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Effect of P and Zn Sources and Their Levels on the Expression of P - Zn Relationship in Corn

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Screen-house experiment was conducted using a Zn deficient Typic Torripsamments to study effect of P and Zn sources and their levels on their relationship in maize, using DAP, MCP and SSP (50 and 250 ppm P) as source of P and $ZnSO_4$, R-Zn and ZnO (0 and 50 ppm Zn) as source of Zn. MCP and DAP at 250 ppm P depressed the yield, while SSP enhanced it. Zinc concentration was decreased in shoot and root both, when MCP and DAP were used as P sources with ZnO. The order of Zn sources in increasing Zn content of shoot was $ZnSO_4 \cdot 7H_2O$ = R—Zn/ZnO. The efficiency of ZnO and R—Zn was generally enhanced when applied with SSP, whereas, at other two P sources $ZnSO_4$ was the best source. Root and shoot P increased with P application and MCP was more efficient than DAP and SSP as far as utilization of P by plants was concerned. Zinc decreased P concentration and decrease was more in shoot than root. Under Zn deficient conditions P concentration in shoot was much higher than applied Zn.

Studies on P - Zn interaction in maize and other crops are well documented in literature (Olsen, 1972; Takkar *et. al.* 1976). These findings vary from P-induced Zn deficiency to its either no effect or enhanced plant growth and Zn uptake. These variations may be associated with the nature and amount of P fertilizers applied and soil and plant in question as suggested by Bingham and Garber (1960) and Shukla (1972). Besides above, very few workers (Gupta *et al.* 1970; Gupta, 1973) evaluated the effect of Zn on P uptake and none reported the effect of Zn and P sources. Therefore, the present investigation was undertaken to study the effect of different sources of P and Zn and their levels on the expression of P-Zn relationship in corn under green-house.

MATERIAL AND METHODS

A green - house experiment was conducted using a Zn-deficient loamy sand soil (Typic Torripsamments) of pH 8.4, EC 0.25 mmhos/cm, $CaCo_3$ 1.75%, organic carbon 0.14%, CEC 3·48 me/100g of soil, available N 29.1 ppm, available P 0.2 ppm, available K 121 ppm and dithizone extractable Zn (Shaw and Dean, 1952) 0. 0 ppm. Soil properties were determined by standard laboratory procedures as described by Jackson (1962).

Four kg of well- mixed air-dry so were filled in polythene lined clay

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pots of 25 diameter. Treatments consisted of three possible combinations diammonium phosphate (DAP), monocalcium phosphate (MCP) and single superphosphate (SSP) each @ of 50 and 250 ppm P and one treatment without P, and four Zn treatments, no Zn and 5 ppm Zn through $ZnSO_4 \cdot 7H_2O$, ZnO any rayplex-Zn (hereafter written as R-Zn). In all there were 28 treatments. Each was replicated three times in a complete randomized block design and received a basal application of N, K, Mg, Mn, and Cu @ 100, 50, 25, 10 and 1 ppm, respectively. All the fertilizer materials, except ZnO which was mixed in powder form, were applied in solution form and mixed thoroughly with the soil before sowing. Four plants of maize (*Zea mays* L.) per pot were grown for a period of seven weeks. Both shoot and root portions of the plants were harvested and washed immediately, successively with tap water, distilled, acidifed deionized, deionized and glass redistilled water. Dry matter yields were recorded after drying the samples in a forced draft electric oven at 70°C and ground in a wiley mill with stainless steel parts. Half gram of each sample was digested with diacid mixture of redistilled HNO_3 and $HClO_4$ in the ratio of 4 : 1. Zinc in the plant digest was determined by atomic absorption spectrophotometry. Phosphorus was determined by Vanadomolybdophosphoric yellow colour method (Koenig and Johnson, 1942).

