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EFFECT OF PRIMARY NUTRIENT AND ZINC ON NUTRIENT UPTAKE AND YIELD ATTRIBUTES OF MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Field experiments were conducted in factorial design with three replications involving 9 treatment combination (three primary nutrient levels: 0, 50 and 100% RDF and zinc levels: 0, 10, and 20 kg/ha) to evaluate the effect of primary nutrient and zinc application on nutrient uptake, growth and yield attribute of maize (Zea mays L.). Results revealed that treatment combination P_2M_2 (@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}) significantly enhanced the growth and yield attribute, primary nutrient and zinc uptake, over their respective counter treatments. The highest dry weight in P_2M_2 (360.00 g) and the minimum was recorded in control of (307.33 g). Maximum grain yield (5.95 t ha^{-1}) and stover yield of (13.10 t ha^{-1}) was recorded in P_2M_2 followed by P_1M_1. The highest N, P_2O_5, K and $ZnSO_4$- uptake by grain (67.54, 10.73, 21.97 Kg ha^{-1} and 49.67 mg kg ha^{-1}) and stover (43.29, 4.83, 59.319 Kg ha^{-1}and 89.41 mg kg ha^{-1}) was recorded in the treatment combination i.e 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}. Treatment P_2M_2 was found to be the best.

INTRODUCTION

India with its vast population is confronted with food problem, where millions of people lack a wholes some diet face the increasing food requirement, decreasing of the availability of land per capita. The per capita land has decreased from 1.37 to 0.15 by the year 1999 inspite of increase in cultivated area of the country due to rehabilitation and better management (Behera and Sharma, 2007). World production of maize during 1995 amounted to 514.51 million tonnes with a yielding capacity of 3736 kg ha^{-1}, accounting for 63.93 % of the coarse grains and 27.1 percent of the total cereal production respectively. World production of maize during 2006-07 amounted to 686.75 million tonnes. Maize has the potential to supply large amounts of energy- rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic prussic acid (Jha *et al*., 2015).

In India it occupies an area of about 6.4 million ha with a production of 11.5 million tones and a productivity of 1.7 tonnes hectare. It is cultivated in diverse production environments, ranging from the temperate hill zones of Himachal Pradesh to the semi – arid deserts of Rajasthan. Uttar Pradesh stand first occupying 1396.6 thousand hectare and producing 1061.3 thousand tones (Economic Survey 2000-2001 and Ministry of Agriculture). Uttar Pradesh production of maize is 9 % out of 100 % percent world productions. Production of maize in Allahabad during 2005-06 amounted to 185 million tonnes. (Karvy comtrade limited, 2007).

Nitrogen is a component of protein and nucleic acids and when nitrogen is sub-optimal, growth is reduced (Singh *et al*., 2013). The recovery of applied nitrogen is low. Particularly in rainy season, the split application of nitrogen usually enhances its recovery and utilization. Demand of plants for nitrogen is more than any other nutrients but deficiencies is noticed at every stage of growth, especially at. Tasseling and silking stage, may lead to virtual crop failure. The nitrogen utilization pattern is found to be increased from seedling to knee- high stage and reach peak at tasseling stage when the plants remove nearly 4-5 Kg N ha^{-1} per day. It is interesting to note that the response of applied nitrogen is highest in poor fertility conditions than the normal ones. Therefore, split application of the same is needed. Best result are achieved when nitrogen applied in three split, *viz* ½th at sowing stage, ¼th at Knee stage (35-40 DAS) and remaining 1/4th at tessling stage. Fertiliser placement below the seed and side dressing of nitrogen at second and third application gives best results. Under ideal fertility management, it is reported than new plant types yield 15-25 Kg grain per kg of applied nitrogen. The crop is grown under rain fed or partially irrigated condition. During rainy season nitrogen loss through leaching becomes very obvious from the field.Phosphorus is one of the essential nutrient elements required by plants. Recommended dose of phosphorus in maize crop 60 kg ha^{-1} (Shekhawat *et al*. 2012). Phosphorus is helps in root formation, cell division and stimulates growth. Phosphorus make plants more drought and resistant. Increase protein and mineral contents in plant. Increase the ratio of grain to straw in cereals and thus increases the yield of grain. Phosphorus deficiencies show that growth is stunted, leaves become smaller in size, delay maturity and in maize leaves and stem become purple. Phosphorus available forms of nutrients in soil HPO_4^-. Potassium is one of the three major essential nutrient elements required by plants. Potassium is essential in all process needed to sustain plant life. The functions of potassium in the plant are numerous and complex. Potassium is expressed in terms of K_2O .Recommended dose of potassium in maize crop 40 kg ha^{-1} (Ibragimov, 1990). Potassium is absorbed by plants in the ionic form K^+. Generally in plant nutrition and for composition of fertilizers, potassium is expressed in terms of K_2O. Potassium is essential in nearly all processes needed to sustain plant life.

