CRITICAL CONCENTRATIONS OF ZINC IN WHEAT

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ABSTRACT

Representative samples of the surface soil encompassing a range in dithizone extractable zinc were collected from several locations in Vijalpur, Tulewal and Fatehpur soil series of the soil and water management project, Patiala. In the greenhouse, wheat variety Kalyansona was grown on these soils. Plant samples were taken at 20 and 60 day's growth of the plants and also at maturity. Twenty ppm of zinc in wheat plant was found to be the critical concentration.

INTRODUCTION

The concentration of a nutrient in the plant tissue varies considerably during various phases of its growth. An important factor controlling crop yield is the phased application of required amount of nutrients in accordance with the periodical demands of the plant. If plant analysis shows low values of zinc early in the growth period, remedial action can be taken. The present investigation was, therefore, undertaken to study the zinc content in wheat at different stages of its growth and to relate it with zinc uptake and dry matter yield, and to find out the critical concentration of zinc in wheat.

MATERIAL AND METHODS

Bulk soil samples, representing a range in the ammonium acetate-dithizone extractable zinc, were collected from a depth of 0-15 cm, from 29 locations in Vijalpur, Tulewal and Fatehpur soil series of the Soil and Water Management Project, Patiala (ANONYMOUS, 1971). These were analysed for their texture, pH, electrical conductance and organic carbon by the methods described by PIPER (1950), and for $CaCO_3$ by the method of PURI (1949). Soil samples were analysed for available zinc by extraction with ammonium acetate-dithizone (SHAW AND DEAN, 1952).

A greenhouse study was conducted by growing wheat variety Kalyansona in Polythene lined pots, each having 3 kg soil. Three replications were provided. The soil was treated with zinc sulphate solution to provide 0, 2.5, 5.0 and 10.0 ppm zinc. A basal dose of N, P_2O_5 and K_2O at the rate of 120, 60 and 60 ppm was applied as ammonium sulphate, potassium dihydrogen orthophosphate and potassium sulphate respectively. The pots were irrigated with deionized water during crop growth. Plant samples were taken at three different stages of growth, i.e. 20 and 60 days after germination and at maturity. These were washed in succession with 0.1 N HCl, distilled water and deionized water, dried and ground before analysis. Dried samples were digested in triple acid mixture of perchloric acid, distilled HNO_3 and H_2SO_4 (all A. R. grade) in the ratio 3 : 9 : 1 and the zinc in the digest was determined by atomic absorption spectrophotometer.

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The Bray's (1948) per cent yield was worked out as under:

$$\text{Bray's per cent yield} = \frac{\text{Yield without zinc application}}{\text{Yield with optimum zinc application}} \times 100$$

Bray's per cent zinc uptake was also calculated similarly.

RESULTS AND DISCUSSION

The texture of the experimental soils varied from sand to sandy loam, pH from 8.1 to 9.8, electrical conductance from 0.02 to 0.84 m mhos/cm, organic carbon from 0.02 to 0.52 per cent, $CaCO_3$ from traces to 2.43 per cent and available zinc from 0.22 to 2.25 ppm (Table 1).