RESULTS AND DISCUSSION

Shoot and root dry matter yield increased with Zn application (Table I). The increase in shoot yield with Zn alone over no Zn, no P treatment (hereafter also referred as control) was 14 per cent, whereas, the increase with Zn + P treatment over P alone was 80 per cent. This showed that magnitude of Zn response was much higher in the presence of added P. Application of MCP and DAP decreased the yield which was more pronounced at 250 ppm P. The yield was even lower than the control. Whereas, SSP under similar conditions enhanced the yield. A similar pattern, though diffenences among treatments were not statistically significant was observed in root. The decrease in yield due to MCP and DAP was primarily on account of decreased absorption of Zn by plants, whereas, increase in yield with SSP was probably due to the presence of water soluble Zn (54 ppm) and other impurities in SSP which perhaps partially fulfilled the Zn rquirements of plant. Tshis was also revealed by the data on Zn concentration (Table II).

The highest response of 237 per cent to applied Zn over no Zn - treatment was observed when MCP and $ZnSO_4$ were the P and Zn sources, and the lowest (4%) with combination of ZnO and SSP. Rayplex-Zn appeared to be superior to other sources of Zn when DAP or SSP was the P source. But in case of root, all the three Zn sources were statistically at par. Thus, the above results showed that the expression of P-Zn relationship in yield could be modified by P and Zn sources and their levels. These findings are in agreement with those of Shukla (1973) who observed P dependent Zn responses in corn.

Phosphorus application resulted in a significant decrease in shoot Zn depending upon Zn and P sources (Table II). In the absence of applied Zn maximum decrease in Zn was with DAP followed by MCP and SSP at both the levels of P. In contrast to above, the application of SSP did not cause much effect on shoot Zn. probably due to the presence of Zn in SSP as an impurity. Bingham (1959) and Shukla (1973) also made similar observations. The effect of P on root Zn was similar to shoot, but lesser in magnitude. sharma *et al*. (1968) also reported that P had less effect on root than shoot Zn.

The decrease in root and shoot Zn due to P treatment could be due to formation of $Zn_3(PO_4)_2$ or the restricted translocation of Zn to the above ground parts. Burleson and Page (1967) and Paulson and Rotimi (1968) also suggested that P and Zn reacted together within the root in a manner that either reduced their mobility or solubility.

Root and shoot Zn increased the application of Zn. The proportionate increase was more in shoot than root.

The efficiency of R-Zn and ZnO was enhanced when applied with SSP. Mortvedt and Giordano (1968) also found that $ZnSO_4$ was more effective than ZnO when applied with concentrated superphosphate.

If only pure sources of P are taken into consideration the results are in agreement with the observations of several workers in the past (Gupta, 1973; Takkar *et al*. 1976). However, a critical evaluation of these results showed that the effect of P on Zn was modified by P and Zn sources and their levels, similar to dry matter production. These results are agreement with those of Shukla (1972) who suggested consideration of P sources and levels in the interpretation of P-Zn relationship.

It is evident from the data (Table III) that application of Zn decreased shoot and root P, depending upon P sources and their levels and Zn sources. The proportionate decrease was less in root P than shoot P. When Zn was not applied, P concentration in shoot was 3 to 4 times to that in root. This might be due to less growth or disturbance in the mechanism of retention of P in root consequently increasing P in shoots. Paribok (1970) and Gupta *et al*. (1970) observed that the absence of Zn increased the absolute amount of P in shoots but had little effect on roots.

These results showed that Zn was perhaps necessary for active absorption of P by roots and its utilization in the plant for growth and development (Skoog, 1940). The pattern of concentration in root and shoot in relation to Zn level also showed the occurrence of P-Zn interactions in soil, at the absorption sites and in translocation from root to shoot. The decrease in P concentration in corn with Zn was also observed by Gupta (1973) and Khan and Zende (1976). There was increase in root and shoot P concentration with an increase in P level. Although MCP was found to be most efficient source of P as compared to DAP and SSP, but for soils deficient in Zn, the use of SSP might be preferred because of its impurities.

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TABLE I Effect of various zinc sources on the dry matter yield of shoot and root of maize in relation to different phosphorus and sources levels.

