Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 707-709
Received: 01-05-2019
Accepted: 03-06-2019

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Response of maize (*Zea mays* L.) to foliar application of zinc and planting geometry

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Abstract
A field experiment was conducted during *kharif* season of 2018 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad to study the growth and yield of Maize (*Zea mays* L.) as influenced by foliar application of zinc and planting geometry. The experiment is comprised of Randomized Block Design with three replications and twelve treatments. It consisted of foliar applied Zn concentrations (control, 0.5%, 0.75% and 1.0%) and three planting geometry (30 x 30 cm, 45 x 20 cm and 60 x 15 cm). It was observed that T_{11} (1.0% Zn l^{-1} at 45 x 20 cm) gave highest plant height (174.99 cm). It also gave highest number of grains cob^{-1} (302.45), grain yield (9.34 t ha^{-1}), test weight (284.19 g) and highest net return (₹ 121399.67 ha^{-1}) and B:C ratio (3.24) indicating better yield attributes as compared to other treatments. However, T_{10} (1.0% Zn at 30 x 30 cm) was found to be more effective for higher stover yield up to 10.11 t ha^{-1}.

Keywords: Maize, nitrogen, zinc, planting geometry

Introduction

Maize (*Zea mays* L.) is one of the most important staple food crops after rice and wheat, in the world as well as in India. It is a miracle crop and is also referred to as 'Queen of Cereals'. In India, maize is presently grown in an area of 8.69 million hectares, with production of 21.81 million tonnes and productivity of 2509 kg ha^{-1} (Agricultural Statistics at a Glance, 2016) [7]. At present, about 35 per cent of the maize produced in the country is used for human consumption, 25 per cent each in poultry feed and cattle feed and 15 per cent in food processing (corn flakes, popcorn etc.) and other industries (mainly starch, dextrose, corn syrup, corn oil etc.).

Zn deficiency is a well-documented problem in food crops. Maize was also recognized by farmers for a long time as a crop of high response to Zn supply. Limited supply of Zn may result in poor root development, stunted growth, small leaves, short internodes, delayed tasseling, etc. Zn helps in the synthesis of growth hormones and proteins, production of chlorophyll and carbohydrate metabolism and cell elongation. Zn activates the plant enzymes by carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, maintaining the integrity of cellular membranes, protein synthesis and regulation of auxin synthesis. It was documented that foliar application of Zn is a simple way for quick correction of plant nutritional status. Foliar application of Zn significantly improves starch content of forage maize. Application of Zn as foliar alone or combination with basal application is also reported to improve the grain Zn content (Cakmak, 2008), and could solve Zn deficiency related health problems in humans.

Materials and Methods

The experiment was conducted in *kharif* season during 2018 on a sandy clay loam soil having pH 7.4, organic carbon 0.961%, NPK (341.15, 36.3, 254.3 kg ha^{-1}), EC of 0.413 dS m^{-1} at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The Crop Research Farm is situated at 25º24'41.27" N latitude, 81°51'3.42" E longitude (*Google map*, 2016) and 98 m attitude above the mean sea level. It has a sub-tropical and semi-arid climate with the monsoon commencing from July and withdrawing by the end of September. The experiment consisted of a Randomized Block Design with 3 replications and 12 treatments. Four levels of Zn (control, 0.5%, 0.75% and 1.0%) were applied to three planting geometry (30 x 30 cm, 45 x 20 cm, 60 x 15 cm). Nutrients were applied through Urea, DAP, MoP and $ZnSO_4$ to supply the required amount of NPK and Zn. Full dose of P_2O_5 and K_2O, and 50% of N (60, 60 and 60 kg ha^{-1}) were applied as basal. The rest 50% N was applied as split doses 20 DAS and 40 DAS as top dressing. Zn_2SO_4 was applied as foliar spray at vegetative stage and reproductive stage (anthesis). The data on various growth and yield attributes were recorded and statistically analyzed.

Results and Discussion

Growth and growth attributes

Foliar application of Zn at different planting geometry significantly affected the plant height. Significantly higher plant height was observed in T_{11} (1.0% Zn at 45 x 20 cm) at 174.99 cm, whereas significantly higher dry weight was observed in T_{10} (1.0% Zn at 30 x 30 cm) at 54.33 g, as seen in Table 1.

Foliar application of Zn at 1.0% considerably increased the plant height and other growth attributes. This may be due to the positive effect of Zn applied at higher doses. Zn aids in the synthesis of growth hormones and plays a vital role in cell elongation. Increase in plant height with respect to increased Zn application rate indicates maximum vegetative growth of plant under higher Zn availability. This finding is in relevance with Yasin *et al.*, 2018 [16].

The increase in growth and growth attributes with difference in planting geometry shows the competition among plants for available resources. The results are in close accordance with findings of Mathukia *et al.*, 2014 [10].

Yield

Grain Yield

Maximum grain yield (9.34 t ha^{-1}) was observed under T_{11} (1.0% Zn at 45 x 20 cm) as shown in Table 2. This was 21.84% higher as compared to lowest grain yield (7.30 t ha^{-1}) recorded from T_2 (Control at 45 x 20 cm). However, T_{10} (1.0% Zn at 30 x 30 cm) was found to be statistically on par with the treatment.