Zinc is secondary essential nutrient for plants and applied for Zn deficiency. Recommended dose of zinc in maize crop 20 kg ha^{-1} (Nayyar *et al*., 2001). In field crops are widespread all over the world because of increased Zn demands of intensive cropping system and adoption of high–yielding cultivars with relatively greater Zn demand. Zn –deficient areas are enhance production of crops on soils that contain low levels of Zn, increased use of high analysis fertilizers containing low amounts of Zn, decrease use of animal manures, compost, and crop residues, and involvement of natural and anthropogenic factors that limit adequate plant nutrient availability and create nutrient imbalances (Fageria *et al*., 2002). One study has found Zn deficiency in nearly 47% soil samples collected from agriculture crop fields (Singh, 1988). Keeping these facts in mind, the present investigation was attempted to study the effect of primary nutrient and zinc on nutrient uptake and yield attributes of maize (*Zea mays* L.).

MATERIALS AND METHODS

Climate and weather conditions

Sam Higgin bottom Institute of Agriculture, Technology and Sciences, Allahabad is situated at 25.57° North latitude and 81.5° East longitudes and a height of 98 m above mean sea level. This tract enjoys a semi arid, sub-tropical climate with extreme of temperature during summer (May-June) and the winter (Dec.-Jan.) are severe with minimum temperature of 3°C and in summer the temperature often goes to 48°C accompanied with hot and desiccating winds.

Experimental details

The experiment was laid out in 3 x 3 factorial designs with three replication in Maize as test crop during the Kharif season (mid June-mid November) of the year 2011 and 2012 in sandy loam soil (Sand 60.80%, Silt 24.10% and Clay 15.10%). Recommended Dose of Fertilizer (RDF) for N, P, K and Zn was 120 kg ha^{-1}, P_2O_5 60 kg ha^{-1}, K_2O 40 kg ha^{-1} and $ZnSO_4$ –20 kg ha^{-1}, respectively for maize.

Levels of primary nutrient (P)

Details of treatments and their combinations

Treatment	Combination	Description
T_0	P_0M_0	Control
T_1	P_0M_1	[@ 0 kg N ha^{-1} + 0 Kg P_2O_5 ha-[1] + 0 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_2	P_0M_2	[@ 0 kg N ha^{-1} +0 Kg P_2O_5 ha^{-1} + 0 Kg K_2O ha^{-1} + (@ 20 Kg $ZnSO_4$ ha^{-1}]
T_3	P_1M_0	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 0 Kg $ZnSO_4$ ha^{-1}]
T_4	P_1M_1	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_5	P_1M_2	[@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}]
T_6	P_2M_0	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1}+ @ 0 Kg $ZnSO_4$ ha^{-1}]
T_7	P_2M_1	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1}]
T_8	P_2M_2	[@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1}]

P0 = control

P1 = 50% RDF, N, P and K [(@ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1})]

P2 = 100% RDF, N, P and K. [(@ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1}

Levels of micronutrient (M)