Zinc	Phosphorus (ppm)							Mean
		DAP		MCP		SSP		
	0	50	250	50	250	50	250	
Shoot, g/pot								
No zinc	14.83	20.72	9.28	11.50	7.33	24.55	27.18	16.46
ZnSo₄	17.33	31.53	35.22	32.88	30.07	27.62	34.10	29.82
R-Zn	17.42	29.78	37.03	27.73	28 67	29.68	37.82	29.88
ZnO	15.72	26.90	30.77	25.83	25.13	25.87	28.07	25.47
Mean	16.34	27.23	28.01	24.43	22.80	26.93	31.79	—
CD at (.05) Zinc sources - 3.86; P sources - 5.11; Zn x P - 9.85.								
Root, g/pot								
No Zinc	5.35	5.00	4.65	4.93	2.15	8.30	7.55	5.47
ZnSo₄	7.60	7.30	7.50	8.80	5.65	8.60	9.10	7.77
R-Zn	7.70	8.90	6.05	9.45	8.60	12.20	12.80	9.24
ZnO	7.65	6.30	8.40	11.35	11.40	11.10	9.55	9.39
Mean	6.83	6.88	6.65	8.64	6.95	10.05	9.75	—
CD at (.05) Zinc sources : 2.30.								

TABLE II Effect of various zinc sources on zinc concentration of shoot and root of maize in relation to different phosphorus and sources levels.

Zinc	Phosphorus (ppm)							Mean
	DAP			MCP		SSP		
	0	50	250	50	250	50	250	
Shoot Zn, ppm								
No zinc	17.3	9.8	9.7	15.6	14.6	14.5	17.8	14.2
$ZnSO_4$	64.1	40.5	39.1	27.6	25.5	26.3	24.3	35.3
R—Zn	70.5	33.8	31.5	26.0	22.5	34.6	20.3	35.5
ZnO	48.1	17.6	17.0	16.3	15.0	29.6	27.6	24.6
Mean	50.0	25.4	24.3	21.4	19.4	26.0	25.0	—
CD (.05) Zinc sources — 3.5; P sources — 5.0; Zinc × P source — 10.05								
Root Zn, ppm								
No zinc	41.2	37.5	43.5	28.5	48.5	44.0	49.0	41.7
$ZnSO_4$	72.0	66.5	36.5	47.5	42.0	31.5	44.0	48.5
R – Zn	78.5	70.5	34.0	43.5	42.5	42.5	39.0	51.0
ZnO	63.0	35.0	38.5	49.0	43.5	51.4	39.0	45.6
Mean	63.6	52.3	38.1	42.1	44.1	42.3	44.7	—
C. D. (.05) P = 17.1								

TABLE III　Effect of various zinc sources on phosphorus concentration in shoot and root of maize in relation to different phosphorus sources and levels.

Zinc	Phosphorus (ppm)							Mean
		DAP		MCP		SSP		
	0	50	250	0	250	0	250	
Shoot P, Percentage								
No Zinc	0.11	0.31	0.89	0.47	1.10	0.21	0.26	0.48
$ZnSO_4$	0.12	0.15	0.27	0.13	0.25	0.15	0.15	0.18
R—Zn	0.11	0.16	0.28	0.16	0.30	0.15	0.16	0.19
ZnO	0.11	0.17	0.25	0.13	0.27	0.14	0.21	0.18
Mean	0.11	0.20	0.42	0.22	0.48	0.16	0.19	—
C. D. (.05) : Zinc sources — 0.20; P sources — 0.26								
Root P, Percentage								
No Zinc	0.09	0.10	0.19	0.16	0.22	0.09	0.20	0.15
$ZnSo_4$	0.07	0.12	0.16	0.12	0.22	0.12	0.18	0.14
R—Zn	0.05	0.13	0.23	0.11	0.27	0.10	0.12	0.14
ZnO	0.07	0.12	0.12	0.12	0.20	0.10	0.13	0.12
Mean	0.07	0.12	0.18	0.13	2.23	0.11	0.16	—
C. D. (.05) P sources — 0.05.								