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Effect of Zinc Smelter Effluent and Soil Amendments on Metallic Cations Build-up in Soil and Yield of Crop Plants

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Abstract A pot culture study was undertaken in a sandy loam soil using five dilutions of Zinc Smelter's treated effluent with well water for irrigation and five soil amendment treatments to raise maize, sorghum, wheat and barley. The dry matter production of maize, sorghum and barley significantly decreased when undiluted effluent was used for irrigation. However, effluent when diluted with well water and used for irrigation has improved the dry matter yield. Incorporation of phospho-gypsum has increased the dry matter yield of maize and barley and lowered the level of available Fe, Mn and Zn build-up in soil.

Key words Amendments, Cation build-up, Crop yields, Smelter's effluent

Irrigation with water containing higher concentration of elements Cu, Zn, Pb, Cd and Ni results in the enrichment of the surface soil (Anderson & Nelson 1976, Totawat 1991) and become phytotoxic to the plants. Effluent discharged in river Berach from Zinc Smelter, Debari at the rate of 3000 to 4000 m^3 day^{-1} pollutes the wells water of the area (Totawat 1987) with heavy metals. The farmers of this area use the effluent as well as polluted well waters for irrigation. Thus, a study was undertaken to elucidate the effect of Zinc Smelter's effluent applied as a source of irrigation to amended soil on dry matter of crop plants and cation composition of soil.

Materials and Methods

A pot culture experiment with treatments, (Table 2) was carried out during 1982-83 and 83-84. Each treatment replicated thrice in a randomised block design under a cage house protected from rain from the top with a transparent polythene sheet. The composition of well water and effluent used are presented in table 1. Two soils used under study were sandy loam, calcareous, non saline and low in available N,P and K but adequate in the supply of Zn, Fe and Mn. The status of $CaCO_3$ (%), EC (dS m^{-1}), pH, O.C. (%), available P and K (kg ha^{-1}) and DTPA extractable Zn, Fe and Mn (mg kg^{-1}) in soils under study were 3.3, 0.23, 8.3, 0.2, 1.9, 71, 1.9, 5.8 and 10.8 for 1982-83 and 6.2., 0.43, 8.4, 0.27, 5.2, 128, 2.0, 9.2 and 10.9 for 1983-84, respectively.

Table 1 *Composition of well water and smelter's treated effluent used for preparing irrigation waters*

Constituents	Well water*	Smelter effluent
pH	8.2	6.6
Ec (dS m^{-1})	1.9	4.4
Cations (mg L^{-1})		
Ca	136.0	546.5
Mg	92.3	179.5
Na	250.0	360.6
K	8.0	10.1
Anions (mg L^{-1})		
Cl	360.0	219.5
SO_4^2	710.0	1957.2
Po_4^3	6.0	11.4
F	–	8.2
Micronutrients (mg L^{-1})		
Fe	0.17	0.68
Zn	1.07	10.6
Cu	0.05	0.05
Pb	0.08	0.05

* From the well situated at C2 (a) field, Agronomy Farm,

Table 2 *Effect of diluted effluent and soil amendments on dry matter yield (g pot^{-1}) of crop plants*

Treatments	Maize			Sorghum			Wheat			Barley		
	83	84	pooled	83	84	pooled	83–2	83–84	pooled	82–3	83–4	pooled
Effluent dilutions												
E : W												
0 : 1	8.45	19.11	13.78	7.83	20.98	14.40	5.33	9.15	7.24	6.47	9.18	7.82
1 : 0	7.59	16.66	12.12	6.56	15.43	10.99	4.51	9.48	6.99	4.35	9.03	6.69
1 : 2	7.69	18.61	13.15	6.83	20.23	13.53	5.09	9.59	7.34	6.15	8.72	7.43
1 : 1	8.58	18.63	13.60	7.96	19.69	13.82	4.96	9.28	7.12	6.21	8.95	7.58
2 : 1	8.14	17.55	12.84	8.31	17.99	13.15	4.88	9.24	7.06	5.83	8.38	7.10
LSD (0.5)	NS	1.27	0.85	NS	2.13	1.31	0.36	NS	NS	0.51	0.46	0.38
Soil amendments ($10\ t\ ha^{-1}$)												
No-amendments	7.33	18.35	12.84	7.11	18.65	12.88	4.84	9.32	7.08	5.65	9.17	7.41
Phospho-gypsum	8.33	19.13	13.73	7.26	19.28	13.27	5.06	9.67	7.36	5.95	9.00	7.47
Gypsum	8.31	16.87	12.59	7.59	19.43	13.51	4.91	9.67	7.29	5.97	9.31	7.64
Pyrite	8.53	18.15	13.34	7.52	18.39	12.95	5.06	9.34	7.20	5.62	8.65	7.13
FYM	7.96	17.56	12.76	8.03	18.63	13.33	4.89	8.75	6.81	5.92	8.12	7.02
LSD (0.05)	NS	1.27	0.85	NS	NS	NS	NS	0.59	NS	NS	0.46	0.38

