

## Effect of phosphorus and zinc nutrition of wheat (*Triticum aestivum*) in soils of sub-humid southern plains of Rajasthan

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### ABSTRACT

A field experiment was conducted to study the individual and interactive effect of P and Zn on yield, nutrient composition and uptake of nutrients in wheat (*Triticum aestivum* L. emend. Fiori & Paol.). The grain and straw yields increased significantly with increasing doses of P and Zn. The interaction between P and Zn also had significantly beneficial effect on the yields of wheat. The content and uptake of N by wheat grain and straw increased significantly with P and Zn application. The content of P in grain and straw decreased but its uptake increased with applied Zn. There was adverse effect of higher level of Zn on P uptake and vice-versa. The content and uptake of Zn increased significantly with increasing levels of Zn. Variation of P : Zn ratio due to increasing level of P also indicated the reduction in Zn content in grain and straw.

**Key words :** Phosphorus, Zinc, Nutrition, Wheat

A favourable balance between phosphorus and zinc should be maintained for optimum growth of plant. Most of the soils in Rajasthan have been rated as deficient in available zinc (Akbari *et al.*, 1995) and wide-spread Zn deficiency has been reported on several crops. Ismail *et al.* (1996) reported antagonistic effect of zinc on phosphorus nutrition in wheat. The information on Zn and P relationship in an important crop like wheat is not adequate, especially in situations where both the interacting nutrients (P and Zn) are deficient or low in soil. Therefore the present investigation was carried out to study the effect of P and Zn application on yield and nutrient uptake in wheat grown in soil of sub-humid southern plains of Rajasthan.

### MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 1997–98 and 1998–99 and farmers field in Kochar Village of Udaipur district of Rajasthan. The experimental soil had pH 7.4, EC (1: 2) 0.11 dS/m, organic carbon 0.21%, available N 55 kg/ha, available P 7.0 kg/ha and DTPA- extractable Zn 0.32 mg/kg. Four levels each of P (0, 30, 60 and 90 kg P<sub>2</sub>O<sub>5</sub>/ha as diammonium phosphate) and ZnSO<sub>4</sub> (0, 10, 20 and 40 kg/ha) were applied in 16 treatment combinations, replicated thrice in randomized block design. A common basal dose of 120 kg

N/ha through urea and 60 kg K<sub>2</sub>O/ha through muriate of potash was applied to all the plots. The plot size was 5.0 m × 3.6 m with row spacing of 20 cm. Wheat var. 'Raj. 1482', was sown on 15 and 17 November in 1997 and 1998 and harvested on 8 and 9 April in 1998 and 1999 respectively. Grain and straw samples collected at maturity and were analysed for their P and Zn contents. Processed samples were digested in diacid (HNO<sub>3</sub>: HClO<sub>4</sub>) mixture and P in acid extract was estimated by Vanadomolybdo phosphoric yellow method. Zinc was determined by atomic absorption spectrophotometer.

### RESULTS AND DISCUSSION

Successive increase in P level up to 90 kg P<sub>2</sub>O<sub>5</sub>/ha resulted in enhanced grain and straw yields yield of wheat (Table 1). The level 60 kg P<sub>2</sub>O<sub>5</sub>/ha appeared optimum dose, as that level increased the grain and straw yields significantly by 12.1 and 9.2%, respectively, over the control. The subsequent higher level of P (90 kg P<sub>2</sub>O<sub>5</sub>/ha) was statistically at par with 60 kg P<sub>2</sub>O<sub>5</sub>/ha in increasing the yield. The increase in yield of wheat grain and straw with P application is due to fact that soil under study was deficient in available P (7.0 kg P/ha). Choudhary *et al.* (1997) and Sharma and Bapat (2000) also observed increase in yield of wheat with increasing levels of P on phosphorus-deficient soils. The yield of wheat grain

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**Table 1.** Effect of and zinc sulphate levels on yield, content and P Zn ratio in wheat grain straw (pooled data)

Treatment	Yield (q/ha)		P content (%)		Zn content (mg/ka)		P : Zn ratio	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
<i>P</i> (kg $P_2O_5$ /ha)								
0	37.63	55.95	0.17	0.09	32.5	28.5	53.1	31.2
30	42.17	61.11	0.18	0.10	29.5	25.5	63.7	41.0
60	44.26	65.02	0.21	0.11	27.8	23.8	76.1	49.5
90	44.63	66.49	0.22	0.13	25.5	21.9	87.6	63.2
CD (P=0.05)	1.03	1.47	0.15	0.013	0.56	0.41	5.70	6.21
<i>ZnSO<sub>4</sub></i> (kg/ha)								
0	39.87	59.22	0.22	0.13	26.2	22.2	83.9	59.5
10	41.49	61.67	0.21	0.12	28.0	24.0	74.8	50.9
20	42.58	63.46	0.19	0.10	29.4	25.7	65.3	41.3
40	43.70	65.06	0.17	0.08	31.7	27.8	56.5	33.3
CD (P=0.05)	1.03	1.47	0.15	0.13	0.56	0.41	5.70	6.21

straw (Table 1) increased significantly owing to application of zinc by 9.6 and 10.0 %, respectively, with the application of 40 kg  $ZnSO_4$ /ha. This might be due to its function as catalyst or stimulant in most of the physiological and metabolic processes and metal activator of enzymes, resulting in increased growth and development, which ultimately gave higher grain and straw yields of wheat. However, the response was better at lower rate of zinc sulphate (20 kg/ha) application rather than at higher rate. Increase in yield due to application of Zn is quite obvious, as the soil under study was deficient in available zinc (0.32 mg/kg). Patel *et al.* (1995) also noted a significant response of wheat to zinc applied to deficient soils. Based on mean of 2 years data, the interaction effect of P and Zn was significant for grain and straw yield (Table 2). All the levels of zinc sulphate increased the grain yield of wheat significantly at each level of P and vice versa. Maximum grain and straw yields were recorded at 90 kg  $P_2O_5$ + 40 kg  $ZnSO_4$ /ha treatment. This favourable effect of P and Zn combination may be because addition of Zn with P might have maintained a favourable balance between P and Zn in the wheat plants for optimum growth. Sharma and Bapat (2000) also reported response of wheat to P and Zn applied in deficient soil.

