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Effect of planting geometry, nitrogen levels and zinc application on growth and yield of hybrid maize (*Zea mays* L.)

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Abstract
A field experiment was conducted during (*kharif*) season of 2016 at the Crop Research Farm, Department of Agronomy, SHUATS, Allahabad in Randomized Block Design with three replications and twelve treatments entitled "To study the effect of planting geometry, nitrogen levels and zinc application on growth and yield of Hybrid Maize (*Zea mays* L.)". This experiment was conducted for comparing the performance of hybrid maize variety "MM2255". It consisted of two planting geometry (60×15 cm and 45×20 cm), three levels of nitrogen (150,120 and 90 kg ha^{-1}) and two levels of zinc (7.5 and 15.0 $kgha^{-1}$). It was found that in T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}) highest plant height (200.47 cm), number of leaves per plant (14.27), dry weight (48.53 g). It also gave highest grain yield (5.70 t ha^{-1}), and stover yield (14.76 t ha^{-1}).The same treatment also gave highest B:C ratio(2.49) and net return of Rs 50018.56 ha^{-1} compared with the other treatments. This indicates that 60×15 cm spacing with nitrogen level of 150 kg $ha^{-1}$and zinc 15 kg $ha^{-1}$is suitable to get higher maize yield, compared to other treatments.

Keywords: Maize, Nitrogen, Zinc, Planting geometry

Introduction
Maize, the third most important cereal crop of India as well as the world, has diversified uses as food for human, feed for livestock and raw material in industries. Due to this immense potential it is called as "miracle crop" and also known as "Queen of cereals". In India, maize is grown in area of 9.43 million hectare, with production of 24.53 million tonnes and productivity of 2583.00 kg ha^{-1} (Agricultural statistics at a glance, 2014). It comes after rice and wheat but has the highest productivity potential among the cereals. Its botanical name is *Zea mays* L. and belongs to the family *Gramineae*, sub-family *Poaceae* and chromosome number is 20 (2n).An increase in the yield of crop can be brought forward either by increasing the area under cultivation or by increasing the productivity per unit area. Since the area is limited, yield levelper unit area has to be increased. With the change in weather condition its growth duration and yield potentiality also change.

In modern maize production systems, enhanced plant-to-plant variability often results from increased competition among individual plants at progressively higher plant densities for limiting resources such as N, incident photo synthetically active radiation (IPAR), and soil moisture. Past studies have often emphasized that standard uniformity is essential for high productivity levels, and that the increased plant-to-plant variability (determined and expressed using a variety of maize growth and developmental parameters) reduces per-unit-area maize grain yields (GYA) through reduced stress tolerance. Therefore, at higher plant populations, resource availability must be adequate to help maintain uniform growth, development, and grain yield of adjacent plants in a maize canopy. In order to achieve higher cob yields, maintenance of stand density is the most important factor. A spatial arrangement of plant governs the shape and size of the leaf area per plant, which in turn influences efficient interception of radiant energy as well as proliferation and growth of roots and their activity. Maximum yield can be expected only when plant population allows individual plant to achieve their maximum inherent potential. Thus, there is need to work out an optimum population density by adjusting inter and intra row spacing in relation to other agronomic factors. Judicious use of fertilizer is a key to bumper maize crop production as they alone contribute 40-60 per cent of the crop yield (Dayanand, 1998) [3]. Maize responds more favourably to plant densities because of higher LAI (leaf area index) at silking, which results in more interception of photo synthetically active radiation and have higher radiation use efficiency during grain filling. The yield potential of maize can be realised only when if it is grown with adequate fertilization and optimum plant population.

The impact of plant density on yield of rice fallow maize has been studied extensively, as it varies with genotype, agronomic management practices, and location. The importance of plant and crop geometry of planting factors in deciding growth and yield of maize is well established. Among the different agronomic practices, plant density is one of the most important factor determining grain yield and other agronomic attributes of maize. There is an optimum plant density for each crop. Under low plant density, although single-plant production increases, yield per unit area decreases. On the other hand, excessive density can increase the competition and decrease the yield.

