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ON THE ROLE OF SOIL MEDIUM IN P-INDUCED Zn DEFICIENCY IN PLANTS

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Introduction

Various crops suffer from Zn deficiency on many alkaline calcareous soils of Pakistan.[1-3] These soils receive liberal applications of P fertilizers. There are several reports demonstrating that P fertilization may intensify Zn deficiency in many plant species.[3-10] Whatever the specific cause of the abnormal growth where P accentuates Zn deficiency, it is readily corrected by Zn applications either to the soil or foliage.

Because of the low solubility of $Zn_3(PO_4)_2$, it was first supposed that Zn deficiency resulted when the applied phosphates reacted with Zn to reduce the level of soluble Zn in the soil.[11] More recently it has been shown that P application did not greatly affect extractable Zn, but tended to increase the Zn rather than decrease it.[12] Some authors[6, 11, 13] have claimed that P affects the absorption of Zn by roots in soil in some other way than by precipitation of an insoluble $Zn_3(PO_4)_2$. The reports are contradictory and there still appears to be no clear conception of the P-Zn relationship in soil and plant media. These observations emphasize the need for a critical study of the P-Zn relationship in soil and plant. The present paper reports the effect of P applications on Zn solubility in two upland alkaline calcareous soils.

Materials and Methods

The experiment was carried out in the laboratory on two alkaline calcareous soils of different textures collected from Thikriwala and Kamalia towns of the District Faisalabad. The surface samples up to 15 cm depth were drawn, air dried and crushed to a fineness of 1 mm. Physico-chemical properties of the soils used have been reported elsewhere.[14] Twenty five g portions of each soil were taken in flat-bottomed plastic vessels. Treatments in triplicate consisted of 0, 2.5, 5.0 and 10.0 ppm Zn as $ZnSO_4.7H_2O$ and 0, 16, 32 and 64 ppm P as KH_2PO_4. The difference in K level of the soils by the application of different amounts of KH_2PO_4 was compensated by KCl application. P and Zn sources and KCl were applied as their aqueous solutions by adjusting the moisture level in the soil of each vessel to 75% of its field capacity. Soils maintained at this moisture level were incubated at $30 \pm 1°$ for 13 days, a period found sufficient for the maximum fixation of Zn (data not shown). At the end of the incubation period, the soils were extracted with 0.005M DTPA (diethylenetriaminepentaacetic acid) and Zn concentration in the soil extracts was determined by atomic absorption spectrophotometery.[15]

Data were subjected to analysis of variance and the difference between different means was evaluated by the least significant difference test.

Results and Discussion

Irrespective of the P levels, DTPA-extractable Zn of both soils progressively increased with an increase in Zn rate ($P<0.01$, Table 1). On the light textured Thikriwala soil, extractable Zn was affected quite appreciably by P application ($P<0.01$). Extractable Zn in this soil increased progressively with increasing rate of P application. On the heavy textured Kamalia soil, however, P application had little effect on extractable Zn even at the highest rate of P application. Stukenholtz *et al.*[16] from their incubation studies reported that the P application even at the rate of 1000 ppm P had no effect on 0.1 N HCl-extractable Zn in calcareous soils.

TABLE 1. 0.005 M DTPA-EXTRACTABLE Zn AS INFLUENCED BY VARYING LEVELS OF PHOSPHORUS AND ZINC IN TWO SOILS INCUBATED FOR 13 DAYS AT 30 + 1° AND 75% FIELD CAPACITY.

Applied Zn	0.005 M DTPA- extractable Zn		
	P	Thikriwala soil	Kamalia soil
		ppm	
0	0	0.39	0.70
	16	0.38	0.63
	32	0.37	0.64
	64	0.39	0.66
2.5	0	2.12	2.32
	16	2.10	2.21
	32	2.06	2.19
	64	2.06	2.04
5.0	0	3.61	3.82
	16	3.65	3.78
	32	3.95	3.78
	64	3.86	3.74
10.0	0	6.76	6.90
	16	7.18	7.03
	32	7.18	6.99
	64	7.48	7.07
LSD (0.05) (P means)		0.09	NS
LSD (0.05) (Zn means)		0.09	0.11
LSD (0.05) (P × Zn means)		0.25	NS

The data of the present investigation show that probably P as such did not have any adverse effect on the availability of Zn in these soils. A possible reason for increased Zn availability in the Thikriwala soil might be the soil pH depression which was probably the result of acidic nature of KH_2PO_4 (5% solution, pH 4.3 at 25°). Such a decrease in pH would help in the solubilization of more Zn/or in decreasing Zn fixation. Shukla[17] studied the effect of different P sources including KH_2PO_4 on Zn solubility in soils. He observed that, in general, P source which decreased soil pH increased Zn solubility, whereas those with the exception of dipotassium phosphate, which had increased the pH, decreased Zn solubility. The absence of any effect of acidic KH_2PO_4 on the extractable Zn of the heavy textured Kamalia soil might be due to high buffering capacity of the soil against pH changes.[18]

The observations on the effect of KH_2PO_4 on Zn availability were similar to the findings of Binghum and Garber.[13] Keefer and Singh[19] observed that when soil P levels were increased, acid extractable Zn from soils either showed no change or increase. Several workers[16, 20, 21] who found that P application reduces Zn availability, have not taken into consideration the soil in question, its type and the amount of P fertilizer compounds. In general, only the plant analysis was the criterion for evaluation and not soil analysis.

