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Effect of combined levels of nitrogen and zinc on yield and yield attributes of *kharif* maize (*Zea mays* L.)

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Abstract
A field experiment was conducted at Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jagatpura, Jaipur-Rajasthan during *kharif* season of 2018 to study the effect of combined levels of nitrogen and zinc on yield and yield attributes of maize (*Zea mays* L.)" The experiment was laid down in randomized block design (RBD) with three replications. The maize crop was subjected to three different treatment levels of nitrogen (150,120 and 90 kg ha^{-1}) along with two levels of zinc (15 and 25 kg ha^{-1}) and untreated control which were used and arranged into seven different treatment combinations. It was revealed from the present investigation that the progressive increase in yield () and yield attributes like cob length (17.86 cm), cob weight (121.18 g), cobs/plant (2.66), number of grain rows per cob (14.73), 100 grain weight (24.93 g), harvest index (40.99 g) per ha^{-1} was noted in combined treatment comprised of 150kg N + 25kg $ZnSo_4$ against significantly minimum in plots with zero application of both nitrogen and zinc (control). The same treatment also gave highest B:C ratio (1.63) and net return of Rs.59108.00 ha^{-1} as compared to other treatments under study. Thus it is concluded from the present investigation that 150 kg nitrogen ha^{-1} in combination with 25 kg zinc ha^{-1} was found more effective in enhancing higher maize yield, yield attributes as well economic parameters than rest of the treatments.

Keywords: Maize, nitrogen, zinc, yield, yield attributes and economics

Introduction
Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals, used for various purposes including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 MT) in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 35 % of the total production in the world. Maize in India, contributes nearly 9% in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material, integrated to thousands of industrial products that includes starch, oil, proten, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, tectile, gum, package and paper industries etc. (Chaudhary *et al.*, 2013) [10]. Among various macro and micronutrients, nitrogen and zinc are one of the most important elements used to improve growth, yield and yield attributes of crop plants including maize. Nitrogen is an essential element for all organisms as it is composed of proteins, nucleic acid and other important organic compound. A deficiency of it makes it impossible for the plant to complete normally its vegetative/reproductive stages. This element is directly involve in the nutrition of plant and quite apart from its possible effect in correcting some unfavourable microbiological or chemical condition of the soil (Takujiand Kuni 2010). It is an integral component of many compounds essential for plant growth process including chlorophyll and many enzymes. Nitrogen also mediates the utilization of potassium, phosphorus and other elements in plants. The optimum amounts of elements in the soil cannot be utilized efficiently if nitrogen is deficient in plants. (Agrodi *et al.*, 2011). Thus nitrogen is the key element in increasing productivity of crop plants. On the other side, zinc is also essential for the proper growth and development of crop plants. It is a vital source forcrop nutrition as it is required by the plant in performing various enzymatic reaction, metabolic process, and oxidation reaction. In addition Zn is also essential for many enzymes which are needed for nitrogen metabolism, energy transfer and protein synthesis. Zinc deficiency not only retarded growth and yield of plants

also seem to affect the capacity for water uptake and transport in plants (Hafeez *et al.*, 2013). Therefore, the present investigation was undertaken to study the combined effect of different levels of nitrogen and zinc and to work out ontheir optimum dose suited to improve yield and yield attributes of maize.

Materials and Methods

Maize crop experiment was taken in *kharif* season during 2018 on a sandy loam soil having pH 8.48, organic carbon 0.40%, low in available NP (0.0, 42.00kg ha^{-1}) medium in K(290.00 kg ha^{-1}) electrical conductivity (EC) of 0.32 dS/m, at the Crop Research Farm, Department of Agronomy, school of Agriculture, Suresh gyanvihar University, Jaipur (Rajasthan). 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 7 treatments were tested under three replications by using randomized block design. The three nitrogen level (150, 120 and 90 kg ha^{-1}) and two level of zinc (15 and 25 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 80 and 60 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 (15 and 25 kg ha^{-1}) as basal dressing. The data on various growth and yield were recorded in different treatments. All the data were statistically analysed.

Results and Discussion

Yield Attributes

Cob length

Maximum cob length was recorded with the highest dose of nitrogen Treatment T6 (150kg N ha.$^{-1}$ in combination with 25kg $ZnSO_4$ ha^{-1}) which was statistically at par with the second highest treatment combination T5 (150kgN + 15kg $ZnSO_4$ ha.$^{-1}$) followed by 120kgN + 25kg $ZnSO_4$ ha.$^{-1}$. The minimum cob length was recorded in plots where neither nitrogen nor zinc was applied i.e., control. The reason for the better cob length may attribute to the fact that of more photosynthetic activities of the plant on account of adequate supply of nitrogen along with zinc. Both nitrogen and zinc are essential requirement of cob growth. Therefore, the better the development of cob length will be the index of better economic yield of maize crop (Khan *et al.*, 2008) [14].

Cob weight

The result of the treatment combination indicate thatT6 (150kg N ha^{-1} and 25kg $ZnSO_4$ ha^{-1}) observed significantly effective in respect of recorded maximum cob weight than rest of treatments under study whereas, significantly the lowest cob weight was recorded in control. The positive response of higher levels of nitrogen along with zinc on crop weight to be described as overall an improvement incrop growth that enabled the plant to absorbed more nutrient and moisture which empowered theplant to manufacture more quantity of photosynthesis and accumulating them insink. These results are in conformity with Jeet *et al.*, (2017) [13].

