

ZINC AND PHOSPHORUS INTERACTION ON GROWTH AND NUTRIENT UPTAKE BY WHEAT

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ABSTRACT

A field experiment on zinc and phosphate fertilization to wheat was undertaken in *rabi* 1981-82 on a silty clay loam soil. Application of zinc and phosphorus alone or in combination recorded a significant increase in grain, straw and nutrient yield in wheat. Significantly highest yield of these parameters were recorded in phosphate fertilized plots when zinc was applied as foliar spray in conjunction with lime. Significant decrease in the concentration of zinc and phosphorus occurred as a result of P and Zn fertilization, respectively. Soil application of $ZnSO_4$ beyond 20 kg/ha level, resulted in significant decrease in yield of grain, straw and various nutrients.

INTRODUCTION

Looking to the importance of zinc in plant nutrition and breaking up the present day yield potential of the high yielding varieties, it comes on priority to evolve better methods and optimum level of its application, alone or in combination, specially with phosphorus. With these objectives a field experiment was conducted taking wheat (*Triticum aestivum* L.) var. Lok-1 as a test crop to assess the effect of different levels of zinc and phosphorus in conjunction with mode of zinc application.

MATERIAL AND METHODS

The experiment on wheat (var. Lok-1) was conducted at Vidhya Peeth Farm of Sukhadia University, Udaipur during *rabi* 1981-82. The soil of the

experimental field was normal in reaction (pH 8.3 and EC 0.9 mmhos/cm), silty clay loam in texture, high in nitrogen, organic carbon (0.82%), medium in phosphorus (26 kg available P_2O_5 /ha) and low in potassium (150 kg available K_2O /ha). The available zinc status (DTPA extractable) of the soil was 1.6 ppm.

Three levels (0, 20 and 40 kg $ZnSO_4$ /ha) of zinc as soil application were compared with two foliar sprays of 0.5 per cent solution (1000 litres/ha of solution per spray) of zinc sulphate with and without lime (0.25%) at 60 and 70 days of crop growth in conjunction with two levels (0 and 40 kg P_2O_5 /ha) of phosphorus. The experiment was conducted in a randomized block design replicating each treatment thrice in a plot size of 4×3 m. A basal dose of

40 kg N/ha and 40 kg K₂O/ha was given at the time of sowing Top dressing of 40 kg N/ha was done in two splits i.e. at tillering and flag leaf initiation stages of wheat. Eight irrigations were given to maintain the proper soil moisture regime. Crop was harvested at maturity and yields of grain and straw were computed in q/ha. Grain and straw samples were drawn treatment-wise and then analysed for nitrogen, phosphorus, potassium and zinc contents following standard methods of analysis.

RESULTS AND DISCUSSION

Zinc when applied as soil or foliar spray, significantly increased the grain as well as straw yield of wheat (Table 1). However, application of zinc as foliar spray with lime was better

than the soil application and resulted in significantly highest grain and straw yields, respective increase in yield over no zinc treatment being 39.9 and 40.0 per cent. Soil application of zinc improved the yield of grain and straw only upto 20 kg ZnSO₄/ha level (Brar and Sekhon, 1978) and the magnitude of increase recorded over no zinc treatment was 25.0 and 25.0 per cent, respectively. Similar observations were made by Sharma *et al.* (1970) and Kene and Deshpande (1980). The superiority of foliar spray of zinc sulphate over its soil application is in conformity with the findings of Ahlawat (1974) and Prem Kumar *et al.* (1979). Like zinc, phosphorus fertilization also significantly increased the grain and straw yield of wheat (Table 1).

Table 1. Effect of zinc and phosphorus fertilization on the yield and total uptake of nutrients by wheat

Treatments	Yield (q/ha)		Nutrient uptake (Grain + Straw)			
	Grain	Straw	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Zinc (g/ha)
<i>ZINC</i>						
Soil application (kg ZnSO ₄ /ha)						
0	24.97	37.50	59.31	8.09	37.71	102.09
20	31.22	46.88	81.03	9.06	44.88	136.69
40	28.72	43.18	72.89	7.13	42.22	129.71
Foliar spray						
ZnSO ₄ (0.5%)	29.85	45.00	72.93	8.26	43.08	137.95
ZnSO ₄ (0.5%) + Lime (0.25%)	34.95	52.50	86.36	10.70	52.82	170.47
S. Em ±	0.52	0.76	1.544	0.333	1.061	2.743
CD 5%	1.54	2.27	4.587	0.990	3.153	8.150
<i>PHOSPHORUS</i>						
Phosphorus application (kg P ₂ O ₅ /ha)						
0	27.46	41.25	65.99	7.02	39.59	122.42
40	32.42	48.75	83.01	10.27	48.69	148.34
S. Em ±	0.32	0.48	0.976	0.211	0.671	1.734
CD 5%	0.98	1.43	2.901	0.626	1.994	5.154

