Original Research Article

Influence of Spacing and Zinc Application on Growth and Productivity of Baby Corn (*Zea mays* L.)

Abstract

The present trial was undertaken at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh during the 2021 summer season (*Zaid)*. The test was a Randomized Block Design having three replicates. A total of nine treatments were designed with different levels of spacing and quantity of zinc application. The cultivation land was uniform with sandy loam soil with pH neutral. The soil had low level of organic carbon (0.72%), medium level of available nitrogen (278.28 kg ha^{-1}) and potassium (233.24 kg ha^{-1}) and higher level of phosphorus (27.80 kg ha^{-1}). Amongst all the treatments, T_9 having 60 X 20 cm spacing and 25 kg/ha $ZnSO_4$ had the maximum plant height (168.13 cm), number of leaves per plant (13.25), dry plant mass (90.96 g/plant), number of cobs per plant (2.37), length of the cob per plant (18.77 cm), cob weight with husk (47.92 g), cob weight without husk (22.70 g). Further, the maximum crop growth rate (30.45 g/m^2/day), cob yield with husk (14.63 t/ha), cob yield without husk (5.09 t/ha) and green fodder yield (28.83 t/ha) was observed for T_3 having 40 ~~X~~ x 20 cm spacing and 20 kg/ha $ZnSO_4$.

Keywords: Baby Corn, Zinc Application, Productivity, Spacing

1. Introduction

Baby corn has become one of the most sought-after crops at the global level with great processing and export possibilities. Known by different names such as young corn, mini corn or candle corn, baby corn is maize (*Zea mays* L.) cob or ears harvested early from the female flower without any fertilization while the stalks are undeveloped. At present. China and Thailand are the leading producers and its widespread used has increased in India (**Singh *et al*., 2015**) as well since it can be grown at any point in the year and marketable as a vegetable crop (**Dass *et al*., 2008**). Different regions of Meghalaya, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Haryana are the major players in the production of baby corn (**Rani *et al*., 2017**).

Based on the endosperm of grain, maize is defined into eight groups of which baby corn is utilized for vegetable purposes. It is the immature maize cob or ear harvested before the pollination of the flower or when there is surfacing of the baby corn ~~silk..~~silk. For better marketability, yellow-coloured cobs with row array being regular having 10-12 cm spacing and 1-1.5 cm broadness is preferential. Globally, this crop is harvested in Thailand, Taiwan, Sri Lanka, Myanmar, Guatemala and South Africa. In India, for a growth area of 8.49 m per hectare, the production and yield rate are 21.28 m per tonnes and 2507 kg per hectare respectively. Diversification to this high-value crop is beneficial to the Indian farmers due to low financial risk and economic wellbeing (~~(~~**Pandey *et al.*, 2002).**

The metabolic reactions in plants are driven by an important mineral, Zinc. Zinc deficiency results in poor production of chlorophyll, carbohydrates, proteins, auxins and hindrance in growth and development of maize **(Marschner, 1995)**. It has an indispensable part in regulation of RNA and DNA structure and certain enzymes such as hydrogenase and carbonic anhydrase **(Tisdale *et al*., 1995 or 1984??)**.

The plant yield is affected based on the density population since optimum spacing promotes resourceful usage of resources such as water, soil, nutrients and sunlight **(Monneveux et al., 2005)**. Optimal growth is obtained through ideal spacing though the productivity results vary depending on cultivar and environment **(Bruns and Abbas, 2005).** Plants in closed spacing results in overcrowding and poor yield and plant growth (**Gozobenli et al., 2004)**.

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2. Materials and Methods

The present trial was undertaken using Super Goldy variety at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh (25.57°N, 87.19°E, 98 m) during the 2021 summer season (*Zaid)*. The test was a Randomized Block Design having three replicates. Different levels of spacing and quantity of zinc application were set and nine treatment were obtained- T_1: 15 kg/ha $ZnSO_4$ + 40 cm x 20 cm, T_2: 20 kg/ha $ZnSO_4$ + 40 cm x 20 cm, T_3: 25 kg/ha $ZnSO_4$ + 40 cm x 20 cm, T_4: 15 kg/ha $ZnSO_4$ + 50 cm x 20 cm, T_5: 20 kg/ha $ZnSO_4$ + 50 cm x 20 cm, T_6: 25 kg/ha $ZnSO_4$ + 50 cm x 20 cm, T_7: 15 kg/ha $ZnSO_4$ + 60 cm x 20 cm, T_8: 20 kg/ha $ZnSO_4$ + 60 cm x 20 cm, T_9: 25 kg/ha $ZnSO_4$ + 60 cm x 20 cm.