Materials and Methods

Exhaustive maize crop experiment was taken in *Kharif* season during 2016 on a sandy clay loam soil having pH 7.10, organic carbon 0.45%, medium in available NPK (284.60, 18.00 257.00 kg ha^{-1}) electrical conductivity (EC) of 0.28 dS/m, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.). The Crop Research Farm is situated at 25º24'41.27" N latitude, 81°51'3.42" E longitude (*Google map*, 2016) [6] and 98 m attitude above the mean sea level. Allahabad. Climate of the region is sub-tropical and semi-arid climate with the monsoon commencing from July and withdrawing by the end of September. For the intended study 12 treatments were tested under three replications by using randomized block design. Two planting geometry *viz*., 60 * 15 and 45 * 20 cm, were applied through three nitrogen level (150, 120 and 90 kg ha^{-1}) and two level of zinc (7.5 and 15 kg ha^{-1}). Nutrient management was done through Urea, DAP, MoP and $ZnSO_4$ to supply the required NPK and Zn. Full dose of P_2O_5, K_2O each of 50 kg ha^{-1} and half amount of RDN (45, 60 and 75 kg ha^{-1}) were applied as basal dressing rest of 50% N through urea was applied at 30 DAS as top dressing. $ZnSO_4$ was acclaimed from the treatment levels (7.5 and 15 kg ha^{-1}) as basal dressing. The data on various growth, yield attributes and yield were recorded in different treatments. All the data were statistically analysed.

Results and Discussion

Growth and growth attributes

Table 1 showed that treatment T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}) recorded significantly higher plant height (200.47 cm), number of leaves (14.27), plant dry weight (48.53 g) and CGR (14.73 g g^{-1} day^{-1}) at harvesting stage.

Positive expression of growth and growth attributes viz., plant dry weight, number of leaves and CGR might be due to the competition of light under 60×50 cm spacing with closer plant to plant space for requirement of light. Wider row spacing had taller plant due to better availability of resources. This finding is in agreement with (Paulpandi *et al*., 1998) [9].

The increase in growth and growth attributes with respect to increased nitrogen application rate indicates maximum vegetative growth of plant under higher nitrogen availablity. These results are in the comformity with the result obtained by (Akber *et al*., 1999) [1].

The favourable effect of applied zinc on plant height and other growth attributes may be ascribed to its stimulatory effect on most of the physiological and metabolic processes of plant (Chaab *et al*., 2011) [2].

Yield

Grain yield

Maximum grains yield (5.70 t ha^{-1}) was obtained by the treatment T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}) and it was 24.56% higher compared to the lowest grain yield (4.30 t ha^{-1}) observed in treatment T_{11} (45 × 20 cm + 90 kg N ha^{-1} + 7.5 kg Zn ha^{-1}). However, T_1 (60 × 15 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}) was found to be statistically at par with T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}).

Optimum utilization of solar light, higher assimilates production and its conversion to starches resulted higher grains number and weight that resulted more seed yield (Derby *et al*, 2004) [4].

Stover yield

The data shows that maximum stover yield in t per ha (7.00 t ha^{-1}) was found to the treatment T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}) and it was 31.42% higher as compared to the lowest value (4.80 t ha^{-1}) observed in treatment T_{12} (45 × 20 cm + 90 kg N ha^{-1} + 15 kg Zn ha^{-1}). However, treatment T_1 (60 × 15 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}) was found to be statistically at par with treatment T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}).

The increase in yield could be attributed to the proper supply of Zn up to harvesting stages in soil and which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby finally increased dry-matter accumulation. These results are in accordance with Hussain and Yasin (2004) [13]. The increase of stover yield with the increase of plant densities may be due to increasing numbers of plants and dry matter yield. (Vega *et al*, 2000) [12] reported that maize grain yield is affected to a greater extent by variations in plant density than in other members of the grass family due to its tillering capacity (Tollenaar *et al*., 1997) [11].

Economics

Maximum net returns (₹ 50018.56 ha^{-1}) and the benefit cost ratio (2.49) were recorded in treatment T_2 (60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}) which were respectively higher as compared with the lowest net returns (₹31434.56 ha^{-1}) and the benefit cost ratio (1.91) which was recorded with T_{11} (45 × 20 cm + 90 kg N ha^{-1} + 7.5kg Zn ha^{-1}).

Latha *et al*, (2001) [8] reported that increased zinc availability at all stages of maize crop with enrichment of manure with $ZnSO_4$ is enough for maximum net returns.

Suryavanshi *et al*, (2008) [10] reported that levels of nitrogen application improved the net realization has higher than the production cost as well as proved significantly superior over other lower levels of nitrogen.