Cobs per plant

Among all the treatment tried in the experiment treatments, level of N and $ZnSO_4$applied in combination significantly affected number of cobs per plant of maize. Significantly maximum number of cobs plant^{-1}wasobtained in plots where nitrogen was applied @ T6 (150 kg ha^{-1} in combination with 25kg $ZnSO_4$) against minimum from T0 (Control). These findings are accordance with the work reported by Potarzycki *et al.*, (2015) [15].

Number of grain rows cob^{-1}

The data showed that it was significantly affected by different treatment combination of nitrogen and zinc including T0 (Control). Nitrogen at 150 kg ha^{-1} along with zinc at 25 kg ha^{-1}found to be best by obtaining more number of grains cob $^{-1}$against minimum recorded from control. Adequate supply of nitrogen is decisive for the activity of enzymes responsible for the number of starch granules in developing kernels while on the hand, zinc application to maize is a factor affecting positively its grain formation. The results are in agreement with those of Ayman *et al.*, (2015) [4].

100 grain weight (g)

Data exhibited significant effect of N and $ZnSO_4$levels also on 100 grain weight of maize. Grain weight of maize was increased significantly dueto application ofNitrogen combination with zinc @ T6 (150kg N+25kg $ZnSo_4$ ha^{-1}) gave highest 100 seeds grain weight against minimum control because less fertilization probably disturbed the source and sink relationship. Therefore, higher levels of nitrogen along with zinc increased 100 grain weight, producing well developed and bold maize grains. The results are conformity with the findings of Asif *et al.*, (2013) [1].

Harvest index (%)

The combined effect of N and $ZnSO_4$ at different levels under study affected harvest index significantly. Maximum harvest index was recorded from T6 (150kgN+25kg $ZnSo_4$ha^{-1}) treatment combination which was statistically at par with T5 (150kg N+15kg $ZnSo_4$ ha^{-1}). Minimum harvest index was recorded in control. These results are accordance with the findings of Azab (2015) [3]. In respect to harvest index.

Yield

Grain yield

Maximum grains yield (37.03 q ha $^{-1}$) was obtained by the treatment T6 (150 kg N ha $^{-1}$ + 25 kg Zn ha $^{-1}$) and it was 27.02% higher compared to the lowest grain yield (10.65 q ha $^{-1}$) observed in treatment T0 (Control). However, T6 (150 kg N ha -1 + 25 kg Zn ha $^{-1}$) was found to be statistically at par with T5 (150 kg N ha $^{-1}$ + 15 kg Zn ha $^{-1}$). These results support the findings of Abunyewa and Quarshie (2004) [2].

Fodder yield

The data shows that maximum fodder yield in q per ha (53.29 q ha $^{-1}$) was found to the treatment T6 (150 kg N ha $^{-1}$+ 25 kg Zn ha $^{-1}$) and it was 52% higher as compared to the lowest value (28.09 t ha $^{-1}$) observed in treatment T0 (Control). However, treatment T5 (150 kg N ha $^{-1}$ + 15 kg Zn ha $^{-1}$) was found to be statistically at par with treatment T6 (150 kg N ha $^{-1}$ + 25 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 Ghodpage *et* al., (2008) [11].

Conclusion

Based on one year experimental results, it is concluded that among all the treatment combinations studied in the present investigation, treatment combination that comprised of 150 kg N ha^{-1} along with 25 kg Zn ha^{-1} was found to be far superior in increasing yield and yield attributes of maize crop. The same treatment also gave highest B:C ratio as well as net return compared with the other treatments respectively.

Table 1: Response of nitrogen in combination with zinc on cob length, cob weight, cobs per plant, no. of. Grain rows per cob, 100 grain weight, harvest index of *Kharif* maize (*Zea mays* L.)

Treatments		Cob length (cm)	Cob weight (g)	Cobs /plant	No of grain rows/cob	100 grain weight (g)	Grain yield	Fodder yield	Harvest index (%)	Net Returns (₹)	B:C ratio
T_0	Control	5.61	65.86	1.00	6.03	11.22	10.65	28.09	16.48	2518.70	0.08
T_1	90 kg N/ha+ 15 kg Zn/ha	13.13	109.17	1.66	9.53	23.27	29.79	47.44	37.29	46162.00	1.35
T_2	90 kg N/ha + 25 kg Zn/ha	13.31	113.20	1.66	10.19	23.57	31.25	49.09	38.35	47624.71	1.37
T_3	120 kg N/ha+ 15 kg Zn/ha	14.43	114.52	1.66	12.38	23.81	31.97	49.37	39.30	49190.60	1.41
T_4	120 kg N/ha+ 25 kg Zn/ha	15.46	116.71	2.33	13.34	24.70	33.17	50.18	39.79	51059.50	1.44
T_5	150 kg N/ha+ 15 kg Zn/ha	16.40	118.90	2.33	14.41	24.73	35.16	51.97	40.35	55749.86	1.57
T_6	150 kg N/ha+ 25 kg Zn/ha	17.86	121.18	2.66	14.73	24.93	37.03	53.29	40.99	59108.00	1.63
F- test		S	S	S	S	S	S	S	S		
S. Ed. (±)		0.17	0.89	0.23	0.24	0.085	0.22	0.45	0.27		
C. D. (P = 0.05)		0.39	1.98	0.51	0.54	0.188	0.50	1.01	0.60		

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