Based on the regression equations, the response of wheat to P was quadratic ( $Y = 37.485 + 0.1662X - 0.0010X^2$ ), whereas it was linear to Zn application. The optimum doses of P was 82.44 kg  $P_2O_5$ /ha.

The P content of grain and straw of wheat increased significantly with increasing doses of P (Table 1) in both crop-seasons which may be attributed to root proliferation by phosphorus, resulting in higher content of P in the crop. Application of zinc significantly decreased the P content in both grain and straw. The P content in grain

decreased from 0.22% at the control to 0.17% with 40 kg zinc sulphate/ha. The corresponding reduction in P content in straw was from 0.13 to 0.08%. Damodar Reddy and Yadav (1994) also reported decrease in P content due to zinc application. A significant increase in the Zn content of grain and straw of wheat with a corresponding increase in the Zn dose was observed (Table 1). In the first year, application of 40 kg  $ZnSO_4$ /ha increased the zinc content of grain by 5.5 mg/kg and that of straw by 5.6 mg/kg over the control. Almost similar was the extent of increase in Zn content of grain and straw in the second year. Similar results were reported by Sahu *et al.* (1996). Zinc content of the grain and straw of wheat decreased significantly as the dose of P increased. This decrease in Zn content at an increased P level may be due to the depressive effect of P on zinc. Phosphorus was found to inhibit the translocation of zinc from roots to the above-ground portions of the plants, thus affecting zinc concentration adversely in plant tissue. Sharma and Bapat (2000) also reported similar findings.

The P : Zn ratio of the grain and straw of wheat decreased significantly with the increase in level of Zn, indicating high responsiveness of wheat due to zinc applica-

**Table 2.** Interaction effect of phosphorus and zinc levels on grain yield (q/ha) of wheat (pooled data)

P ( $P_2O_5$ kg/ha)	Zinc sulphate (kg/ha)			
	0	10	20	80
0	35.55	37.68	38.82	38.46
30	39.32	40.59	41.66	42.95
60	42.57	43.76	44.63	46.08
90	42.05	43.94	45.21	47.32
CD (P=0.05)		2.06		

**Table 3.** Effect of phosphorus zinc sulphate on uptake of P and Zn and economic of wheat (pooled data)

Treatment	Phosphorus (kg/ha)		Zinc (g/ha)		Net profit (Rs/ha)	Benefit : cost ratio
	Grain	Straw	Grain	Straw		
<i>P</i> (kg $P_2O_5$ /ha)						
0	6.4	4.8	123.0	160.5	8,376.25	1.79
30	7.6	6.2	125.4	156.9	9,581.50	1.86
60	9.3	7.6	124.1	157.6	10,600.50	1.91
90	9.9	9.1	114.5	147.0	10,239.50	1.84
CD (P=0.05)	0.60	0.72	5.19	6.01		
<i>ZnSO</i> <sub>4</sub> (kg/ha)						
0	8.7	7.8	106.0	131.1	9,117.25	1.83
10	8.7	7.4	117.9	148.1	9,677.25	1.86
20	8.1	6.6	125.0	162.6	9,971.00	1.87
40	7.8	5.9	138.1	180.0	10,032.25	1.84
CD (P=0.05)	0.60	0.72	5.19	6.01		

tion. Increased application of P increased the ratio due to higher concentration of P as a result of P application. Higher P : Zn ratio in grain as compared to straw is mainly due to higher P accumulation in the former than in the latter. It may be mentioned here that there was no reduction in grain and straw yields compared to control even in P : Zn ratios were as low as 55.1 in grain and 32.2 in straw, indicating thereby the tolerance of wheat for higher doses of Zn. A decrease in P : Zn ratio of wheat grain and straw due to Zn application was also reported by Damodar Reddy and Yadav (1994).

The P uptake by grain and straw increased significantly with increasing levels of P application over the control (Table 3). The highest uptake was recorded at 90 kg  $P_2O_5$ /ha and lowest in the control during both the years. Among various levels of P the higher levels could probably maintain the available P status in soil to facilitate its uptake at an optimum level. This increase in P uptake may be attributed to higher P content as well as grain and straw yields with higher dose of P. The results are in conformity with the findings of Choudhary *et al.* (1997). The uptake of Zn was also influenced significantly by P application. Uptake of Zn increased up to 30 kg  $P_2O_5$ /ha and then decreased at higher level due to antagonistic effect of P on Zn. Our results confirm the of Ismail *et al.* (1996). The uptake of zinc by wheat grain and straw increased significantly with increasing levels of zinc over the control due to increase

in yield and zinc content as a result of zinc application. The monetary advantage (Table 3) based on 2 years of experimentation indicated that the maximum net return and benefit : cost ratio were obtained with higher dose of P and Zn. This could be ascribed to higher grain yield obtained owing to application of higher levels of P and Zn.

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