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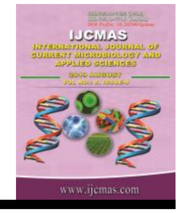

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Response of Various Fertility and Zinc Levels on Growth, Quality and Productivity of Maize (*Zea mays* L.) under Sub-Humid Zone of Rajasthan

Dinesh Chandra Jat[1], S.C. Meena[1], J. Choudhary[2*] and Somdutt[2]

[1]Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur -313 001 (Rajasthan), India
[2]Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur -313 001 (Rajasthan), India

**Corresponding author*

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A B S T R A C T

A field experiment was conducted at Rajasthan College of Agriculture, Udaipur (Rajasthan) during *kharif* 2018 to study the effect of different fertility and zinc levels on growth, quality and productivity of maize in sub-humid zone of Rajasthan. The experiment was laid out in factorial randomized block design comprising four fertility levels *viz.*, control, 50%, 75%, 100% NPK ha^{-1} and four zinc levels *viz.*, control, 4.0, 5.0 and 6.0 kg ha^{-1}. Results revealed that application of 100% NPK ha^{-1} and 6.0 kg zinc ha^{-1} applied in maize to significantly improved growth parameter *i.e.* plant height at 30 and 60 DAS and at harvest, grain yield, stover yield and biological yield, yield attributes *viz.*, grains cob^{-1}, cob length, seed index and quality parameters *viz.*, chlorophyll content and protein content net return and benefit cost ratio in sandy clay loam soil of agro-climatic zone lVa of Rajasthan.

Introduction

Maize is the third most important cereal crop next to wheat and rice in world as well as in India (Paramasivam *et al.*, 2010). It is grown successfully in warm, temperate regions as well as in humid and sub-tropical zones and is also cultivated in tropics. Maize grain contains about 70 per cent carbohydrate, 10 per cent protein, 4 per cent oil, 2.3 per cent crude fibre, 10 per cent aluminizes and 1.4 per cent ash. The productivity of maize is very high because of its C_4 nature of plants and it is very efficient in converting solar energy into production of dry matter. It is a miracle crop that is why it is also called "*Queen of Cereals*" (Singh *et al.*, 2017). It is used as food, feed and fodder and now a days it is gaining immense importance on account of its potential uses in the manufacture of starch, plastic, rayon, dye, resins, boot polish, syrups ethanol etc. In India important maize cultivating states are Gujarat, Rajasthan, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh and Bihar. Maize is grown in an area of 8.69 million hectares with production of 21.8 million tonnes and productivity of 2509 kg ha^{-1} (Annual Progress Report *kharif* Maize, IIMR, 2016). Rajasthan is one of the major state in India cultivating maize over an area of 0.88 million hectares with a production of 1.14 million tonnes and productivity of 1318 kg ha^{-1} (Annual Progress Report, AICRP on maize, 2016).

Nitrogen as a major constituent of cell plays a vital role in cell division and elongation by virtue of being an essential part of amino acids, protein, nucleic acids, porphyrins, flavins, puriens and pyramidine nucleotides, enzymes, co-enzymes and alkaloids. Therefore, it is a vitally associated with the activity of every living cell. Thus, greater availability of nitrogen at higher fertilizer doses might have improved protein synthesis and photosynthesis leading thereby to rapid cell division and enlargement, which ultimately resulted in the vigorous plant growth.

Phosphorus is the second most essential nutrient after nitrogen required for high growth and yield of maize. Phosphorus has a great role in energy storage and transfer and closely related to cell division and development of maize tissues. It is also important for seed and fruit formation and speed ripening of fruits hence counteracting the effect of excess amount of nitrogen. Similarly, Potassium plays an important role in stimulation of enzymes activity, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem transport, cation-anion balance and stress resistance (Gul *et al.,* 2015). In maize, potassium produces strong stiff straw and reduces lodging. Potassium imparts an increased vigour and disease resistance to plant. Maize is the most susceptible crop to zinc deficiency. Because high yielding maize varieties are selectively grown, chemical fertilizers used have been of increased purity and cropping has become increasingly intensive; zinc deficiency in soil-crop system has become more prevalent in last decades (Fageria *et al.,* 2010). Zinc plays an important role in the correct functioning of many enzyme systems, the synthesis of nucleic acids and, protein metabolism and normal crop development and growth. Phosphorus and zinc, essential for plant growth, are antagonistic to each other in certain circumstances, such as when phosphorus supplied in high level and zinc uptake becomes slower or inadequate.