Table 1—Physico-chemical characteristics of the experimental soil

Location	Texture	pH (1:2 Soil : Water suspension)	E.C. m.mhos/cm	Organic carbon %	$CaCO_3$ %	Available zinc (ppm)
Vijalpur Series						
Kherifattan I ..	Sandy loam ..	8.9	0.14	0.50	0.34	0.45
Kherifattan II ..	,, ..	9.1	0.84	0.52	0.42	0.50
Daraula I ..	,, ..	9.0	0.11	0.31	0.27	0.40
Vijalpur I ..	Loamy sand ..	9.1	0.05	0.21	0.14	0.25
Vijalpur II ..	Sandy loam ..	8.8	0.32	0.44	2.43	0.17
Samana I ..	,, ..	9.0	0.16	0.34	0.45	0.60
Samana II ..	,, ..	8.6	0.14	0.31	0.06	1.380
Samana III ..	,, ..	8.6	0.16	0.26	—	0.64
Bhanra ..	,, ..	9.0	0.27	0.51	1.12	0.64
Lagroi I ..	,, ..	8.8	0.81	0.45	1.29	0.40
Rajla ..	,, ..	8.6	0.16	0.45	0.06	2.25
Samana IV ..	,, ..	8.9	0.11	0.26	0.20	1.15
Kherifattan III ..	,, ..	8.8	0.22	0.40	0.50	0.22
Tulewal Series						
Daraula II ..	Sandy loam ..	8.4	0.22	0.28	0.11	0.46
Samana V ..	Loamy sand ..	8.5	0.16	0.30	0.50	1.50
Nasupur I ..	Sandy loam ..	8.7	0.05	0.28	..	0.70
Nasupur II ..	,, ..	8.1	0.16	0.41	..	0.40
Bhanra II ..	Loamy sand ..	8.7	0.11	0.31	0.08	0.84
Lagroi II ..	Sandy loam ..	9.5	0.05	0.28	..	0.50
Daraula ..	Loamy sand ..	8.9	0.05	0.16	..	0.25
Futehpur series						
Kherifattan IV	Loamy sand ..	9.0	0.27	0.08	0.59	1.50
Daraula III ..	Sandy loam ..	9.0	0.05	0.37	0.20	0.60
Vijalpur III ..	Loamy sand ..	8.9	0.11	0.19	..	0.40
Nasupur III ..	Sand ..	8.8	0.05	0.19	..	0.65
Bhanra III ..	Loamy sand ..	9.4	0.05	0.11	..	0.45
Bhanra IV ..	,, ..	8.8	0.11	0.49	1.23	1.08
Asarpur ..	Sand ..	9.0	0.02	0.02	..	0.80
Daraula IV ..	Loamy sand ..	9.5	0.08	0.24	..	0.25
Chohat ..	,, ..	9.8	0.08	0.08	0.14	0.60

The data on zinc content in wheat at different stages of growth (Table 2) indicate that application of zinc increased the zinc content in plant at all its growth stages. Zinc content was maximum at 20 days growth in all the zinc treatments and it decreased subsequently. This is likely due to greater accretion in dry matter production than zinc uptake during this period. It may partly be due to greater metabolic need of the plant for zinc during this interval. The period between 60 days growth and maturity represents a phase of translocation of the nutrients earlier absorbed by the plants. The results are in accordance with those of ISHIZUKA (1964) for the mineral nutrition of rice plants in general. CHAHAL (1971) also noticed higher zinc content in wheat at 20 day's growth than at 60 days or at maturity. This would suggest the importance of zinc in mineral nutrition of plants during early stages. However, a study of the partial nutrient efficiencies of the plant can throw more light on the critical stage of plant growth with respect to zinc nutrition.

Table 2—Effect of zinc application on zinc content (ppm) in wheat at different stages of growth

Stages of growth (days)	Zinc applied to greenhouse pots (ppm)				Mean
	0	2.5	5.0	10.0	
20	22.8	35.0	46.2	60.0	41.0
60	18.6	28.0	85.0	44.1	31.4
Maturity	12.5	21.6	26.7	32.3	25.3
Mean	17.9	28.2	35.6	45.5	

The amount of zinc content in plants grown in zinc untreated pots at 20 and 60 day's growth, Bray's per cent zinc uptake and Bray's per cent dry matter yield are given in Table 3. The zinc content in plants at 20 and 60 day's growth varied from 13.6 to 42.2 ppm and 10.0 to 33.7 ppm with a mean value of 22.8 and 18.6 ppm. Zinc uptake and dry matter yield in the absence of zinc application was 18.7 to 63.4 per cent and 75.5 to 98.0 per cent of that due to zinc application at maturity. The rest of zinc uptake (36.6 to 81.3 per cent) and dry matter yield (2.0 to 24.5 per cent) may be attributed to zinc application.

In order to determine the critical levels of zinc in wheat plant at 20 and 60 day's growth, the values of zinc content in plants grown in zinc untreated pots at these stages were plotted against Bray's per cent zinc uptake at maturity (Figs. 1, 2), in accordance with the procedure of CATE AND NELSON (1965). The critical values thus obtained were 20 and 17 ppm respectively. If we consider a soil which gives 90 per cent of the maximum yield without zinc application (90 per cent Bray's per cent yield) as non-responsive to applied zinc, add the number of soils that produce plants with zinc content less than the critical levels at 20 day's and 60 day's growth but respond to zinc application and the number of soils that produce plants above the critical values but do not show a response, and express it in terms of percentage of all the soils, we get an overall predictive value. The predictive value thus obtained for both the stages was 55 per cent for dry matter yield and for the Bray's per cent zinc uptake there were 62 and 69 per cent at 20 and 60 day's

Table 3—Zinc concentration. Bray's per cent zinc uptake and Bray's per cent dry matter yield of wheat

