40 cm, owing to increased competition within the plants in closer spacing versus wider spacing. With low and medium row spacing, competition for space, light, nutrients, and moisture inside the intra-row plants was at its peak, resulting in a fall in stem girth thickness. Natural shadowing due to overcrowding of plants appears to have lowered the availability of light within the crop canopy and prevented elongation of lower internodes, resulting in a considerable drop in plant growth with decreasing row spacing. The findings were very similar to Neupane et al*.* [7]. The involvement of micronutrients in several physiological processes such as enzyme activation, electron transport, chlorophyll production, stomatal regulation, and others could explain the increase in plant height. Plant height increased as zinc levels increased, which could be due to enhanced photosynthetic activity and chlorophyll production resulting from zinc fertilization, resulting in improved vegetative development. According to Arab et al., the outcomes were as expected [8].

3.1.2 No. of leaves/plant

The highest Number of leaves per plant (12.25) was observed in the treatment with the application of 60cm x 20 cm + 25 kg/ha $ZnSO_4$, which was significantly higher than the other treatments. However, the treatments with 50cm x 20 cm + 25 kg/ha $ZnSO_4$ (12.07) and 60cm x 20 cm + 20 kg/ha $ZnSO_4$ (12.14) which were found to be statistically at par with 60cm x 20 cm + 25 kg/ha $ZnSO_4$. The number of leaves increased as zinc levels climbed and dropped as zinc levels fell. Increased cell division, absorption rate, and metabolic activities in the plant could explain the larger number of functioning leaves under higher fertilizer levels. The current findings are in line with Tariq et al*.* [9].

3.1.3 Plant dry weight (g/plant)

Treatment with 60cm x 20 cm + 25 kg/ha $ZnSO_4$ was recorded with a significantly maximum dry weight (141.58 g/plant) over all the treatments. However, the treatments with 60cm x 20 cm + 20 kg/ha $ZnSO_4$ (141.00 g/plant) and 50cm x 20 cm + 25 kg/ha $ZnSO_4$ (140.20 g/plant) which were found to be statistically at par with 60cm x 20 cm + 25 kg/ha $ZnSO_4$. Dry matter accumulation increased from 20 to 80 DAS due to the availability of higher sunshine and CO_2 under spacing of 60 x 20 cm might have resulted in higher photosynthetic productivity than 50 x 20 and 40 x 20 cm spacing. This was evident from more dry matter accumulation under 60 x 20 cm spacing followed by 50 x 20, 40 x 20 cm spacing. Similar results were reported by Sumeria et al*.* [10]. The highest biomass increase was observed because of increasing levels of zinc. Although the application of zinc as a basal dose to sweet corn increased its dry matter significantly, Long plant height, high stem girth, and high root weights result in a high dry matter under those treatments. Palai et al*.* [11].

3.2 Impact on Yield Parameters of Sweet Corn

Significantly Maximum Number of cobs/plant (1.76) was recorded with the treatment of 60cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the treatments. However, the treatments 50cm x 20 cm + 25 kg/ha $ZnSO_4$ (1.68) and 60cm x 20 cm + 20 kg/ha $ZnSO_4$ (1.73) were found to be statistically at par with 60cm x 20 cm + 25 kg/ha $ZnSO_4$. Zinc influences the activity of growth enzymes, glucose metabolism, cellular membrane integrity, protein synthesis, and regulation of auxin synthesis and pollen development, all of which contribute to a higher number of cobs. The findings were found to be similar to Anjum et al*.* [12].

Significantly highest length of cob/plant (16.90 cm) was recorded with the treatment 60cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the treatments. However, the treatments 50cm x 20 cm + 25 kg/ha $ZnSO_4$ (16.57 cm) and 60cm x 20 cm + 20 kg/ha $ZnSO_4$ (16.73 cm) were found to be statistically at par with 60cm x 20 cm + 25 kg/ha $ZnSO_4$. The highest Girth of the Cob (15.46 g) was recorded with the treatment application of 60cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the treatments. However, the treatments with (15.16 g) in 50cm x 20 cm + 25 kg/ha $ZnSO_4$ and (15.27 g) in 60cm x 20 cm + 20 kg/ha $ZnSO_4$ which were found to be statistically at par with 60cm x 20 cm + 25 kg/ha $ZnSO_4$. The formation of photosynthates and their transfer to the sink require the availability of mineral nutrients, which has boosted zinc uptake. Soil application of zinc had an apparent positive effect on photosynthetic activity, metabolite and growth-regulating substance synthesis, oxidation and metabolic activities, and found to be a better crop growth and development, which led to increase in yield attributes. These results are similar to those of Arab et al. [8] and Naik et al. [13].

Significantly maximum cob yield (6.45 t/ha) was recorded with the treatment application of 40cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the treatments. However, the treatments with (6.26 t/ha) in 40cm x 20 cm + 20 kg/ha $ZnSO_4$ and (6.07 t/ha) in 50cm x 20 cm + 25 kg/ha $ZnSO_4$ which were found to be statistically at par with and 40cm x 20 cm + 25 kg/ha $ZnSO_4$. Less intra row spacing increases competition in solar radiation, which inhibits the growth of some intra row plants in the vegetative phase and prevents them from reaching the reproductive phase, resulting in increased seed output under 40 x 20 cm compared to other treatments. Although the yield influencing variables were higher than suggested spacing, productivity was poor due to the reduced plant population reaching the reproductive phase. Ariraman et al. findings.'s were confirmed [14]. Zinc supplementation to sweet corn crops promotes fruit growth by promoting the synthesis of tryptophan and auxin. The enhancing effect on cobs/plants and their length and weight was linked to the beneficial effect of Zn treatment on crops on nutrient metabolism, biological activity, and growth parameters. As a result, zinc application resulted in taller and more active enzymes, stimulating more cobs and increased cob production. Similar findings were reported earlier by Naik et al. [13].

Significantly higher Green fodder yield (20.55 t/ha) was recorded with the treatment application of 40cm x 20 cm + 25 kg/ha $ZnSO_4$ over all the treatments. However, the treatments with (20.49 t/ha) in 40cm x 20 cm + 20 kg/ha $ZnSO_4$ and (20.35 t/ha) in 50cm x 20 cm + 25 kg/ha $ZnSO_4$ which were found to be statistically at par with and 40cm x 20 cm + 25 kg/ha $ZnSO_4$. Zinc is involved in various physiological processes in plants, including chlorophyll production, stomatal control, starch utilization, and biomass buildup, contributing to increased green fodder supply. Zinc also contributes to crop yield by converting ammonia to nitrate. Tamil Amutham et al. have reported similar findings [15].

4. CONCLUSION

Based on the research done in one season, it may be concluded that treatment (T3) 40cm x 20 cm + 25 kg/ha $ZnSO_4$ performed exceptionally in obtaining a higher cob yield, green fodder yield, and benefit cost ratio of sweet corn. Hence, 40cm x 20 cm + 25 kg/ha $ZnSO_4$ is beneficial under U.P Conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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