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Effect of different levels of phosphorus and zinc on yield and nutrients uptake of maize (*Zea mays*) with and without irrigation

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 1994 and 1995 at New Delhi, to study the response of maize (*Zea mays* L.) to different levels of phosphorus and zinc with and without irrigation. An application of 90 kg P_2O_5/ha resulted in significantly more grain and straw yields, nutrients uptake and protein yield, compared with 60, 30 and 0 kg P_2O_5/ha. Significantly higher grain and straw yields, nutrients uptake and protein yield of maize were obtained with 30 kg $ZnSO_4$/ha than 15 kg $ZnSO_4$/ha. Irrigation significantly increased the yields and quality parameters over no irrigation during both the years.

Key words : Maize, Nutrients, Water-use efficiency, *Zea mays*, Synthesis, Metabolism

In India, maize occupies fifth rank in area (6.02 million ha), forth position in total production (9.4 million tonnes) and third position in respect of productivity (1,570 kg/ha) (AICMIP, 1996). The average yield of maize in our country is very low compared to the world's productivity, due to erratic rainfall, insufficient and unbalanced fertilizer use and excessive weed growth in rainy (*kharif*) season. For sustainable agriculture, it has become desirable to diversify crop production with its wider adaptability, higher yielding ability and fast-growing habit as a potential alternative. Therefore an attempt was made to increase the productivity and quality of maize with different levels of phosphorus and zinc under irrigated conditions.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 1994 and 1995 at the Indian Agricultural Research Institute, New Delhi. The treatment combinations, comprising 4 levels of phosphorus, viz. 0, 30, 60 and 90 kg P_2O_5/ha, 2 levels of zinc viz, 15 and 30 kg $ZnSO_4$/ha and 2 levels of irrigation with (as and when required) and

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without irrigation (no irrigation), were evaluated in factorial randomized block design with 4 replications. The soil of experimental field was sandy loam, having pH 7.50. The soil was low in organic carbon (0.38%), total available N (0.03%), available P (12.53 kg/ha) and medium in available K (153.62 kg/ha). Maize seed was sow dibbled on 11 July 1994 and 15 July 1995 at a spacing of 75 cm between rows and 20 cm between plants. The harvesting was done on 11 October 1994 and 23 October 1995. A uniform dose of 120 kg N/ha was applied in 3 equal splits at sowing, knee high and tasselling stages. However, phosphorus and zinc were applied as per treatments at time of sowing. A basal dose of 40 kg K_2O/ha was also used. Total rainfall was received 652 mm and 680 mm during the crop-growth period in 1994 and 1995 respectively.

RESULTS AND DISCUSSION

Yield

Significantly higher grain and stover yields were obtained with 2 irritations given as and when required as compared with no irrigation (Table 1). An increase in grain and stover yield with irrigation was 7.62 and 6.06% and 39.3 and 12.2% over unirrigated control during 1994 and 1995 respectively. The adequate availability of irrigation water and plant nutrients with 1 irrigation might have been the cause for higher yield as compared to no irrigation. The increase in yield of maize with irrigation was also reported by Jadhav *et al.* (1992) and Bhoi and Desai (1994).

Among the various levels of phosphorus, P at 90 kg P_2O_5/ha resulted in significantly higher grain and stover yields than the other levels. The magnitude of increase in grain and stover yield was 17.2, 54.4 and 82.3% and 6.5, 37.3 and 59.6% in 1994 and 22.1, 26.2 and 56.2% and 20.9, 22.7 and 39.3% in 1995 with 30, 60 and 90 kg P_2O_5/ha over the control respectively. Ahlawat and Singh (1991) also reported an increase in the grain and stover yields owing to improvement in growth and yield component.

Significantly higher grain and stover yields of maize were obtained with zinc applied at 30 kg $ZnSO_4$/ha compared to 15 kg $ZnSO_4$/ha during 1994 and 1995 respectively. The increase in grain and stover yield was 9.6 and 9.3% and 6.3% and 5.6% during 1994 and 1995 respectively. The grain and stover yields increased owing to zinc application which takes part in metabolism of plant as an activator of several enzymes and in turn may directly or indirectly affect the synthesis of carbohydrate and protein (Narwal *et al.*, 1993).

Nutrients uptake

Nutrients uptake in grain and straw (Table 2) showed that P, K and Zn uptake in grain and straw increased with irrigation than without irrigation. The N uptake both in grain and straw increased significantly under without irrigation treatment as compared to with irrigation. The higher content of phosphorus with irrigation as compared to without irrigation might have been due to rate of conversion of P into soluble form (ferric) from that of insoluble form (ferrous) under irrigated condition. The uptake of nutrients might be because of better root establishment, resulting in

Table 1. Grain and stover yields and harvest index of maize as affected by irrigation, phosphorus and zinc

