

## IRON DEFICIENCY IN MAIZE UNDER SODIC CONDITION

N. K. MEHROTRA, V. K. KHANNA AND S. C. AGARWALA

Botany Department, Lucknow University, Lucknow - 226 007

Poor growth of plants, on salt affected alfisols and mollisols is attributed, amongst other factors, to low availability of certain micronutrients (Mehrotra and Agarwala 1987). Earlier reports from this laboratory have shown that high ESP induced Cu deficiency in barley (Mehrotra et al. 1982) and Zn deficiency in maize (Mehrotra et al. 1986) and high SAR water irrigations induced B deficiency in sugar-beet (Mehrotra et al. 1989). This paper reports the effect of soil ESP on Fe-deficiency in maize.

Maize (*Zea mays* L.) cv. Ganga 2 plants were grown in a Gomti upland alluvial soil (ustifluent) collected in a bulk from Arjunganj, Lucknow, sandy loam soil had cation exchange capacity  $7.2 \text{ me } 100\text{g}^{-1}$ , organic matter 0.72%,  $\text{CaCO}_3$  0.25%,  $\text{EC}_e$   $0.23 \text{ dSm}^{-1}$  and DTPA extractable Fe 12 ppm, Cu 0.9 ppm and Zn 0.5 ppm and ESP 12. By addition of  $\text{NaHCO}_3$  (Agarwala et al. 1964), eight graded levels of exchangeable sodium percentage (ESP- 14, 20, 25, 30, 36, 39, 48 and 56) were created. Sufficient N, P, K, Mn, Cu and Zn (at 100, 22.2, 40.5, 10, 2 and 5 ppm w/w, respectively) were added to meet their requirements in soils of  $\text{ESP} \geq 14$ . For NPK application  $\text{NH}_4\text{NO}_3$ ,  $\text{KH}_2\text{PO}_4$  and  $\text{K}_2\text{SO}_4$  salt solutions were purified against Fe by the phosphate adsorption procedure and for making Mn, Cu and Zn application, their analytical reagent grade sulphate salts were used. Nitrogen was supplied in split doses, 1/2 before sowing and 1/4 each when plants were 4 and 9 weeks old.

The experiment was conducted in the pots which were periodically irrigated with deionised water. There were four replicates in each treatment arranged in two blocks. Out of 10 plants, maintained in each pot after germination, 5 were sampled at day 19, 2 at day 30, 1 at day 75 and 2 at day 112 at maturity. Dry matter yield of tops sampled at day 19 and 30 and the dry matter in young leaves of plants sampled at day 75 was recorded after oven-drying at  $80^\circ\text{C}$ . At 112 days, the sun-dried weight of cobs, grains and straw was determined separately. The fresh plant-tops sampled at day 30 and young leaves at day 75 were thoroughly washed in a detergent, 0.01 N HCl, deionised and glass distilled water before drying. A portion of the crushed and mixed dried plant material was digested in nitric-perchloric acids (1 : 15 : 1) and analysed for Na by flame photometer, Ca by versenate titrimetric method, P-colorimetrically and Fe, Mn, Cu and Zn on atomic absorption spectro-photometer following standard procedures.

Growth rate of plants was computed by the formula :

$$\text{Growth rate} = \frac{\text{Log}_e W_1/W_0}{t}$$

where  $W_1$  : final dry weight,  $W_0$  : initial dry weight and  $t$  : period of growth in days between the two dry weight observations. At harvest (day 112), composite soil samples were collected from each block separately and analysed for extractable Fe (Lindsay and Norvell 1978) on atomic absorption spectrophotometer. Data were statistically analysed (Panse and Sukhatme 1961).

**Available soil Fe :** DTPA extractable soil Fe decreased with increase in soil sodicity from ESP 14 to 30 and above by > 50% (Table 1), even to levels indicative of its deficiency (Elgala et al. 1986). The results are in accordance with Dahiya and Singh (1979).