M0 = Control

M1 = 50% RDF, $ZnSO_4$ [(@ 10 Kg $ZnSO_4$ ha^{-1})]

M2 = 100% RDF, $ZnSO_4$ [(@ 20 Kg $ZnSO_4$ ha^{-1})]

[Source: Urea (N), Single Super Phosphate (P_2O_5), Murate of Potash (K_2O), Zinc Sulphate]

Observation recorded in crop

During pre-harvest observation of plant height (cm), number of leaves per plant, stem diameter (cm), dry weight of the plant (g), no. of cobs per plant, at 30, 60 and 90 DAS were taken. Similarly, during Post-harvest, observation of length of cob (cm), no. of grains per cob (g), weight of cob (g), seed Index (1000), grain yield (Kg ha^{-1}), stover yield (kg ha^{-1}) were taken.

Soil observations

Post- harvest soil sample were taken to the plough layer (0-15cm depth) of each plot for determination of its chemical by using standard procedure i.e available N by Subbiah and Asija (1956), available phosphorous by Olsen *et al*. (1954), available potassium by Jackson (1973) and available Zn by Lindsay & Norvell, (1978).

Statistical analysis

The data will be recorded during the course of investigation were subjected to statistical analysis by 'analysis of variance technique' (Fisher, 1950) for drawing conclusion. The significant differences between the means were tested against the critical difference at 5% level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth attributes

There was a significant increase in plant height at 100% RDF of macronutrient level over 50 % RDF of macronutrient and

Table 1: Effect of different level of phosphorous and zinc on growth parameters of maize (2 year pool data)

Treatment	Plant height (cm)			No. of leaves per plant			Stem diameter (cm)			Dry weight (g)		
	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)
T_0	61.0	90.7	132.0	4.9	7.4	8.8	0.93	1.9	2.7	1.1	30.0	175.7
T_1	81.7	132.2	148.3	6.1	8.3	8.3	0.99	2.2	2.9	1.2	31.2	200.0
T_2	75.9	141.8	151.6	5.9	9.0	8.3	1.45	2.35	2.92	1.3	31.2	209.7
T_3	65.7	148.2	153.3	6.3	8.7	8.2	1.45	2.3	2.94	1.4	32.5	210.5
T_4	83.8	154.8	162.7	7.2	9.4	10.0	1.73	2.65	3.78	1.6	39.8	234.3
T_5	74.0	141.6	147.3	6.3	9.0	8.2	1.77	2.6	3.75	1.5	35.3	228.0
T_6	67.3	143.4	153.0	5.9	8.8	7.6	1.75	2.76	3.15	1.4	36.2	231.3
T_7	70.7	146.0	153.0	5.9	8.9	8.4	1.82	2.85	3.84	1.5	36.7	227.3
T_8	103.1	157.4	172.3	8.3	10.8	10.2	1.84	3.01	3.88	1.7	42.2	237.7
S. Em. (±)	0.31	0.54	2.71	0.09	0.13	0.11	0.054	0.057	0.045	0.271	0.569	2.802
C.D. at 5%	0.662	1.148	5.741	0.194	0.266	0.236	0.113	0.121	0.096	NS	1.207	5.940

Table 2: Effect of different levels of phosphorous and zinc levels on yield attributes of maize (2 year pool data)

Treatment	No. of cobsper plant	Length of cob (cm)	Weight of cob (g)	No. of grains per cob
T_0	1.00	15.5	67.3	279.16
T_1	1.00	17.13	88.33	373.83
T_2	1.00	17.83	86.5	382.50
T_3	1.50	18.28	81.66	386.33
T_4	1.83	20.93	102.8	482.66
T_5	1.66	20.75	97.52	472.00
T_6	1.66	19.8	98.8	454.00
T_7	1.50	20.5	92.68	463.00
T_8	2.00	21.75	105.26	485.33
S. Em. (±)	0.180	1.343	0.2	3.143
C.D at 5%	NS	NS	0.585	6.663

Table 3: Effect of different levels of phosphorous and zinc on grain yield of maize (2 year pool data)