Materials and Methods

The present study was conducted at the Instructional Farm, Rajasthan College of Agriculture, Udaipur during *kharif* 2018. The site is situated at south-eastern part of Rajasthan at an altitude of 579.5 m above mean sea level, at 24°35’ N latitude and 74°42’ E longitude. The region falls under NARP agro-climatic zone IV-a (Sub-humid southern plain and Aravali hills) of Rajasthan. The treatment consisted of different fertility and zinc levels *viz.,* F_1Z_1(control), F_2Z_1[50% NPK + Zinc (control)], F_3Z_1[75% NPK + Zinc (control)], F_4Z_1[100% NPK + Zinc (control)], F_1Z_2 [NPK (control) + 4.0 kg zinc], F_2Z_2 [50% NPK + 4.0 kg zinc], F_3Z_2 [75% NPK + 4.0 kg zinc], F_4Z_2 [100% NPK + 4.0 kg zinc], F_1Z_3 [NPK (control) + 5.0 kg zinc], F_2Z_3 [50% NPK + 5.0 kg zinc], F_3Z_3 [75% NPK + 5.0 kg zinc], F_4Z_3 [100% NPK + 5.0 kg zinc], F_1Z_4 [NPK (control) + 6.0 kg zinc], F_2Z_4 [50% NPK + 6.0 kg zinc], F_3Z_4 [75% NPK + 6.0 kg zinc], F_4Z_4 [100% NPK + 6.0 kg zinc] were laid out in a factorial randomized block design with three replication; using seed rate of 25 kg ha^{-1} and variety Pratap hybrid maize-3 (PHM-3). Sources of nitrogen, phosphorus, potassium and zinc are Urea, DAP, MOP and $ZnSO_4.7H_2O$, respectively. Fertilizers were applied as per treatment recommendation. Full dose of phosphorus, potassium, zinc and 1/3rd dose of nitrogen were applied at the time of sowing. The rest 2/3rd amount of nitrogen was top dressed in two split doses at knee high and tasselling stage. Five plants were selected randomly from each plot to record observations on growth and yield attributing characters.

Results and Discussion

Growth

Data Table 1 shows that increasing fertility levels up to 100% NPK ha^{-1} had significantly increased plant height 85.96, 198.02 and 217.65 cm at 30, 60 DAS and at harvest respectively, which was 15.78, 9.51 and 3.91 per cent higher than control at respective stages of growth. Application of 100% NPK statistically increased chlorophyll content (1.935 g mg^{-1}) of fresh leaves at 50 DAS. Amongst mineral nutrients N, P and K are considered to be most important for exploiting genetic potential of the crop for its growth and development. Under the present investigation the effect of increasing rates of application of NPK kg ha^{-1} on growth parameters of the crop was due to improvement in nutritional environment of the plants. The significant improvements in nutrient status of plant at harvest also suggest better availability of nutrients for growth and development of plant. Thus better nutritional environment in plant under the influence of increased NPK seems to have promoted height of plant by way of active cell elongation. These significant improvements in growth parameters of crop under the influence of NPK fertilizers are in close conformity with finding of Kumar *et al.,* (2014) and Kwadzo *et al.,* (2016), who had also observed similar results in maize with respect to plant height.

Increasing levels of zinc significantly increased plant height 85.58, 195.19 and 216.47 cm under 6.0 kg ha^{-1} zinc, which was statistically at par with 5.0 kg ha^{-1} zinc at 30, 60 DAS and at harvest respectively. Increasing levels of zinc significantly increases chlorophyll content of leaves at 50 DAS (1.906 mg g^{-1}) under zinc 6.0 kg ha^{-1}, which was statistically at par with 5.0 kg zinc ha^{-1} (1.896 mg g^{-1}). The favorable effect of applied zinc on plant height may be due to its stimulatory effect on most of the physiological and metabolic processes of plants.

Zinc is a constituent of carbonic anhydrase, and there is direct relationship between carbonic anhydrase and photosynthetic carbon dioxide assimilation on growth of plants. It is well known fact that zinc is involve in the protein synthesis, biosynthesis of Indole 3-acetic acid and hence increased plant height. It also performs many catalytic functions in the plant besides transformation of carbohydrates and chlorophyll synthesis.

The significant response to zinc in terms of improvement in plant height is further supported by the fact that soil of the experimental field was low in zinc status and its early supply corrected the deficiency and considerably improved the crop growth. Jangir *et al.,* (2015) and Gupta *et al.,* (2018) have confirmed the similar findings.

Yield attributes and yield

Data (Table 1) clearly indicates that the application of fertilizers up to 100% NPK ha^{-1} significantly increased number of grains cob^{-1} (387.17), cob length (22.80 cm) and 100 seed weight (25.84 g). The productivity of maize in terms of grain (2875.88 kg ha^{-1}), stover (4343.14 kg ha^{-1}) and biological yield (7219 kg ha^{-1}) also showed significant response with the application of 100% NPK over 50, 75% NPK and control (Table 2).