**Growth and yield :** An increase in soil sodicity decreased both height of tops and leaf dry matter, the effects being significant at ESP  $\geq 36$  for the former and ESP  $\geq 25$  for the latter (Table 1). The depression, as compared to lowest ESP, was  $\geq 50\%$  in height at ESP  $\geq 48$  and in leaf dry matter at ESP  $\geq 39$ . An increase in soil sodicity also delayed tasseling in plants by 2 days in the ESP range 25-36 and by 5 days at ESP 39. No reproductive parts could be made out visually at ESP  $\geq 48$ . An increase in soil sodicity above ESP 20 markedly decreased the harvest yield of plants with  $\geq 50\%$  reduction at ESP  $\geq 30$ ; the effect was more marked in the cob and grain yield as compared to the straw yield which in turn also decreased the harvest index (Table 1). There was no trend in the plant growth rate between 19-30 and 30-112 days period at different ESP, levels except at ESP 56 during the latter period. The sodicity induced depression in plant growth may be due to changes in the plant metabolism induced prior to week 3, the period of development of Fe-deficiency-chlorosis symptoms by sodicity induced high pH in the rooting medium due to  $\text{HCO}_3$  accumulation (Agarwala et al. 1964) and consequently, the increased cytoplasmic pH in the leaf tissue, which is reported to inhibit the activity of  $\text{Fe}^{3+}$  reductase located in the plasmalemma (Mengel and Geurtzen 1986).

#### **Tissue Na and other nutrient elements**

An increase in soil sodicity increased the tissue concentration and content per plant of Na and P and decreased those of Fe in the tops of 30 days old plants Table 2. The observed increase at the highest ESP (56) in tissue concentration of Na and P was 6 folds and the decrease in tissue Fe was to a level indicative of its deficiency (Chapman 1965). At day 75 also, an increase in soil sodicity resulted in a build up of tissue Na and P and a decrease in tissue Ca, Fe, Mn, Cu and Zn in young leaves (Table 2). The decrease in leaf tissue Ca at ESP  $\geq 30$  and that of Zn at ESP 56 was even to levels indicative of their deficiencies (Chapman 1965; Melsted et al. 1969). This indicated that 5 ppm soil Zn application was not sufficient to raise the

Table 1. Effect of soil sodicity on available soil Fe, growth attributes and yield of maize

ESP	DTPA Ext. Fe, ppm	Height of tops		Leaf wt. at 75 days g	Dry matter		Yield		No. of Grains/ Cob at 112th day	1000 grain Wt. g	Growth rate		Harvest index	
		68th days	87th days		19th days	30th days	Grain g/plant	Total g/plant			mg/plant/day 19-30	mg/plant/day 30-112	Cob basis	Grain basis
14	13.1	72.8	90.8	0.76	1.05	0.26	4.0	24.3	22.5	178	126	71	48	16.4
20	8.6	72.4	104.9	0.64	0.79	0.23	4.5	21.3	39.0	115	113	81	43	20.9
25	6.9	65.2	83.5	0.56	0.79	0.22	2.7	14.3	22.5	120	116	54	36	18.9
30	6.4	69.0	81.0	0.44	0.69	0.15	2.1	12.4	20.5	105	137	54	35	16.7
36	5.9	50.2	77.8	0.40	0.45	0.13	1.9	11.8	20.0	92	119	74	31	16.3
39	5.7	46.3	69.3	0.39	0.34	0.06	0.3	8.5	5.0	64	155	73	17	3.8
48	5.4	35.2	44.8	0.28	0.21	0.06	—	5.3	—	—	110	77	—	—
56	6.0	16.5	30.8	0.10	0.22	0.04	—	1.9	—	—	151	26	—	—
LSD	0.9	11.4	13.2	0.14	0.13	0.03	1.6	3.8	3.5	36	21	17	—	—

P=0.05

Table 2. Effect of soil sodicity on tissue concentration (dry mater) of P, Ca, Fe, Mn, Cu and Zn in tissues\* of maize

ESP	Na %		P %		Ca %		Fe ppm		Mn ppm		Cu ppm		Zn ppm	
	Tops	YL	Tops	YL	YL	YL	Tops	YL	YL	YL	YL	YL	YL	YL
14	0.29	0.20	0.28	0.34	0.40	0.40	202	209	79		13.4		25	
20	0.51	0.32	0.45	0.52	0.50	0.50	257	130	69		11.7		32	
25	0.84	0.35	0.41	0.49	0.41	0.41	217	113	46		95.0		21	
30	1.16	0.47	0.45	0.43	0.35	0.35	202	113	54		9.1		23	
36	0.93	0.46	0.38	0.66	0.20	0.20	196	104	41		7.2		16	
39	1.43	0.49	0.69	0.84	0.16	0.16	61	104	51		7.8		17	
48	1.87	1.05	0.81	0.91	0.10	0.10	83	87	36		7.2		16	
56	1.82	1.15	1.92	0.98	0.11	0.11	45	78	41		7.4		11	
LSD	0.16	0.09	0.16	0.26	0.06	0.06	95	39	12		0.9		5	
P0.05														