The results of the present study also indicated that precipitation of Zn as $Zn_3(PO_4)_2$, as was thought previously,[11] was not possible in these soils. In another study,[22] as a source of Zn for sorghum in greenhouse pots, $Zn_3(PO_4)_2$ was equal to ZnO, $ZnCO_3$ and $ZnSO_4 \cdot 7H_2O$ on Ritzville fine sandy loam, (pH 7.2). This evidence indicates strongly that the precipitation of $Zn_3(PO_4)_2$ is not involved in P-induced Zn deficiency in plants. Other researchers[23,26] also concluded that Zn deficiency does not result from P rendering Zn insoluble or unavailable in the soil.

It is obvious from the above discussion that P application to these calcareous soils may not adversely affect Zn solubility in these soils. Thus the decrease in Zn concentration of plants from P application in the absence of Zn confirms the antagonistic relationship of P and Zn during absorption and translocation in the plant as reported by earlier researchers.[16, 20, 21]

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References

1. F. M. Chaudhry and M. Sharif, in *Isotope-aided Micronutrient Studies in Rice Producion with Special Reference to Zinc Deficiency*, Proc. Combined Panel Res. Coord. Meet. Vienna, Sep. 23-27, 1974, IAEA-172, p. 1 (1975).
2. A. Rashid, Rahmatullah, F. Hussain, A. Latif and M. Sharif, unpublished results.
3. M. A. Kausar, F. M. Chaudhry, A. Rashid, A. Latif and S. M. Alam, Plant Soil, **45**, 397 (1976).
4. L. C. Boawn and G. E. Leggett, Soil Sci., **95**, 137 (1963).
5. L. C. Boawn and G. E. Leggett, Soil Sci. Soc. Amer. Proc., **28**, 229 (1964).
6. C. A. Burleson, A. D. Dacus and C. J. Gerard, Soil Sci. Soc. Amer. Proc., **25**, 365 (1961).
7. R. Ellis, Jr., J. F. Davis and D. L. Thurlow, Soil Sci. Soc. Amer. Proc., **28**, 83 (1964).
8. E. J. Langin, R. C. Ward, R. A. Olson and H. F. Rhoades, Soil Sci. Soc. Amer. Proc., **26**, 574 d (1962).
9. L. F. Seatz, A. J. Sterges and J. C. Kramer, Agron, J., **51**, 457 (1959).
10. R. C. Ward, E. J. Langin, R. A. Olson and D. D. Stuckenholtz, Soil Sci. Soc. Amer. Proc., **27**, 326 (1963).
11. F. T. Binghum, Soil Sci. Soc. Amer. Proc., **27**, 389 (1963).
12. A. L. Brown, B. A. Krantz and J. L. Eddings, Soil Sci., **110**, 415 (1970).
13. F. T. Binghum and M. J. Garber, Soil Sci. Soc. Amer. Proc., **24**, 209 (1960).
14. F. Hussain and A. Rashid, Pakistan J. Sci. Ind. Res. (in press, 1977).
15. W. L. Lindsay and W. A. Norvell, Agron. Abstr., p. 84 (1969).
16. D. D. Stukenholtz, R. J. Olsen, G. Gogan and R. A. Olson, Soil Sci. Soc. Amer. Proc., **30**, 759 (1966).
17. U. C. Shukla, Agrochimica, 16, 435 (1972).
18. M. A. Kausar, F. M. Chaudhry, A. Rashid and Rahmatullah, Pakistan J. Sci. Ind. Res., **19**, 80 (1976).
19. R. F. Keefer and R. N. Singh, 9th Intern. Congr. Soil Sci. Trans., Vol. II, paper 38, p. 367.
20. C. A. Burleson and N. R. Page, Soil Sci. Soc. Amer. Proc., **31**, 510 (1967).
21. J. R. Melton, B. F. Ellis and E. C. Doll, Soil Sci. Soc. Amer. Proc., **34**, 91 (1970).
22. L. C. Boawn, F. G. Viets, Jr. and C. L. Crawford, Soil Sci., **83**, 219 (1957).
23. R. E. Warnock, Soil Sci. Soc. Amer. Proc., **34**, 765 (1970).
24. A. W. Pauli, Roscoe Ellis, Jr., and H. C. Moser, Agron. J., **60**, 394 (1968).
25. K. C. Sharma, B. A. Krantz, A. L. Brown and J. Quick, Agron. J., **60**, 652 (1968).
26. U. C. Shukla and H. D. Morris, Agron. J., **59**, 200 (1967).