The cultivation land was uniform with sandy loam soil with pH neutral. The soil had low level of organic carbon (0.72%), medium level of available nitrogen (278.28 kg ha^{-1}) and potassium (233.24 kg ha^{-1}) and higher level of phosphorus (27.80 kg ha^{-1}). The fertilizers used included urea, DAP and MOP at basal level during sowing. The data was recorded for the following growth parameters during harvesting: plant height, number of leaves and dry plant mass. The yield parameters included: number of cobs per plant, cob length (cm), cob mass, green cob productivity (t/ha), green fodder yield (t/ha). The collected data was subjected to analysis of variance (ANOVA) using --- (Gomez K.A. and Gomez A.A. 1984).

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3. Results and Discussion

3.1 Growth attributes

3.1.1. Plant Height

Amongst all the treatments, the maximum height was observed for T_9 (168.13 cm) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (167.57 cm) and T_6, (167.13 cm) showed comparable results to T_9. Wider spacing resulted in better plant height as there was less competition for nutrients, water and sunlight whereas closed spacing leads to decrease in stem circumference. Overcrowding brings out less light to the plant population and the lower internodes have restricted extension. The present results are in line with that of **Neupane *et al.* (2011).** Along with spacing, application of zinc was directly proportional to plant's height. Increase in zinc promotes photosynthesis and formation of chlorophyll and carbohydrates; regulation of stomata and enzyme activities. These results are akin to **Arab *et al.* (2018).**

3.1.2. Number of Leaves per Plant

Amongst all the treatments, the maximum number of leaves per plant was observed for T_9 (13.25) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (13.15) and T_6, (13.07) showed comparable results to T_9. The amount of zinc was directly proportional to the number of leaves per plant. With increment in applied ~~zinc, there~~zinc, there is promotion in growth and development hormone auxin, cell division and plant metabolism. The current results are in accordance to that of **Tariq *et al.* (2014).**

3.1.3. Dry Plant Mass (g/plant)

Amongst all the treatments, the highest dry plant mass was observed for T_9 (90.96 g/plant) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (90.81 g/plant) and T_6, (90.46 g/plant) showed comparable results to T_9. Smaller spacing results in reduced photosynthesis due to poor sunlight and CO_2 level whereas wider spacing improves the dry matter accumulation from 20 to 80 DAS. These results are related to that of **Sumeria *et al.* (2007).** The quantity of zinc applied also had positive effect on the biomass of the plant. The higher quantity of zinc applied inflated the dry plant mass as well. In addition to this, other growth attributes such as plant height, stem girth and weight of roots affected the dry plant mass (**Palai *et al.* 2018)**.

3.2. Yield Attributes

3.2.1 Number of Cobs per Plant

Amongst all the treatments, the maximum number of cobs per plant was observed for T_9 (2.37) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (2.34) and T_6, (2.17) showed comparable results to T_9. These findings are in accordance to **Anjum *et al.* (2017)** where it was stated that zinc plays a vital role in regulation of growth hormones such as auxin, promotes synthesis of carbohydrates, protein as well as pollen which in turn results in higher number of cobs.

3.2.2. Length of Cob per Plant (cm)

Amongst all the treatments, the maximum cob's length was observed for T_9 with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 and T_6, showed comparable results to T_9.

3.2.3. Cob weight (g)

3.2.3.1 With husk

Amongst all the treatments, the highest weigh of cob (with husk) was observed for T_9 (47.92 g) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (47.43 g) and T_6, (46.87 g) showed comparable results to T_9.