Levels of (P)	Levels of (M)			Mean (M)
	M_0	M_1	M_2	
P_0	2.76	3.23	3.65	3.21
P_1	4.83	5.80	5.75	5.46
P_2	4.90	5.70	5.95	5.52
Mean (P)	4.16	4.91	5.12	
	S. Em. (±)	C.D. at 5%		
Macronutrient (P)	0.038	0.081		
Micronutrient $ZnSO_4$ (M)	0.038	0.081		
Interaction (P x M)	0.066	0.140		

Table 4: Effect of different levels of phosphorous and zinc on Stover yield of maize (2 year pool data)

Levels of (P)	Levels of (M)			Mean (M)
	M_0	M_1	M_2	
P_0	8.28	9.76	9.97	9.34
P_1	10.45	12.23	11.75	11.48
P_2	11.95	11.50	13.10	12.18
Mean (P)	10.23	11.16	11.61	
	S. Em. (±)	C.D. at 5%		
Macronutrient (P)	0.081	0.172		
Micronutrient $ZnSO_4$ (M)	0.081	0.172		
Interaction (P x M)	0.140	0.298		

control. At 90 DAS, treatment P_2M_2 (T_8) had maximum plant height of (172.3cm) greater than the control (132.0cm) (Table 1). The increase in number of leaves per plant between control and different level of N P K & Zn were significant at all the successive stage of growth. Among three levels of N P K & Zn, T_8 increased the number of leaves per plant followed by T_4 and showed significant increase over control at 90 DAS. At 90 DAS the maximum stem diameter was (3.88cm) in treatment combination of P_2M_2 followed by (3.84cm) in treatment combination of P_2M_1, respectively and the minimum of (2.70 cm) was found in control. The highest dry weight in T_8 (360.00 g) followed by (355.50 g) in T_4 and the minimum was recorded

Table 5: Effect of different levels of phosphorous and zinc uptake of maize crop (2 year pool data)

Treatment	N-uptake Kg ha^{-1}		K-uptake Kg ha^{-1}		P_2O_5-uptake Kg ha^{-1}		$ZnSO_4$ uptake mg ha^{-1}	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_0	39.85	25.54	11.60	31.32	4.5	2.03	40.63	73.13
T_1	38.21	24.49	14.77	39.879	6.25	2.91	50.00	90.00
T_2	50.60	32.44	17.70	47.79	7.10	3.20	45.33	81.59
T_3	54.60	35.00	12.82	34.614	4.90	2.23	48.00	86.40
T_4	59.45	38.11	18.68	50.436	8.80	3.95	44.67	80.41
T_5	51.66	33.12	15.97	43.119	8.07	3.67	41.67	75.01
T_6	47.70	30.58	15.53	41.931	6.00	2.70	48.00	86.40
T_7	48.80	31.28	13.72	37.044	5.77	2.63	43.33	77.99
T_8	67.54	43.29	21.97	59.319	10.73	4.83	49.67	89.41
S. Em. (±)	0.430	0.394	0.083	0.41	0.035	0.029	0.276	1.16
C.D. at 5%	0.912	0.826	0.175	0.869	0.075	0.061	0.585	2.45

in control of (307.33 g). Sharma *et al*. (1991) from his field experiment conducted at IARI, New Delhi, on sandy loam soil, reported a significant increase in the plant height and number of leaves plant^{-1}, with each successive increase in the level of fertilizers used. From Panthnagar, Shivay and Singh (2000) and Shivay *et al*. (2002) reported increase in plant height and dry matter accumulation in maize with the application of 120 kg N ha^{-1}. Similar findings were reported by Kapur and Rana (1980), Stromberger *et al*. (1994) and Dhingra *et al*. (1991) who supports the findings of the present investigation.