Interaction between zinc and phosphorus fertilization on grain and straw yield of wheat (Table 2) revealed that zinc applied as foliar spray in conjunction with lime on the crop raised in plots receiving 40 kg P₂O₅/ha, resulted in significantly higher grain (39.93 q/ha) and straw (60.0 q/ha) yields. Soil application of zinc sulphate at 20 kg/ha level in phosphate fertilized plots ranked second in improving the grain and straw yields and it remained almost at par with the foliar spray of zinc sulphate alone. Application of zinc sulphate beyond 20 kg/ha level with or without phosphorus, significantly decreased the grain and straw yield of wheat.

Table 2. Zn-P interaction effect on grain and straw yields (q/ha) of wheat

Phosphorus levels	Zinc treatments				
	Soil application (kg ZnSO ₄ /ha)			Foliar spray	
	0	20	40	ZnSO ₄ (0.5%)	ZnSO ₄ + Lime (0.5%) (0.25%)
GRAIN					
0	22.47	29.97	27.27	27.43	29.97
40	27.47	32.47	29.97	32.27	39.93
S. Em ±				0.73	
CD 5%				2.18	
STRAW					
0	33.75	45.00	41.25	41.25	45.00
40	41.25	48.75	45.00	48.75	60.00
S. Em ±				1.08	
CD 5%				3.21	

The soil responded to low level of zinc (20 kg ZnSO₄/ha or 2 ppm of Zn) though the DTPA extractable soil zinc was 1.6 ppm. This showed that the soil under study is marginally deficient in Zn. A critical level of DTPA extractable zinc as 1.4 ppm for maize and 1.6 ppm for rice have also been reported by Singh *et al.* (1977) and Gangwar and Chandra (1976), respectively.

The higher response of zinc when applied as foliar spray in the phosphate fertilized plots may be attributed to the fact that phosphorus fertilization results in more proliferated root system; thereby increasing growth of plants and thus making them more responsive to zinc applied as foliar spray (Brown *et al.*, 1970). Further, the foliar application of zinc eliminates antagonistic effect of zinc and phosphorus and may thus jointly boost the yield of the crop and maintain a favourable balance between P and Zn in plant and may also increase the phosphorus utilization by its effect on phosphate metabolism (Watenabe *et al.*, 1955; Rossel and Ulrich, 1964). Increase in the yield of wheat with the application of zinc in combination with phosphorus have also been reported by Gautam *et al.* (1964), Singh and Tripathi (1974) and Singh and Singh (1979). The boosting effect of lime along with zinc sulphate may be attributed to the fact that lime neutralizes the acidity developed due to zinc sulphate salt in the spray solution and thereby, avoids phytotoxicity.

Fertilization with phosphorus and zinc upto 20 kg ZnSO₄/ha in soil and as foliar spray in conjunction with lime

significantly increased the nitrogen content of grain (Table 3). Beneficial effect of zinc and phosphorus fertilization on the nitrogen content in wheat has also been reported by Raj Gopal and Mehta (1971) and Mallik *et al.* (1965), respectively. The nitrogen content of straw remained unaltered with the levels and mode of zinc applied and rather significantly decreased with phosphorus fertilization. Decrease in nitrogen by phosphorus fertilization may be attributed to the dilution effect owing to the increase in the yield of dry matter (Rossel and Ulrich, 1964). The phosphorus content of grain and straw significantly increased with phosphorus fertilization (Gupta *et al.*, 1969; Khan and Zende, 1976; Tiwari and Pathak, 1978.; Devarajan *et al.*, 1980) and decreased with zinc fertilization (Sambornarman *et al.*, 1968). Further, zinc fertilization either as soil or as foliar spray markedly increased the zinc content of grain and straw (Takkar *et al.*, 1975; Rathore *et al.*, 1978). However, a significant decrease in zinc content was recorded with phosphorus fertilization. Significant decrease in the concentration of zinc and phosphorus with P and Zn fertilization respectively, has also been recorded by Tiwari and Pathak (1978). The potassium content of grain and straw with zinc as well as phosphorus fertilization in the present study is in conformity with the findings of Raj Gopal and Mehta (1971).