\*Tops at 30 days and YL (top 2-6 young leaves) at 75 days growth

Zn status of maize grown at ESP 56 to its sufficiency level. In spite of the young leaves exhibiting distinct Fe chlorosis effects at  $ESP \geq 25$ , the leaf tissue total Fe did not indicate its deficiency. It is consistent with the reports that active and not total Fe is better indicative of physiological Fe status (Mehrotra et al. 1990) and sodic water irrigations reduce  $Fe^{2+}$  total Fe, in young leaves, indicative of physiological unavailability of Fe in maize (Srivastava et al. 1985).

The results indicate that the sodicity induced Fe deficiency, is associated with the decreased availability of Ca to plants. It differs from the lime-induced Fe deficiency which is mostly associated with high Ca in the affected plant tissues (Hamze et al. 1987).

#### REFERENCES

- Agarwala, S.C., Mehrotra, N.K. and Sinha, B.K. 1964. Influence of exchangeable sodium on the growth and mineral composition of plants. I. Paddy and Barley. *Journal of the Indian Society of Soil Science* 12 : 7-24.
- Chapman, H.D. (ed.) 1965. *Diagnostic Criteria for Plant & Soils*. Eurasia Publishing House (P) Ltd., New Delhi (Indian reprint 1975).
- Dahiya, S.S. and Singh, M. 1979. Effect of salinity, alkalinity and iron sources on availability of iron. *Plant and Soil* 51 : 13-18.
- Elgala, A.M., Ismil, A.S. and Ossman, M.A. 1986. Critical levels of iron, manganese and zinc in Egyptian soils. *Journal of Plant Nutrition* 9 : 267-280.
- Hamze, M., Ryan, J., Mikdashi, R. and Solh, M. 1987. Evaluation of chickpea (*Cicer arietinum* L.) genotypes for resistance to lime-induced chlorosis. *Journal of Plant Nutrition* 10 : 1031-39.
- Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42: 421-428.
- Mehrotra, N.K. and Agarwala, S.C. 1987. Micronutrient disorders associated with halomorphic soils of Uttar Pradesh. *Indian Journal of Plant Nutrition* 6 : 51-81.
- Mehrotra, N.K., Khan, S.A. and Agarwala, S.D. 1989. Induction of boron deficiency in sugarbeet irrigated with high SAR (Sodium Adsorption Ratio) waters. *Journal of Sugarbeet Research* 26 : 24-32.
- Mehrotra, N.K., Khanna, V.K. and Agarwala, S.C. 1982. Soil sodicity induces copper deficiency in barley. *Indian Journal of Plant Nutrition* 1 : 37-41.
- Mehrotra, N.K., Khanna, V.K. and Agarwala, S.C. 1986. Soil sodicity induced zinc deficiency in maize. *Plant and Soil* 92 : 63-71.
- Mehrotra, S.C., Gupta, P., Chaturvedi, K. and Bisht, S.S. 1990. Active-Fe in relation to chlorophyll and activities of some Fe-enzymes in maize. *Indian Journal of Experimental Biology* 28 : 348-351.

- Melsted, S.W., Motto, H.L. and Peck, T.R. 1969. Critical plant nutrient composition values useful in interpreting plant analysis data. *Agronomy Journal* 61 : 17-20.
- Mengel, K. and Geurtzen, G. 1986. Iron chlorosis on calcareous soils. Alkaline nutritional condition as the cause for chlorosis. *Journal of Plant Nutrition* 9 : 161-173.
- Panse, V.G. and Sukhatme, P.V. 1961. *Statistical methods for agricultural workers*. 2nd ed.. I.C.A.R., New Delhi.
- Srivastava, P.C., Singh, N., Rawat, U.S. and Talati, N.R. 1985. Effect of different sodium adsorption ratio on iron nutrition of maize. *Current Agriculture* 9 : 27-31.