Treatment	Yield (q/ha)						Harvest index (%)	
	Grain			Stover				
	1994	1995	Pooled	1994	1995	Pooled	1994	1995
Irrigation								
With irrigation	46.41	35.20	40.69	63.81	50.81	57.35	41.58	40.85
Without irrigation	42.87	33.19	38.05	45.82	45.34	45.59	47.96	44.22
CD (P = 0.05)	1.96	1.38	1.21	1.74	2.44	1.58	1.38	0.58
Phosphorus (kg P_2O_5/ha)								
0	32.14	27.11	29.65	43.56	39.31	41.45	42.52	40.94
30	37.67	33.10	35.39	46.40	47.52	46.97	44.67	41.14
60	49.63	34.21	41.93	59.81	48.25	54.04	45.84	41.51
90	58.58	42.35	50.48	69.50	57.35	63.43	46.04	42.54
CD (P = 0.05)	2.77	1.95	1.71	2.46	3.45	2.23	1.95	0.81
Zinc (kg $ZnSO_4$/ha)								
15	42.46	32.68	37.58	53.15	46.79	49.98	44.22	41.18
30	46.55	35.71	41.15	56.50	49.43	52.97	45.32	41.88
CD (P = 0.05)		1.96	1.38	1.21	2.44	1.58	NS	0.58

higher absorption of nutrients to feed and sustain increased growth which led to higher grain and stover yields. Raju and Iruthayaraj (1995) also reported higher uptake of nutrients with irrigation

Among the various levels of phosphorus, increasing dose of P up to highest tested dose increased significantly N, P, K and Zn uptake in grain and straw as compared to rest of the treatments. Application of 60 and 30 kg P_2O_5/ha also significantly increased nutrients (N,P, K and Zn) uptake in grain and straw compared to the control during both the years. The beneficial effect might be due to the fact that application of zinc increased leaf and soil zinc content (Fornasieri Filo, 1994; Gupta *et al.*, 1993).

Application of 30 kg $ZnSO_4$/ha resulted in significantly more N, P, K and Zn uptake in grain and straw than 15 kg $ZnSo_4$/ha.

Protein yield

Protein yield decreased significantly under irrigated condition compared to ramified condition during 1995. The increase in protein yield under rainfed condition to the tune of 3.92% than irrigated condition during 1995. Application of P @ 90 kg P_2O_5/ha resulted in significantly more protein yield than the lower doses of P. Significantly higher protein yield was also recorded with 60 and 30 kg P_2O_5/ha than the control. The magnitude increase in protein yield was 103.40, 75.36 and 63.74% and 34.96, 20,78 and 26.07% with the application of 90, 60 and 30 kg P_2O_5/ha over the control during 1994 and 1995 respectively. Application of

Table 2. Effect of irrigation, phosphorus and zinc on N, P, K and Zn uptake in grain and stover of maize at harvest and on protein yield

Treatment	Uptake (kg/ha)																Protein yield (kg/ha)	
	Grain								Stover									
	N		P		K		Zn		N		P		K		Zn			
	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995		
Irrigation																		
With irrigation	59.52	48.57	18.44	16.17	19.33	16.00	0.21	0.19	39.12	27.11	10.85	8.14	70.83	55.97	0.26	0.20	374.67	306.00
Without irrigation	59.16	50.45	18.85	11.63	16.67	14.00	0.19	0.17	30.24	28.19	7.33	6.80	48.57	48.06	0.17	0.14	374.00	318.00
CD (P = 0.05)	NS	1.89	1.04	0.69	1.06	0.62	0.012	0.010	0.45	0.46	0.42	0.54	1.71	1.92	0.014	0.017	NS	11.99
P (kg P_2O_5/ha)																		
0	40.75	37.41	8.92	8.46	11.33	10.00	0.12	0.12	25.48	20.79	5.73	4.27	43.56	39.31	0.51	0.12	254.67	232.67
30	49.33	47.1411,88		11.46	14.00	13.33	0.16	0.16	28.56	26.43	6.96	6.65	48.26	49.90	0.17	0.15	307.33	293.33
60	67.00	50.28	18.29	13.79	20.00	15.33	0.23	0.19	38.16	27.88	10.77	8.20	66.39	53.08	0.24	0.18	417.33	314.00
90	83.18	65.22	27.50	21.88	26.00	20.67	0.29	0.25	46.51	35.53	15.29	10.90	82.71	65.95	0.32	0.24	518.00	408.00
CD (P = 0.05)	3.77	2.67	1.47	0.98	1.50	0.87	0.017	0.014	0.63	0.65	0.59	0.77	2.42	2.72	0.113	0.140	23.35	16.96
Zinc (kg $ZnSO_4$/ha)																		
15	56.04	47.05	14.88	12.65	15.67	14.00	0.19	0.17	33.21	26.55	8.50	7.02	56.87	49.60	0.20	0.16	352.67	294.67
30	61.44	52.49	18.42	15.15	18.67	16.00	0.21	0.19	36.94	28.75	9.61	7.91	62.15	53.88	0.23	0.18	396.67	330.33
CD (P = 0.05)	2.67	1.89	1.04	0.69	1.06	0.62	0.012	0.010	0.45	0.46	0.42	0.54	1.71	1.92	0.014	0.017	16.51	11.99

30 kg P_2O_5/ha over the control during 1994 and 1995 respectively. Application of 30 kg $ZnSO_4$/ha significantly of increased the protein yield over 15 kg $ZnSO_4$/ha. The vital role played by zinc in synthesis of protein and indole acitic acid, chlorophyll formation and carbohydrate matabolism and in auxin metabolism may be assigned for increased protein content in maize grain. Narwal *et al* (1993) also reported similar results.

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