The increase in grain yield may be due to the adequate supply of Zn during the various growth stages of the plant, which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby, increasing dry-matter accumulation. Proper and adequate supply of Zn as foliar spray results in direct absorption of Zn, which increased the uptake of N during the grain formation stage and ultimately improved the yield component of maize (Siddiqui *et al*., 2009) [15]. The results are in close accordance with the findings of Mohsin *et al.*, 2014 [11].

Stover Yield

Maximum stover yield (10.11 t ha^{-1}) was observed under T_{10} (1.0% Zn at 30 x 30 cm) as shown in Table 2. This was 22.16% higher as compared to lowest stover yield (7.87 t ha^{-1}) recorded from T_2 (Control at 45 x 20 cm). However, the different treatment combinations had no significant difference on the stover yield of the crops.

Application of Zn at adequate doses helps in regulation of various physiological and metabolic activities. It also results in better accumulation of N, leading to higher plant height, dry weight and ultimately higher stover yield. Foliar application of Zn as sole or in combination improves growth, increase yield and yield components of maize even under moisture stress condition, because foliar application of Zn provides the essential nutrients to the plants (Yasin *et al.*, 2018) [16].

Economics

Maximum net return (□ 121399.67 ha^{-1}) and benefit cost ratio (3.24) were recorded in T_{11} (1.0% Zn at 45 x 20 cm). These findings were respectively higher as compared with the lowest net return (□ 86935.7 ha-1) and benefit cost ratio (2.33) observed in T_2 (Control at 45 x 20 cm).

Latha *et al.*, 2001 [9] also reported that increased Zn availability at all stages of maize crop with enrichment of manure with $ZnSO_4$ is enough for maximum net returns.

Table 1: Effect of foliar application of Zn and planting geometry on growth of maize (*Zea mays* L.)

60 DAS				
Treatment	**Plant height (cm)**	**Dry weight (g)**	**Leaf Area Index**	**CGR ($g\ m^{-2}\ day^{-1}$)**
T_1 (Control at 30 x 30 cm)	165.09	47.70	6.86	17.27
T_2 (Control at 45 x 20 cm)	159.72	46.28	6.45	15.84
T_3 (Control at 60 x 15 cm)	160.71	47.43	6.19	17.20
T_4 (0.5% Zn at 30 x 30 cm)	161.43	48.61	6.60	17.08
T_5 (0.5% Zn at 45 x 20 cm)	160.87	49.17	6.66	17.76
T_6 (0.5% Zn at 60 x 15 cm)	168.48	49.17	6.58	17.82
T_7 (0.75% Zn at 30 x 30 cm)	158.81	49.64	6.34	18.26
T_8 (0.75% Zn at 45 x 20 cm)	167.60	48.97	7.13	17.72
T_9 (0.75% Zn at 60 x 15 cm)	165.23	53.34	7.06	18.87
T_{10} (1.0% Zn at 30 x 30 cm)	172.41	54.33	8.25	19.83
T_{11} (1.0% Zn at 45 x 20 cm)	174.99	50.89	7.70	17.34
T_{12} (1.0% Zn at 60 x 15 cm)	170.41	53.14	8.10	19.32
F test	S	S	NS	NS
SE (d)	4.27742	2.19801	0.81014	1.35707
CD (P= 0.005%)	8.87136	4.55867	-	-
C.V.	3.1658	5.39599	14.1902	9.30606

Table 2: Effect of foliar application of Zn and planting geometry on yield of maize (*Zea mays* L.)

Treatment	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Net Return (□ ha^{-1})	B:C ratio
T_1 (Control at 30 x 30 cm)	7.58	8.20	91639.00	2.46
T_2 (Control at 45 x 20 cm)	7.30	7.87	86935.67	2.33
T_3 (Control at 60 x 15 cm)	7.68	8.91	93339.00	2.51
T_4 (0.5% Zn at 30 x 30 cm)	8.09	9.03	100201.00	2.68
T_5 (0.5% Zn at 45 x 20 cm)	8.19	8.93	101901.00	2.73
T_6 (0.5% Zn at 60 x 15 cm)	8.24	9.47	102694.33	2.75
T_7 (0.75% Zn at 30 x 30 cm)	7.93	8.38	97483.67	2.61
T_8 (0.75% Zn at 45 x 20 cm)	8.12	8.74	100600.33	2.65
T_9 (0.75% Zn at 60 x 15 cm)	8.44	9.18	106040.33	2.84
T_{10} (1.0% Zn at 30 x 30 cm)	9.17	10.11	118509.67	3.17
T_{11} (1.0% Zn at 45 x 20 cm)	9.34	9.43	121399.67	3.24
T_{12} (1.0% Zn at 60 x 15 cm)	8.83	9.62	112616.33	3.01
F test	S	NS		
SE (d)	0.2374	0.73265		
CD (P= 0.005%)	0.49236	-		
C.V.	3.52745	9.9791		

Conclusion

The experiment "Response of Maize (*Zea mays* L.) to Foliar application of Zn and Planting Geometry" conducted during *kharif* season of 2018 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj showed best performance in treatment T_{11} (1.0% Zn l^{-1} of water at 45 cm x 20 cm) on the parameters observed, *viz*., plant height (174.99 cm), number of grains cob^{-1} (302.45), grain yield (9.34 t ha^{-1}), test weight (284.19 g). It also gave highest net return (₹ 121399.67 ha^{-1}) and B:C ratio (3.24) compared to the other treatments. These findings are based on a four months trial, therefore it may be repeated to confirm the findings.

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