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INFLUENCE OF SALINITY AND ZINC ON THE AVAILABILITY OF ZINC, COPPER, IRON AND MANGANESE IN TWO ALKALINE CALCAREOUS SOILS

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Abstract. A soil incubation study with two alkaline calcareous soils of varying texture was conducted to find out the influence of salinity and Zn applications on the extractability of Zn, Cu, Fe and Mn by DTPA (diethylenetriaminepentaacetic acid) soil test method. The effect of salinity varied with the two soils. In general, there was not very much effect of salinity on the extractable metals except that Mn in light textured Thikriwala soil showed a marked increase at the highest salinity level while Fe in heavy textured Kamalia soil showed a steady decrease with increasing salinity. The strong inhibition of saline salts on micronutrient absorption by plant roots, however, indicate that under both soil situations, the net effect of salinity will lead towards their deficiency in plants.

Under the conditions of the present study, Zn additions had little effect on the chemically extracted metals studied except that Fe showed a minor decrease in Thikriwala soil.

Our agricultural productions suffer with the growing menace of soil salinity. Between 10 to 20 million acres in Pakistan are affected by varied degree of salinity[1]. It is, therefore, imperative to know if micronutrients can help in raising crop yield on saline soils. The earlier foreign literature on the subject generally indicates decrease in crop yield with salinity, but for a given salinity level there is an increase in yield with the application of macronutrient fertilizers[2-5]. Such observations if documented may have great implication in the country for yield improvement. Micronutrient deficiency have been found on several soils in Pakistan. For example, Zn deficiency commonly exists in rice, wheat and corn[6-9]. The effect appears stronger on relatively more saline soils. It, however, requires proper documentation.

This paper presents results of a soil incubation study on the effects of soil salinity on micronutrient solubility in two soils of different textures. An attempt was also made to find out the influence of salinity on indigenous Cu, Fe and Mn contents of these soils.

Materials and Methods

The soil incubation study was carried out in the laboratory. Two soil samples (0-15 cm) collected from Thikriwala and Kamalia towns of Faisalabad district were utilized in the present study. The soils were selected because of their significant variation in texture and that they earlier produced Zn deficient maize plants[8]. Their physicochemical properties are detailed in Table 1. Four levels of salinity were induced by treating 4 kg air-dried and 2-mm-sieved sample of each soil in polyethylene lined plastic pots, with aqueous solutions of the following salts: NaCl, Na_2SO_4, $MgCl_2.6H_2O$ and $CaCl_2.2H_2O$ in the proportion of 4:10:1:5 respectively. The moisture in soils was raised to field capacity. Untreated soils were used as controls and received only deionized water. The soils were incubated at room temperature for about 2 weeks without further addition of water and then allowed to dry out. The air-dried soils were ground to pass a 2-mm-sieve. The induced salinity levels and the resulting conductivities and pH values are given in Table 2. The pH of the soil was measured overnight after equilibriation. The electrical conductivities were estimated according to the method of US Salinity Laboratory[10].

Twenty five g soil from each salinity treatment was taken in flat bottomed plastic vessels and the treatments were superimposed with 0, 2.5, 5.0 and 10.0 ppm as $ZnSO_4$ $7H_2O$ aqueous solution. Amount of water was adjusted to bring the soil in each vessel to its 75% field capacity and was maintained throughout the experimental period. Samples in triplicate were kept for incubation at 30 ± 1^o for 13 days, a period found sufficient for maximum fixation of Zn (data not shown). At the end of the incubation period, the soil samples were extracted with 0.005 M DTPA and Zn, Cu, Fe and Mn in soil extracts were determined by atomic absorption spectrophotometry[11].

All the salt solutions used to induce salinity were purified by shaking with 0.01% dithizone solution in carbon tetrachloride. The experimental apparatus was washed successively with 0.2 M EDTA (ethylenediaminetetraacetic acid), deionized water, 10% HNO_3 and again deionized water.[12]

Results

Soil Reaction. A slight decrease in pH of both the soils was recorded with salinization (Table 2).

Salinity Effects on Indigenous and Applied Zn. Irrespective of salinity levels, DTPA-extractable Zn of both the soils increased markedly with increasing rate of Zn application ($P < 0.01$, Table 3). Effect of salinity on the DTPA-extractable Zn of both the soils was also considerable ($P < 0.01$). However, the effect of salinity was non-consistent in the two soils. DTPA-extractable Zn in Thikriwala soil increased slightly with increasing salinity while in case of Kamalia soil, a slight decrease was recorded in DTPA-extractable Zn with salinization.

Salinity Effects on Indigenous Cu, Fe and Mn of Thikriwala Soil. Salinization of this soil had little effect on extractable Fe. A minor effect of salinity was noted on DTPA-extractable Cu of this soil. However, Mn was affected markedly ($P < 0.01$). Extracted Mn remained unaffected with increasing Ec_e from 2.2 to 3.5 mmhos/cm, but after that there was an increase in Mn with an increase in salinity level. A marked increase in DTPA-extractable Mn was noted at the highest salinity level. While Zn applications had little effect on indigenous Cu and Mn, a slight decrease in Fe was noted with increasing Zn level.

Salinity Effects on Indigenous Cu, Fe and Mn of Kamalia Soil: Salinization of Kamalia soil affected the DTPA-extractable Cu and Mn considerably ($P < 0.01$, Table 3). A little decrease in their extractability was noted with salinization. DTPA-extractable Fe of the soil was affected markedly ($P < 0.01$). A steady decrease in DTPA-extractable Fe was noted with increasing salinity. The decrease in Fe was greater than that of Cu or Mn. Zinc additions had little effect on the extractable Cu, Fe and Mn.