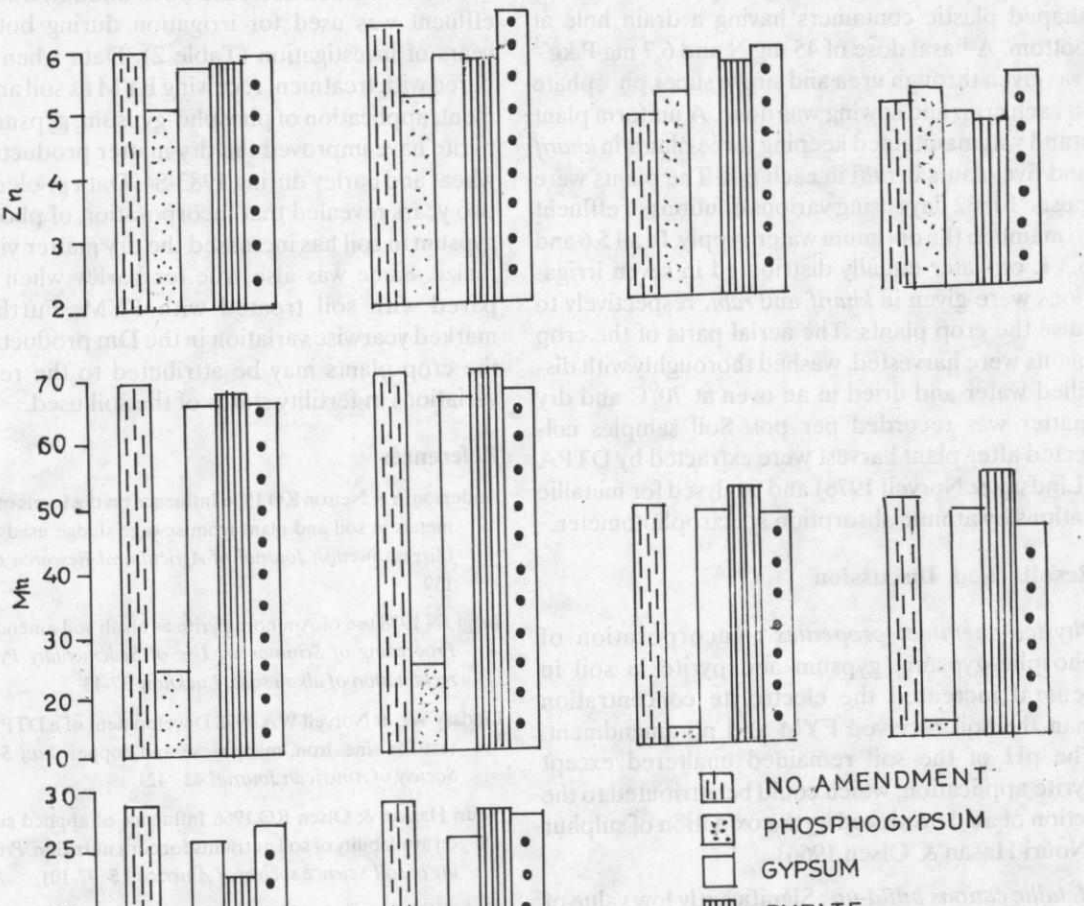

Fig 1 Effect of soil amendments on metallic cations build up (mg kg^{-1}) in soil irrigated with Smelter effluent

Five kg soil was treated with soil amendment at the rate of 10 t ha^{-1} for every crop; filled in barrel shaped plastic containers having a drain hole at bottom. A basal dose of 45 mg N and 6.7 mg P kg^{-1} was given through urea and single super phosphate in each crop and sowing was done. A uniform plant stand was maintained keeping three plants in *kharif* and five plants in *rabi* in each pot. The plants were raised for 62 days using various dilutions of effluent to maintain the optimum water supply. In all 5.6 and 6.3 L of water equally distributed in seven irrigations were given in *kharif* and *rabi*, respectively to raise the crop plants. The aerial parts of the crop plants were harvested, washed thoroughly with distilled water and dried in an oven at 70°C and dry matter was recorded per pot. Soil samples collected after plant harvest were extracted by DTPA (Lindsay & Norvell 1978) and analysed for metallic cations by atomic absorption spectrophotometer.

Results and Discussion

Physico-chemical properties : Incorporation of phospho-gypsum, gypsum and pyrite in soil in general increased the electrolyte concentration than the soil received FYM and no amendment. The pH of the soil remained unaltered except pyrite application, which could be attributed to the action of acid produced by the oxidation of sulphur (Nouri Hasan & Olsen 1966).

Metallic cations build-up : Significantly low value of DTPA- extractable Fe, Mn and Zn was recorded for the soil treated with phospho-gypsum , whereas pyrite has maintained a higher level of Fe and Mn in soil (Fig 1).This may be due to increased availability of native micronutrients by the acidity around the pyrite particles (Jaggi 1978). The lower values of Fe, Mn and Zn in soil treated with phospho-gypsum may be due to formation of compounds of lower solubility with phosphate released from the amendment (Tiwari & Pathak 1978).

Dry matter : Shoot yields of *kharif* and *rabi* cereals showed a marked decrease when undiluted smelter effluent was used for irrigation during both the years of investigation (Table 2). Data when compared with treatment receiving FYM as soil amendment, application of phospho-gypsum, gypsum and pyrite have improved the dry matter production of wheat and barley during 1983-84. Data pooled over two years revealed that incorporation of phospho-gypsum in soil has increased the dry matter yield of maize. Same was also true for barley when compared with soil treated with FYM. Further, a marked yearwise variation in the Dm production of the crop plants may be attributed to the relative variations in fertility status of the soil used.

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