Table 1: Effect of Planting Geometry, Nitrogen Levels and Zinc Application on Growth and Growth Attributes of Hybrid Maize (*Zea mays* L.)

Treatment	Plant height 60 DAS	Number of leaves 60 DAS	Dry weight (g) 60 DAS	CGR (g m^2 day^{-1})
T_1 60 × 15 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	193.57	13.13	44.97	14.70
T_2 60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}	200.47	14.27	48.53	14.76
T_3 60 × 15 cm + 120 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	188.00	11.53	42.63	12.52
T_4 60 × 15 cm + 120 kg N ha^{-1} + 15 kg Zn ha^{-1}	195.70	11.97	45.67	13.06

T_5 60 × 15 cm + 90 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	175.27	10.47	38.33	10.20
T_6 60 × 15 cm + 90 kg N ha^{-1} + 15 kg Zn ha^{-1}	171.33	11.00	41.03	11.35
T_7 45 × 20 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	197.60	11.53	47.63	14.04
T_8 45 × 20 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}	198.40	12.20	47.33	14.44
T_9 45 × 20 cm + 120 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	191.40	11.40	41.93	12.54
T_{10} 45 × 20 cm + 120 kg N ha^{-1} + 15 kg Zn ha^{-1}	195.40	11.80	43.70	13.46
T_{11} 45 × 20 cm + 90 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	167.47	10.53	36.77	10.87
T_{12} 45 × 20 cm + 90 kg N ha^{-1} + 15 kg Zn ha^{-1}	170.60	10.87	39.57	11.94
F test	S	S	S	S
SE.d ±	2.26	0.27	0.63	0.40
CD (P=0.05%)	4.68	0.55	1.42	0.83

Table 2: Effect of Planting Geometry, Nitrogen Levels and Zinc Application on Yield and Yield Attributes of Hybrid Maize (*Zea mays* L.)

Treatments	grain yield (t/ha)	Stover yield (t/ha)	Net return (₹ha^{-1})	B:C ratio
T_1 60 × 15 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	44.97	14.70	47941.28	2.41
T_2 60 × 15 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}	48.53	14.76	50018.56	2.49
T_3 60 × 15 cm + 120 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	42.63	12.52	49541.28	2.41
T_4 60 × 15 cm + 120 kg N ha^{-1} + 15 kg Zn ha^{-1}	45.67	13.06	40311.28	2.23
T_5 60 × 15 cm + 90 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	38.33	10.20	40938.56	2.17
T_6 60 × 15 cm + 90 kg N ha^{-1} + 15 kg Zn ha^{-1}	41.03	11.35	33907.28	2.06
T_7 45 × 20 cm + 150 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	47.63	14.04	46818.56	2.31
T_8 45 × 20 cm + 150 kg N ha^{-1} + 15 kg Zn ha^{-1}	47.33	14.44	40161.28	2.22
T_9 45 × 20 cm + 120 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	41.93	12.54	39338.56	2.12
T_{10} 45 × 20 cm + 120 kg N ha^{-1} + 15 kg Zn ha^{-1}	43.70	13.46	32457.28	2.01
T_{11} 45 × 20 cm + 90 kg N ha^{-1} + 7.5 kg Zn ha^{-1}	36.77	10.87	31434.56	1.91
T_{12} 45 × 20 cm + 90 kg N ha^{-1} + 15 kg Zn ha^{-1}	39.57	11.94	34234.56	1.99
F test	S	S		
SE.d ±	0.63	0.40		
CD (P=0.05%)	1.42	0.83		

Conclusion

The experiment "Effect of planting geometry, nitrogen levels and zinc applicatoin on growth and yield of Hybrid Maize (*Zea mays* L.)" conducted during (*kharif*) season of 2016 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad showed best performance in treatmentT_2(60×15 cm +150 kg N ha^{-1}+15 kg Zn ha^{-1}) with fertilizer level of 150kg Nha^{-1} and 15 kg Zn ha^{-1} and spacing of 60 × 15cm on all parameters observed, *viz*., plant height(200.47cm), no of leaves per plant (14.27), dry weight (48.53g), grain yield (5.70t ha^{-1}) and stover yield (7.00 t ha^{-1}). The same treatment also gave highest B:C ratio (2.49) and net return of Rs 50018.56 ha^{-1} compared with the other treatments. The finding is based on one year trial, therefore it may be repeated to confirm the findings.

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