Discussion

The results of the present study revealed that there was not much effect of salinity on the DTPA-extractable metals studied except that Mn in Thikriwala soil showed a marked increase at the highest salinity level and that Fe in Kamalia soil showed a steady decrease with increasing salinity. As the pH of both the soils decreased slightly with salinization (Table 2), effects cannot be attributed to pH changes. The mechanism is yet to be explored. However, whatever the mechanism may

TABLE 1. PHYSICOCHEMICAL PROPERTIES OF THE SOILS USED FOR EXPERIMENT.

Soil location	Clay	Texture	pH	$EC_e x10^3$	$CaCO_3$ equi.	Organic matter	$NaHCO_3$ extractable P	0.005 M DTPA-extractable Zn	Cu	Fe	Mn
	%				%	%	ppm	ppm	ppm	ppm	ppm
Wali Model Farm, Thikriwala	13.8	Sandy loam	8.2	2.2	4.1	0.67	6.51	0.46	1.08	3.2	9.5
Ilam Din Model Farm, Kamalia	26.6	Loamy clay	8.2	2.6	4.6	0.91	6.56	0.62	2.86	9.0	7.5

TABLE 2. INDUCED SALINITY LEVELS AND THE RESULTING CONDUCTIVITIES AND pH VALUES IN THE TWO SOILS USED.

Induced salinity level (mmhos/cm)	Resultant conductivity ($EC_e x 10^3$) Thikriwala soil	Kamalia soil	pH of the soil after raising salinity Thikriwala soil	Kamalia soil
Control	2.2	2.6	8.2	8.2
5	3.5	3.2	7.9	8.0
15	12.0	11.6	7.8	7.9
25	20.0	17.6	7.9	7.9

TABLE 3. DTPA-EXTRACTABLE ZINC, COPPER, IRON AND MANGANESE AS INFLUENCED BY ZINC LEVELS AND VARIOUS REGIMES OF SALINITY IN TWO ALKALINE CALCAREOUS SOILS INCUBATED FOR 13 DAYS AT 75% FIELD CAPACITY.

Thikriwala soil						Kamalia soil					
Applied Zn(ppm)	Resultant conductivity ($EC_e x 10^3$)	0.005 M DTPA-extractable				Applied Zn (ppm)	Resultant conductivity ($EC_e x 10^3$)	0.005 M DTPA-extractable			
		Zn	Cu	Fe	Mn			Zn	Cu	Fe	Mn
		ppm						ppm			
0	Control	0.26	0.55	2.02	5.10	0	Control	0.62	1.57	8.02	6.19
	3.5	0.25	0.52	2.02	4.87		3.2	0.39	1.45	6.39	5.36
	12.0	0.30	0.55	1.89	5.45		11.6	0.43	1.47	5.71	5.40
	20.0	0.35	0.58	2.21	7.96		17.6	0.50	1.51	5.57	5.13
2.5	Control	1.80	0.53	1.89	5.54	2.5	Control	2.10	1.56	7.34	5.59
	3.5	1.72	0.51	2.02	5.14		3.2	1.86	1.50	6.66	5.13
	12.0	1.87	0.53	1.89	5.72		11.6	1.86	1.45	5.44	5.26
	20.0	2.01	0.59	2.15	8.67		17.6	1.90	1.53	5.57	5.26
5.0	Control	2.84	0.52	1.82	5.05	5.0	Control	3.32	1.54	7.75	5.26
	3.5	3.12	0.52	2.02	5.14		3.2	3.24	1.42	6.12	5.08
	12.0	3.28	0.56	1.82	5.67		11.6	3.24	1.44	5.71	5.40
	20.0	3.36	0.59	1.82	7.78		17.6	3.40	1.48	5.30	4.76
10.0	Control	6.30	0.49	1.82	5.01	10.0	Control	6.60	1.48	7.95	5.82
	3.5	6.30	0.52	1.76	5.19		3.2	6.40	1.53	6.39	5.50
	12.0	6.22	0.56	1.76	5.46		11.6	6.48	1.47	5.03	4.94
	20.0	6.38	0.61	1.82	7.51		17.6	6.64	1.51	5.44	5.31
LSD(0.05) (Salinity means)		0.09	0.01	NS	0.42			0.09	0.03	0.30	0.32
LSD(0.05) (Zn means)		0.09	NS	0.14	NS			0.09	NS	NS	NS
LSD(0.05) (Salinity x Zn means)		0.26	0.04	NS	NS			NS	NS	NS	NS

be, the salinity depresses micronutrient solubility in alkaline calcareous soils or has only a slight increasing effect (Table 3). The results are yet to be generalized with studies using a greater number of soils. The present preliminary studies may, however, show that the net effect of salinity on micronutrient uptake by plants is most likely to be depressive since saline salts as that of Ca and Mg has been reported to strongly depress Zn[13] and Cu[14] uptake by plants. The effect on Zn uptake by wheat plants was so great that increasing Ca concentration in solution from 0.15 to 2.5 mm depresses rate of Zn absorption from 131 to only 69 nm/g root. Such a strong inhibitory effect will easily offset a slight increasing effect of salinity on Zn solubility in soil wherever it occurs. Similar effect of these salts on Zn absorption was found on Basmati-370 and IR-6 rice varieties of Pakistan.[15]

The study further revealed that Zn applications to saline soils may not affect DTPA-extractable Cu, Fe or Mn of these soils.

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