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Availability of Zinc in Soils Treated with Different Sources of Zinc, Nitrogen and Varying Levels of Phosphate-Soil Incubation Study

By

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ABSTRACT

A soil incubation experiment was carried out to study the availability of Zn in two different soils of varying texture treated with different Zn and N sources at various levels of Phosphate. Availability of Zn was highest under Zn-Chelate and least under Zn-dust. In general, per cent availability of applied Zn in all sources was higher in clayey soil of Ganpatpura than in loamy sand of Anand at both the incubation periods. Addition of phosphate significantly decreased the availability of Zn in both the soils. Application of Urea and Sodium nitrate did not decrease the availability of Zn compared with ammonium sulphate.

INTRODUCTION

Zinc-phosphorus relationship in plant nutrition has been controversial. Reports on the subject are not consistent. Some workers could not find any such relationship (Boawn *et al.*, 1954 and Bingham, 1963). Laker (1967) has shown an increase in Zn uptake due to phosphate application. Further the role of soil medium on this aspect has not been clearly understood. Burleson *et al.*, (1961) suggested the possibility of P-Zn interaction within the plant roots. Lengin *et al.*, (1962) reported that the damaging effect of phosphate on Zn utilisation is physiological within the plant and it is in the root cells. Ellis *et al.*, (1964) and Burleson and Page (1967) also supported the view that the P-Zn interaction is either at the root surface or within the root. Soltanpour (1969) observed antagonistic relationship between P and Zn and indicated that it could be physiological. Contrary to these views, Bingham (1963) and Keefer *et al.*, (1967) noted that soil reactions may also contribute to the phosphate induced Zn-deficiency. Recently Misra and Mishra (1969) and Kalyanasundaram and Mehta (1970) reported that application of P had a depressive effect on available Zn in Soils.

With increasing need for Zn application in many agricultural areas, more economical and effective sources of Zn are desirable.

Some workers have reported that the source of nitrogen influenced the responses of plants to the native and applied Zn (Viets *et al.*, 1957; Giordano *et al.*, 1966)).

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Therefore it was planned to study the availability of Zn as affected by phosphate application, type of Zn compound added and the kind of nitrogenous fertilizer used under controlled conditions.

MATERIALS AND METHODS

A soil incubation study was designed to study the availability of Zn with the following factors:

1. Soils:
   (i) Loamy sand of Anand in Kaira District
   (ii) Clayey soil of Ganpatpura in Baroda District.
2. Incubation periods:
   (i) 2 days
   (ii) 20 days
3. Zinc sources:
   (i) Zinc dust (Zn_1)
   (ii) Zinc oxide (Zn_2)
   (iii) Zinc sulphate (Zn_3)
   (iv) Zinc chelate (Zn_4)
4. Zinc levels:
   0 (Zn_0) and 5 ppm Zn of the above sources
5. Phosphorus levels:
   (i) 0 kg P_2O_5/ha (P_0)
   (ii) 500 kg P_2O_5/ha (P_{500})
   (iii) 1000 kg P_2O_5/ha (P_{1000}) in the form of KH_2PO_4
6. Nitrogen sources:
   (i) Ammonium sulphate (AS)
   (ii) Urea (U)
   (iii) Sodium nitrate (SN) each at the rate of 200 kg N/ha.

Moisture level was maintained at 40 per cent of the water-holding capacity of soil throughout the experiment. The soils were incubated at room temperature. The samples were drawn in duplicate at 2 and 20 days and analysed for available Zn by the method of Shaw and Dean (1952).

Two soils widely varying in their physical and chemical characteristics were selected for this study. Anand soil was loamy sand, non-calcareous and with pH 7.4. Cation exchange capacity was 9.2 m.e/100 gms. It was low in organic carbon, medium in available P (9.5 ppm P) and somewhat above the threshold value of available Zn (0.84 ppm). Ganpatpura soil was clayey non-calcareous with pH 8.2 and CEC 52.6 m. e/100 gms, soil organic carbon content was 0.46 per cent available P low (2.3 ppm P) and available Zn above the threshold value (0.9 ppm).