Yield attributes

The significantly maximum number of cobs per plant was (2.00) in treatment T_8 followed by (1.83) in treatment combination T_4 as reported by Sangoi (1990) (Table 2). The crop showed significant increasing trend in length of cob with each levels of N P K and Zn over the control. The maximum length was (21.75) in treatment T_8 followed by (20.93 cm) in treatment T_4 and minimum length was (15.5) in control. The increased length of cob was due to increasing levels of N P K and Zn. There was a significant difference in weight of cob when the plots were treated with difference levels of N P K and Zn. The maximum weight of cob (105.26 g) was recorded in treatment combination of P_2M_2 followed by P_1M_1 over the control. The effect of different levels of N P K and Zn on number of grains per cob was statistically significant and found higher in T_8 (485.33) and minimum in T_0 i.e 279.16. Verma and Singh (1976) from Agra and Dhillon *et al*. (1987) from Ludhiana reported increase in yield attributing characters with increase rate of N application up to 120 kg ha^{-1} on sandy loam soils.

Yield

There was a significant difference in grain yield when the plots were treated with different levels of N P K and Zn i.e maximum yield (5.95 t ha^{-1}) was recorded in P_2M_2 followed by P_1M_1 over the control (2.76) (Table 3). From a field study conducted during winter seasons on sandy loam soils of Hissar, Nandal and Agarwal (1991) reported a linear response of maize to nitrogen application. These results were supported by the findings of Mishra (1993) and Gill *et al*. (1994).

The maximum Stover yield of (13.10 t ha^{-1}) was recorded in P_2M_2 treatment followed by P_1M_1 (12.23 t ha^{-1}) whereas minimum of (8.28 t ha^{-1}) was found in P_0M_0 (control) (Table 4). Padmaja *et al*. (1991) reported that the grain and stover yields were increased significantly with increase in the level of N from 0 to 150 kg ha^{-1} on clay soils of Bapatla during rabi season. Similar findings were reported by Gaur (1991), Oleson *et al*. (1994) and Stromberger *et al*. (1994).

Nutrient uptake

From the table 5 it may be seen that interaction between different N P K and Zn was significant. The highest N- uptake by grain (67.54 Kg ha^{-1}) and stover (43.29 Kg ha^{-1}) was recorded in the treatment combination of N P K and Zn @ 120 Kg N ha^{-1} + 60 Kg P_2O_5 ha^{-1} + 40 Kg K_2O ha^{-1} + @ 20 Kg $ZnSO_4$ ha^{-1} followed by (59.45Kg ha-1 in grain and 38.11 Kg ha^{-1})in the treatment combination of N P K and Zn @ 60 kg N ha^{-1} +30 Kg P_2O_5 ha^{-1} + 20 Kg K_2O ha^{-1} + @ 10 Kg $ZnSO_4$ ha^{-1} respectively and the minimum of (39.85 Kg ha^{-1}) was found in control. Munaswamy et al (1989) reported that uptake of N at harvest was significantly increased with increasing N levels up to 120 kg N ha^{-1}. Similar findings was observed by Burns and Ebelhar (2006).

The highest P_2O_5 and K uptake by grain (10.73, 21.97 Kg ha^{-1}) and stover (4.83, 59.319 Kg ha^{-1}) by was recorded in T_8 treatment (P_2M_2) followed by 8.80 Kg ha^{-1} and 18.68 Kg ha^{-1} in T_4 (P_1M_1) and minimum in control (4.57, 11.60Kg ha^{-1}) respectively. Ananthi *et al*. (2010) from their study at Coimbatore on sandy loam soils during kharif season reported that uptake of P increased with increase in phosphorus from 75 to 100 kg P_2O_5 ha^{-1}.

The highest $ZnSO_4$- uptake by grain (49.67 mg kg ha^{-1}) and stover (89.41 mg kg ha^{-1}) was recorded in treatment P_2M_2 followed by 44.67 mg kg ha^{-1} in the treatment P_1M_1 and minimum in control (4.63 mg kg ha^{-1}). Similar findings were reported by Uribelarrea *et al*. (2004) and Abunyewaa and Quareshie (2004) who observed that application of Zn at higher levels increased grain yield.

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