Table.1 Effect of different fertility and zinc levels on growth and yield attributes of maize

Treatments	**Plant height (cm)**			**Chlorophyll content in leaves (mg g^{-1}) at 50 DAS**	**Yield attributes**		
	30 DAS	**60 DAS**	**At harvest**		**Grain cob^{-1}**	**Cob length (cm)**	**Seed index (g)**
Fertility levels							
Control	74.24	180.82	209.46	1.587	294.02	15.91	19.98
50 % NPK	78.59	185.62	212.13	1.757	325.74	18.49	22.25
75 % NPK	82.26	193.11	214.56	1.851	356.37	20.65	24.05
100 % NPK	85.96	198.02	217.65	1.935	387.17	22.80	25.84
SE.m ±	1.27	1.66	0.84	0.029	10.59	0.73	0.61
CD (P=0.05)	3.67	4.79	2.42	0.083	30.59	2.11	1.76
Zinc levels (kg ha^{-1})							
Control	74.82	181.27	209.90	1.593	296.40	16.20	19.64
4.0	78.51	186.33	212.36	1.737	332.62	18.75	22.57
5.0	84.79	194.79	215.07	1.896	363.25	20.91	24.39
6.0	85.58	195.19	216.47	1.906	371.03	22.00	25.52
SE.m ±	1.27	1.66	0.84	0.029	10.59	0.73	0.61
CD (P=0.05)	3.67	4.79	2.42	0.083	30.59	2.11	1.76

Table.2 Effect of different fertility and zinc levels on quality and yield, net return and BC ratio of maize

Treatments	Protein content in grain (%)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Net return (Rs.ha^{-1})	Benefit-cost ratio
Fertility levels						
Control	9.35	1945.93	3227.67	5173.59	22747	1.29
50 % NPK	10.02	2254.45	3631.01	5885.46	26511	1.33
75 % NPK	10.43	2555.42	4003.18	6558.60	31176	1.48
100 % NPK	10.83	2875.88	4343.14	7219.01	36018	1.63
SEm ±	0.14	72.21	112.56	120.25	1065	0.05
CD (P=0.05)	0.39	208.57	325.09	347.31	3076	0.15
Zinc levels (kg ha^{-1})						
Control	9.56	1951.46	3221.93	5173.39	21328	1.11
4.0	10.03	2310.94	3669.00	5979.94	27147	1.34
5.0	10.48	2619.72	4062.62	6682.34	32835	1.60
6.0	10.55	2749.56	4251.43	7000.99	35141	1.69
SE.m ±	0.14	72.21	112.56	120.25	1065	0.05
CD (P=0.05)	0.39	208.57	325.09	347.31	3076	0.15

The findings of this investigation confirm the observations of earlier workers, Sharma *et al.*, (2017) and Singh *et al.*, (2017). Further data (Table 1) indicates that increasing rate of zinc up to 6.0 kg ha^{-1} significantly increases grains cob^{-1} (371.03), cob length (22 cm) and 100 seed weight (25.52g), which were at par with application of 5.0 kg ha^{-1} zinc.

Application of 6.0 kg ha^{-1} zinc produced maximum grain (2749.56 kg ha^{-1}), stover (4251.43 kg ha^{-1}) and biological (7000.99 kg ha^{-1}) yield, which were statistically at par with 5.0 kg ha^{-1} zinc.

The positive response of yield components of maize because of due to the greater availability of zinc and metabolites for growth and development of reproductive structure which ultimately led to recognition of higher productivity of individual plant. The increased availability of zinc and photosynthates might have enhanced number of grain cob^{-1} and cob length and test weight resulting in higher grain yield and stover yield (q ha^{-1}). The findings of present investigation are supported by Gupta *et al.*, (2018).

Quality parameters

Data Table 1 shows that increasing fertility levels up to 100% NPK ha^{-1} had significantly increased protein content in grain (10.83%), which was statistically superior over all lower levels of fertility. Further application of zinc 6.0 kg ha^{-1} significantly enhanced protein content in grain (10.55%), which was statistically at par with 5.0 kg ha^{-1} zinc (10.48%). These seems to be partly due to greater availability of nitrogen and phosphorus on account of increasing fertilization, which in turn increased nitrogen content of grain and partly due to accelerating effect of this nutrient on protein synthesis. The results are in close in conformity with Kumar *et al.*, (2014).

Economics

The maximum net return (Rs 36,018 ha^{-1}) and benefit cost ratio (1.63) was obtained under application of 100% NPK ha^{-1}, which was statistically higher over all other lower fertility levels. This could be primarily due to higher grain and stover yield with comparatively less additional cost of fertilizers under the treatment. The findings of this investigation are in close conformity with finding of Sharma *et al.*, (2017) and Singh *et al.*, (2017). Data Table 2 clearly indicating that the application of 6.0 kg zinc ha^{-1} significantly increased net return (Rs 35,141 ha^{-1}) and benefit cost ratio (1.69), which were at par with application of 5.0 kg ha^{-1} zinc. The findings of present investigation are in close conformity with Kumar *et al.,* (2014) and Gupta *et al.,* (2018).

On the basis of the results emanated from present investigation conducted during *kharif* 2018, it could be concluded that application of 100% NPK ha^{-1} and 6.0 kg zinc ha^{-1} may be applied in maize to achieve higher grain yield, net return and B-C ratio in sandy clay loam soil of sub-humid zone (lV-a) of Rajasthan.

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