Table 3. Effect of zinc and phosphorus fertilization on the nutrient contents of wheat

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (ppm)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
<i>ZINC</i>								
Soil application (kg ZnSO ₄ /ha)								
0	1.70	0.44	0.215	0.070	0.22	0.86	21.70	12.95
20	1.90	0.45	0.190	0.055	0.21	0.82	23.60	13.40
40	1.85	0.45	0.165	0.055	0.21	0.84	24.00	14.00
Foliar spray								
ZnSO ₄ (0.5%)	1.75	0.45	0.180	0.063	0.21	0.82	23.70	14.90
ZnSO ₄ (0.5%) + Lime (0.25%)	1.80	0.44	0.200	0.068	0.22	0.86	24.47	16.30
S. Em ±	0.025	0.006	0.008	0.001	0.006	0.017	0.463	0.353
CD 5%	0.074	NS	0.023	0.004	NS	NS	1.376	1.048
<i>PHOSPHORUS</i>								
Phosphorus application (kg P ₂ O ₅ /ha)								
0	1.69	0.47	0.170	0.060	0.21	0.82	23.95	13.68
40	1.91	0.43	0.210	0.071	0.21	0.86	23.04	14.94
S. Em ±	0.015	0.004	0.005	0.001	0.004	0.010	0.293	0.223
CD 5%	0.044	0.012	0.015	0.003	NS	NS	0.871	0.662

Like grain and straw yield, uptake of nitrogen, phosphorus, potassium and zinc (Table 1) was also highest in the wheat plants raised in plots receiving foliar spray in conjunction with lime. Soil application of zinc sulphate beyond 20 kg/ha level markedly decreased and phosphate fertilization at 40 kg P₂O₅/ha significantly increased the uptake of the nutrients. Data on Zn-P interaction (Table 4) indicate that in phosphorus fertilized plots, application of zinc as foliar spray in conjunction with lime resulted in significantly high uptake of various nutrients. This was followed by the soil application of zinc sulphate at 20 kg/ha in the plot fertilized with phosphorus. However, foliar application of zinc sulphate alone remained statistically

at par with the latter treatment and influenced the total uptake of phosphorus, potassium and zinc.

Increase in the nutrient uptake, as a result of zinc and phosphorus fertilization, can be attributed to the increased dry matter production (Mehrotra and Saxena, 1967 and Gupta *et al.*, 1969), Khan and Zende (1976) and Tiwari and Pathak (1978) reported that zinc and phosphorus interaction lead to highly significant increase in the uptake of phosphorus and zinc in wheat and rice crops. Although zinc and phosphorus interaction has no effect on potassium content of plant but increase the uptake of potassium (Raj Gopal and Mehta, 1971).

Table 4. Zn-P interaction effect on total uptake of nutrients by wheat

Phosphorus levels	Zinc treatments					
	Soil application (kg ZnSO ₄ /ha)			Foliar spray		
	0	20	40	ZnSO ₄ (0.5%)	ZnSO ₄ + (0.5%)	Lime (0.25%)
	Nitrogen (kg/ha)					
0	51.49	74.03	66.03	66.81	71.62	
40	67.13	88.04	79.75	79.05	101.11	
S. Em. ±				2.183		
CD 5%				6.488		
	Phosphorus (Kg/ha)					
0	6.30	7.89	6.17	6.65	8.10	
40	9.88	10.22	8.08	9.87	13.29	
S. Em ±				0.471		
CD 5%				1.400		
	Potassium (Kg/ha)					
0	33.05	41.97	40.39	38.42	44.12	
40	42.38	47.79	44.05	47.73	61.52	
S. Em ±				1.501		
CD 5%				4.460		
	Zinc (g/ha)					
0	97.79	125.37	113.08	125.63	150.23	
40	106.39	148.02	146.33	150.26	190.70	
S. Em ±				3.879		
CD 5%				11.526		

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