3.2.3.2 Without husk

Amongst all the treatments, the highest weigh of cob (without husk) was observed for T_9 (22.70 g) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (22.20 g) and T_6, (21.72 g) showed comparable results to T_9.

The yield and its attributes are the sum of both the photosynthates as well as their translocation from source to their sink and this is affected by the presence of minerals. Minerals aid in production of enzymes and co-enzymes which in turn have an influence on photosynthetic pathways. One such mineral, Zinc, promotes synthesis of chlorophyll, metabolites, growth-related hormones such as auxin. Zinc is having a productive role over photosynthesis and other metabolic activities elevating growth and development of plant and thus, more yield. The results of our present findings are in accordance to those ~~of **Arab**~~of Arab ***et al.* (2018)** and **Naik *et al.* (2020).**

3.2.4. Cob yield (t/ha)

3.2.4.1. With husk

Amongst all the treatments, the maximum cob yield (with husk) was observed for T_9 (14.63 t/ha) with 25 kg/ha zinc application and 60 X 20 cm spacing. Two treatments, T_8 (14.24 t/ha) and T_6, (13.67 t/ha) showed comparable results to T_9.

3.2.4.2 Without husk

Amongst all the treatments, the maximum cob yield (without husk) was observed for T_3 (5.09 t/ha) with 25 kg/ha zinc application and 40 X 20 cm spacing. Another treatment, T_2 (4.77 t/ha) showed comparable results to T_3.

The amount of spacing contributes towards competition of nutrients, light and moisture amongst the plant crops. Lowering the plant density has a positive effect on the yield of seeds. With more competitiveness, reduced sunlight hinders the growth at vegetative phase and ultimately the reproductive stage is not achieved which results in low yield. As concluded by **Ariraman *et al.* (2021)** the reduced yield could be because lesser plants achieved reproductive phase.

Along with spacing, zinc application influenced the yield of seed as well. Zinc directly effects the synthesis of tryptophan and auxin which sequentially impacts the seed yield and its attributes such as cobs per plant, length and weight of seeds. Additionally, zinc contributes towards nutrient metabolism, biological activity and growth and development since enzyme activity is improved as well. This results in more cob yield. Similar findings were noticed by **Naik *et al.* (2020).**

3.2.5. Green fodder yield (t/ha)

Amongst all the treatments, the highest green fodder yield was observed for T_3 (28.33 t/ha) with 25 kg/ha zinc application and 40 X 20 cm spacing. Two treatments, T_2 (27.87 t/ha) and T_6, (27.50 t/ha) showed comparable results to T_3.

Zinc has an important role in plant growth and metabolism. It has a positive effect on physiological processes such as synthesis of chlorophyll, carbohydrates and protein as well as forms a vital part in gas exchange through stomata, plant biomass accumulation and starch utilization. The conversion of ammonia to nitrate is regulated via zinc as well. Parellel ???findings have been noted by **Tamil Amutham *et al.* (2018).**

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Various researchers have reported that the concentration of total Zn in soils is around 55 mg.kg-1 (ppm), where the typical range ranges from 10 to 300 ppm (Olivares et al. 2020; Olivares, 2022). This total content is distributed in three fractions. These are: soluble Zn (present in the soil solution); exchangeable Zn (adsorbed to colloids); and fixed Zn (Castillo-González et al. 2018). An inadequate supply of zinc can result in a significant decrease in crop yield and quality (Olivares, 2016; Olivares et al. 2022). Of the three fractions, only the one that is in soil solution and the one that can be easily desorbed is available to plants (4 to 270 $\mu g.L^{-1}$), but it is also easily leached as it happens in tropical soils with high rainfall. (Olivares and Hernández, 2019a).

The soil factors that affect the availability of Zn in the roots are: high level of carbonates (CaCO3) (Olivares et al. 2021a), high pH, clay soils, low content of organic matter, low soil moisture and high levels of Fe and Al oxides (Olivares et al. 2021b). The high contents of phosphorus and low contents of Zn cause a severe deficiency of the latter. The efficiency of crops in transforming solar energy into chemical energy is a function of various factors, among which planting distances (Bertorelli and Olivares, 2020), plant populations and genotypes are of fundamental importance (Olivares and Hernández, 2019b; Olivares et al. 2020).

