Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 385-387
Received: 19-05-2019
Accepted: 21-06-2019

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Response of nitrogen and zinc on growth and yield of *kharif* maize (*Zea mays* L.)

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Abstract
The study entitled "Response of nitrogen and zinc on growth and yield of *kharif* maize (*Zea mays* L.) was conducted at Agricultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jagatpura, Jaipur, during monsoon season of 2018. The experiment was laid down in randomized block design (RBD) with three replications which comprised of seven treatments that includes three levels of nitrogen (90, 120 and 150 kg ha^{-1}) along with two levels of zinc sulphate (15 and 25 kg ha^{-1}) and control. It was revealed from the present investigation that growth parameters (plant height and dry matter production), grain and fodder yield were significantly affected by different combination of nitrogen and zinc levels. Significantly maximum plant height, dry matter production, grain and fodder yield per ha^{-1} was noted in treatment combination that comprised of 150kg N + 25kg $ZnSo_4$ against significantly minimum in plots with zero application of both nitrogen and zinc (Control). Regarding economics of different treatments combinations of nitrogen and zinc levels on maize crop, 150kg N in combination with 25kg $ZnSo_4$ ha^{-1} recorded highest total cost of cultivation, gross and net return as well as benefit cost ratio.

Keywords: Maize, nitrogen, zinc, growth, yield 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 production in India has grown in diverse ecologies and seasons covering 9.86 m ha acreage with 26.26 MT production (Directorate of Economics & Statistics, DAC&FW 2017). Maize in India, contributes nearly 9% in the national food basket. Among different macro and micro nutrients, nitrogen and zinc plays pivotal role in the growth and development of crop plants including maize. Nitrogen is the key element in increasing productivity. It is an integral component of many components essential for plant growth process. Therefore, nitrogen deficiency can result reduction in maize yield. Nitrogen stress during flowering and grain filling stage results in kernel and ear abortion, accelerates leaf senescence, reduce photosynthesis and kernal weight (Zaidi *et al.*, 2005) [16]. On the other hand, zinc is a trace element needed in small quantity but in critical concentrate. If the amount of available zinc is not adequate, plants will suffer with physiological stress. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effect of short periods of plant and salt stress (Hafeez *et al.*, 2013) [9]. Maize is considered as high nutrient demanding crop that needs balanced nutrient application either from nitrogen or zinc as both of these are integral components that are associated with proper growth, development and high productivity of maize crop when applied under appropriate dosage. Therefore, the present investigation has been under taken to evaluate the combined effect of nitrogen and zinc on growth and yield of maize crop and to workout the optimum doses of nitrogen in combination with zinc fertilization.

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 NPK (0.0, 42.00 290.00 kg ha^{-1}) electrical conductivity (EC) of 0.32 dS/m, at the Crop Research Farm, Department of Agronomy, school of Agriculture, Suresh gyan vihar 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

Growth and growth attributes

Table 1 showed that treatment T6 (150 kg N ha^{-1} + 15 kg Zn ha^{-1}) recorded significantly higher plant height (195.05 cm), plant dry weight (141.84 g) at harvesting stage. Positive expression of growth and growth attributes viz., plant dry weight. 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 (Amanullah *et al*., 2014) [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 (Panneerselvam and Stalin 2014) [15].

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) [8].

Economics

Maximum net returns (Rs.59108.00 ha^{-1}) and the benefit cost ratio (1.63) were recorded in treatment T6 (150 kg N ha^{-1} + 15 kg Zn ha^{-1}) which were respectively higher as compared with the lowest net returns (Rs.2518.70 ha^{-1}) and the benefit cost ratio (0.08) which was recorded with T0 (Control).

Table 1: Response of nitrogen in combination with zinc on growth and yield of *kharif* maize (*Zea mays* L.)

Treatments		Plant height (cm) 90 DAS	Plant dry weight (g) 90 DAS
T_0	Control	70.17	53.433
T_1	90 kg N/ha + 15 kg Zn/ha	180.22	130.763
T_2	90 kg N/ha + 25 kg Zn/ha	180.98	134.470
T_3	120 kg N/ha + 15 kg Zn/ha	180.82	138.297
T_4	120 kg N/ha + 25 kg Zn/ha	182.61	138.453
T_5	150 kg N/ha + 15 kg Zn/ha	188.39	139.157
T_6	150 kg N/ha + 25 kg Zn/ha	195.05	141.843
F- test		S	S
S. Ed. (±)		1.491	0.040
C. D. (P = 0.05)		3.285	0.089

Table 2: Response of nitrogen in combination with zinc on growth and yield of *kharif* maize (*Zea mays* L.)

Treatments		Grain yield (q/ha)	Fodder yield (q/ha)	Net returns	B:C Ratio
T_0	control	10.65	28.09	2518.70	0.08
T_1	90 kg N/ha + 15 kg Zn/ha	29.79	47.44	46162.00	1.35
T_2	90 kg N/ha + 25 kg Zn/ha	31.25	49.09	47624.71	1.37
T_3	120 kg N/ha + 15 kg Zn/ha	31.97	49.37	49190.60	1.41
T_4	120 kg N/ha + 25 kg Zn/ha	33.17	50.18	51059.50	1.44
T_5	150 kg N/ha + 15 kg Zn/ha	35.16	51.97	55749.86	1.57
T_6	150 kg N/ha + 25 kg Zn/ha	37.03	53.29	59108.00	1.63
F- test		S	S		
S. Ed. (±)		0.228	0.459		
C. D. (P = 0.05)		0.501	1.012		

Conclusion

The experiment "Response of nitrogen and zinc on growth and yield of *kharif* maize (*Zea mays* L.)" conducted during *kharif* season of 2018 at Crop Research Farm, Department of Agronomy, Suresh gyan vihar university, Jaipur showed best performance in treatment T6(150 kg N ha^{-1}+25 kg Zn ha^{-1}) with fertilizer level of 150kg N ha^{-1} and 25 kg Zn ha^{-1} on all parameters observed, *viz*., plant height(195.05 cm), dry weight (141.843 g), grain yield (37.03 q ha^{-1}) and fodder yield (53.29 ha^{-1}). The same treatment also gave highest B:C ratio (1.63) and net return of Rs 59108.00 ha^{-1} compared with the other treatments.

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