RESULTS AND DISCUSSION

All the four different sources of Zn had a significant effect in increasing the availability of Zn in both the soils (Tables 1 and 2). Availability of Zn with different sources varied significantly in both the soils at both the incubation periods in the following order: Zn chelate (Zn_4) > $ZnSO_4$ (Zn_3) > ZnO (Zn_2) > Zn dust (Zn_1).

Of the four Zn- carriers used in the present investigation, Zn dust and ZnO are water-insoluble, whereas $ZnSO_4$ and Zn-chelate are water-soluble. Due to this fact, availability of Zn was found to be less with water - insoluble sources than with

TABLE 1. Available Zn (ppm) in Anand soil as influenced by various sources of Zn and N at different phosphate levels after 2 and 20 days of incubation.

Incubation period	Treatment	P_0			P_{500}			P_{1000}			Mean for Zn-sources
		AS	U	SN	AS	U	SN	AS	U	SN	
2 days	Zn_0	0.88	0.88	0.87	0.85	0.83	0.88	0.83	0.81	0.90	0.86
	Zn_1	2.25	2.57	2.46	2.50	2.69	2.63	2.00	2.46	2.59	2.46
	Zn_2	3.42	3.63	3.51	3.51	3.42	3.39	3.16	3.52	3.30	3.43
	Zn_3	4.45	4.74	4.81	3.98	4.21	3.83	3.98	4.11	4.33	4.27
	Zn_4	5.78	5.93	6.28	5.91	5.82	5.91	5.46	5.78	5.80	5.85
	Mean for P-levels		3.49			3.36			3.27	C. D. @ 5%	Zn-0.09 P-0.06 N-0.06
	Mean for N-sources	AS : 3.26			U : 3.43			SN : 3.43			
20 days	Zn_0	0.91	0.88	0.83	0.83	0.82	0.88	0.84	0.85	0.86	0.86
	Zn_1	1.52	1.99	1.64	1.76	1.92	1.88	1.42	1.54	1.54	1.77
	Zn_2	2.46	2.73	2.93	2.81	2.82	2.57	2.46	2.69	2.57	2.67
	Zn_3	3.04	3.63	3.73	3.39	3.27	3.51	3.68	3.51	3.74	3.50
	Zn_4	4.22	3.99	4.26	4.13	4.43	4.23	4.11	4.00	4.21	4.18
	Mean for P-levels		2.58			2.62			2.53	C. D. @ 5%	Zn-0.04 P-0.03 N-0.03
	Mean for N-sources	AS : 2.51			U : 2.60			SN : 2.63			

TABLE 2. Available Zn (ppm) in Ganpatpura soil as influenced by various sources of Zn and N at different phosphate levels after 2 and 20 days of incubation.

Incubation Period	Treatment	P_0			P_{500}			P_{1000}			Mean for Zn-sources
		AS	U	SN	AS	U	SN	AS	U	SN	
2 days	Zn_0	0.91	1.05	0.95	0.92	0.86	0.88	0.91	0.91	0.88	0.92
	Zn_1	3.83	3.18	3.21	3.28	3.42	2.81	3.49	3.04	3.35	3.29
	Zn_2	4.64	4.15	4.05	4.39	4.50	4.00	4.02	3.85	4.05	4.18
	Zn_3	4.68	4.69	4.88	4.82	4.88	4.65	4.83	4.55	4.63	4.73
	Zn_4	6.01	5.82	5.89	5.95	5.85	5.91	5.94	5.75	5.93	5.89
	Mean for P-levels		3.86			3.81			3.77	C. D. @5%	Zn-0.09 P-0.05 N-0.05
	Mean for N-sources	AS : 3.92				U : 3.78			SN : 3.75		
20 days	Zn_0	0.88	0.86	0.93	0.94	0.84	0.86	0.84	0.87	0.87	0.88
	Zn_1	2.01	2.55	2.28	2.18	2.69	1.92	1.85	2.14	2.33	2.22
	Zn_2	3.22	3.35	3.08	3.26	3.10	2.90	3.26	3.10	2.95	3.14
	Zn_3	3.48	3.75	4.00	3.38	3.45	3.21	3.10	3.62	3.82	3.53
	Zn_4	4.49	4.55	4.31	4.24	4.30	4.48	4.41	4.21	4.56	4.39
	Mean for P-levels		2.92			2.78			2.79	C. D. @ 5%	Zn-0.10 P-0.06 N-0.06
	Mean for N-sources	AS : 2.77				U : 2.89			SN : 2.83		