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Table 1: Effect of levels of Zinc and Spacing on growth attributes of Baby corn.

Treatments	Plant height (cm)	No. of leaves/plant	Dry weight (g/plant)
1. 15 kg/ha $ZnSO_4$ + 40cm x 20 cm	161.40	12.13	86.02
2. 20 kg/ha $ZnSO_4$ + 40cm x 20 cm	162.77	12.25	87.18
3. 25 kg/ha $ZnSO_4$ + 40cm x 20 cm	164.27	12.70	88.20
4. 15 kg/ha $ZnSO_4$ + 50cm x 20 cm	163.70	12.52	87.84
5. 20 kg/ha $ZnSO_4$ + 50cm x 20 cm	166.30	12.93	89.83
6. 25 kg/ha $ZnSO_4$ + 50cm x 20 cm	167.13	13.07	90.46
7. 15 kg/ha $ZnSO_4$ + 60cm x 20 cm	165.80	12.75	88.67
8. 20 kg/ha $ZnSO_4$ + 60cm x 20 cm	167.57	13.15	90.81
9. 25 kg/ha $ZnSO_4$ + 60cm x 20 cm	168.13	13.25	90.96
F- test	S	S	S
S. Em (±)	0.34	0.09	0.09
C. D. (P = 0.05)	1.03	0.27	0.27

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Table 2: Effect of levels of Zinc and Spacing on yield attributes and yield of Baby corn

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Treatments	No. of cobs/plant	Length of the cob (cm)		Cob weight (g)		Cob Yield(t/ha)		Green fodder Yield (t/ha)
		With husk	Without husk	With husk	Without husk	With husk	Without husk	
1. 1. 15 kg/ha $ZnSO_4$ + 40cm x 20 cm	1.24	13.20	7.30	41.02	17.64	12.39	3.77	26.15
2. 2. 20 kg/ha $ZnSO_4$+ 40cm x 20 cm	1.43	14.47	7.60	42.05	18.14	14.24	4.77	27.87
3. 3. 25 kg/ha $ZnSO_4$+ 40cm x 20 cm	1.72	15.93	7.83	44.15	19.35	14.63	5.09	28.83
4. 4. 15 kg/ha $ZnSO_4$ + 50cm x 20 cm	1.61	15.20	7.67	43.47	18.38	10.98	3.25	24.97
5. 5. 20 kg/ha $ZnSO_4$+ 50cm x 20 cm	1.95	17.20	8.20	45.57	20.85	12.89	4.09	26.94
6. 6. 25 kg/ha $ZnSO_4$+ 50cm x 20 cm	2.17	17.77	8.27	46.87	21.72	13.67	4.53	27.50
7. 7. 15 kg/ha $ZnSO_4$+ 60cm x 20 cm	1.83	16.63	7.90	44.69	20.46	9.60	2.83	23.78
8. 8. 20 kg/ha $ZnSO_4$+ 60cm x 20 cm	2.34	18.07	8.50	47.43	22.20	10.01	3.02	24.12
9. 9. 25 kg/ha $ZnSO_4$+ 60cm x 20 cm	2.37	18.77	8.58	47.92	22.70	11.82	3.43	25.71
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Em (±)	0.07	0.31	0.07	0.39	0.34	0.32	0.20	0.31
CD (P = 0.05)	0.20	0.94	0.21	1.17	1.01	0.97	0.61	0.94

4. Conclusion

Amongst all the treatments, T_9 having 60 X 20 cm spacing and 25 kg/ha $ZnSO_4$ had the maximum plant productivity and its attributes such as plant height, number of leaves per plant, dry plant mass and cob's properties. Further, the maximum crop growth rate, yield and yield attributes such as cob yield and green fodder yield. It can be concluded that wider spacing and increased zinc application has positive effect on plant productivity and growth attributes as well.

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I suggest the authors update the bibliography, many of the citations are more than 15 years old, therefore I suggest adding recent references which address the issue in question. Suggested citations are for genuine scientific reasons that emphasize the current topic of study in context.

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