water soluble ones. Between the two water soluble sources, Zn availability was higher with Zn-chelate than $ZnSO_4$ probably because of less fixation in the former. Judy (1968) extracted more water-soluble and exchangeable Zn from incubated soil treated with Zn-EDTA than from $ZnSO_4$ treated soil. The order of efficiency of different Zn-carriers for available Zn reported in the present investigation is in accordance with the results obtained by Meelu and Randhawa (1970).

In order to know the efficiency of different Zn-sources, the per cent Zn extracted by ammonium acetate-dithizone reagent was worked out.

It can be seen that per cent availability of applied Zn in all sources was higher in clayey soil of Ganpatpura than in loamy sand of Anand (Table 3), exception being the Zn-chelate at 2 day incubation period. The lower percentage availability of applied Zn in the light-textured soil of Anand than that of heavy-textured soil of Ganpatpura may be explained as being due to the fact that Anand soil contained 9.50 ppm of available P as against 2.3 ppm in Ganpatpura soil. Further these two soils were treated with phosphate and there was considerable amount of phosphate fixation in clayey soil immediately after addition and also its initials content of available phosphate was very low. Due to this, phosphate availability was less for the reaction with Zn and hence more availability of Zn was obtained. Sharma *et al.* (1968) observed that the adverse effect of added P on Zn concentration in plant was lower in a soil that fixed more of the added P. On the other hand, in the soil of Anand, besides its initial high content of available P, the availability from added phosphate was also high, probably due to low P fixation. Therefore, the higher P availability might have been responsible for such a lowering of Zn availability. This may be the probable reason for the lower per cent availability of applied Zn in Anand soil in comparison to Ganpatpura soil. Recently Misra and Mishra (1969) also reported more reduction in Zn availability due to phosphate application in red soil (less P fixation) than in black soil (more P fixation).

TABLE 3. Per cent extractability of Zn in different Zn-carriers applied in two soils of different texture as affected by phosphate and nitrogenous fertilizers.

Zinc sources	Anand Soil		Ganpatpura soil	
	2 day incubation	20 day incubation	2 day incubation	20 day incubation
Zn_1	32.0	18.2	47.4	26.8
Zn_2	51.4	36.2	65.2	45.2
Zn_3	68.2	52.8	76.2	53.0
Zn_4	99.8	66.4	99.4	70.2

Regarding the effect of phosphate application on Zn availability it was observed that in Anand (loamy sand) and Ganpatpura (clayey) soils at 2 day incubation period, addition of phosphate at both the levels resulted in a significant decrease in available Zn. At 20 day incubation period in Anand soil, a significant reduction in Zn availability was obtained only at P_{1000} level, whereas in Ganpatpura soil reduction was significant at both the levels of phosphate. Misra and Mishra (1969) and Kalyanasundaram and Mehta (1970) also reported decrease in Zn availability with the application of phosphate.

The effect of different nitrogenous sources on Zn availability showed that the application of urea and sodium nitrate did not decrease the availability of Zn in camparison to ammonium sulphate. The absence of decrease in Zn availability with the application of urea and sodium nitrate over ammonium sulphate may be explained as being due to the fact that soil pH was comparatively higher with urea and sodium nitrate than with ammonium sulphate. Increased pH brought about reduction in phosphate availability and due to this less P was available for the reaction with Zn.

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