Location	Zinc content (ppm) in plants grown in zinc untreated pots at		Bray's per cent zinc uptake (maturity)	Bray's per cent dry matter yield (maturity)
	20 days growth	60 days growth		
Vijalpur Series				
Kherifattan I ..	28.1	11.2	28.3	80.5
Kherifattan II ..	16.6	20.0	50.0	81.2
Daraula I ..	17.2	16.2	31.8	77.2
Vijalpur I	19.4	12.5	46.6	92.3
Vijalpur II ..	15.5	21.2	50.4	90.7
Samana I	13.6	12.5	33.8	98.0
Samana II	20.3	16.2	36.0	75.5
Samana III ..	32.8	16.2	63.4	86.4
Bhanra I	35.9	17.5	52.3	96.4
Lagroi I	25.0	22.5	32 2	86.0
Rajla	21.8	33.7	39.0	95.4
Samana IV ..	42.2	12.5	27.5	98.0
Kherifattan III ..	25.0	20.0	21.9	86.4
Tulewal Series				
Daraula II ..	20.3	20.0	22.9	90.3
Samana V ..	20.3	21.2	38.0	88.5
Naspur I	29.1	26.2	30.6	97.2
Nasupur II ..	17.2	13.7	29.0	90.2
Bhanra II ..	25.0	23.7	49.4	91.0
Lagroi II	19.1	16.2	28.7	85.6
Darauli	17.2	10.0	18.7	86.1
Fatehpur Series				
Kherifattan IV ..	18.7	13.7	16.5	83.5
Daraula III ..	15.5	12.2	24.5	89.1
Vijalpur III ..	13.6	20.0	31.7	81.1
Nasupur III ..	13.6	25.0	19.6	85.1
Bhanra III ..	26.6	21.2	39.0	90.3
Bhanra IV	39.1	25.0	45.3	97.3
Asanpur	29.1	20.0	46.3	86.0
Daraula IV ..	25.0	21.2	30.8	77.4
Chohat	17.2	16.2	33.7	91.6

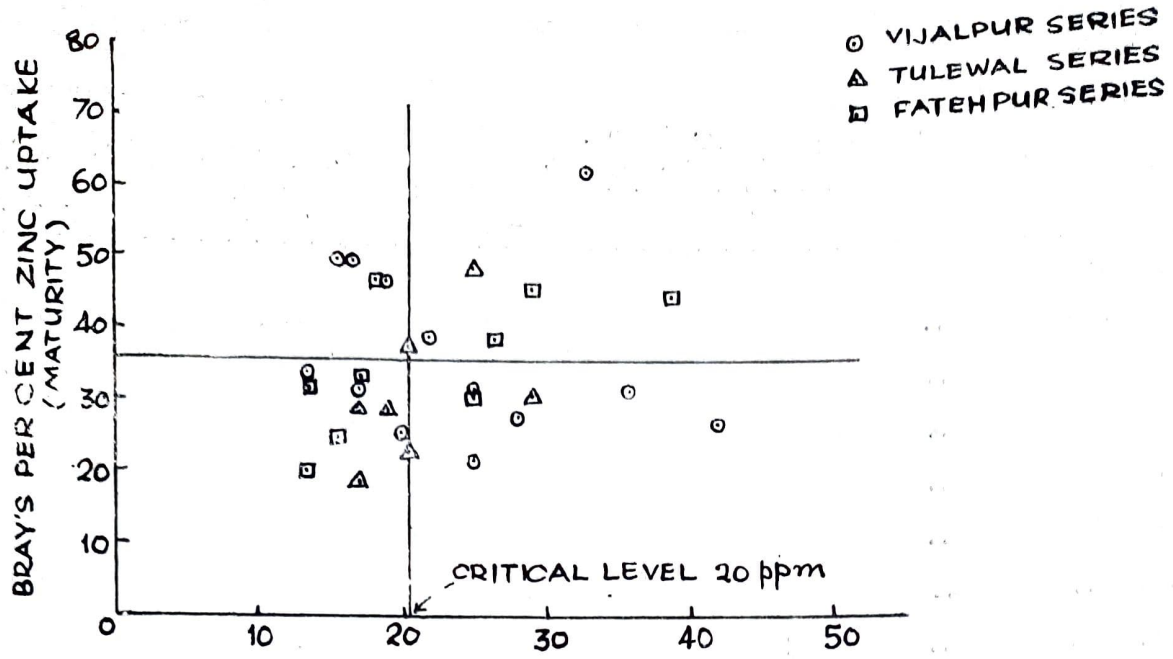

Fig. 1. ZINC CONTENT IN WHEAT IN CONTROL POTS (ppm)

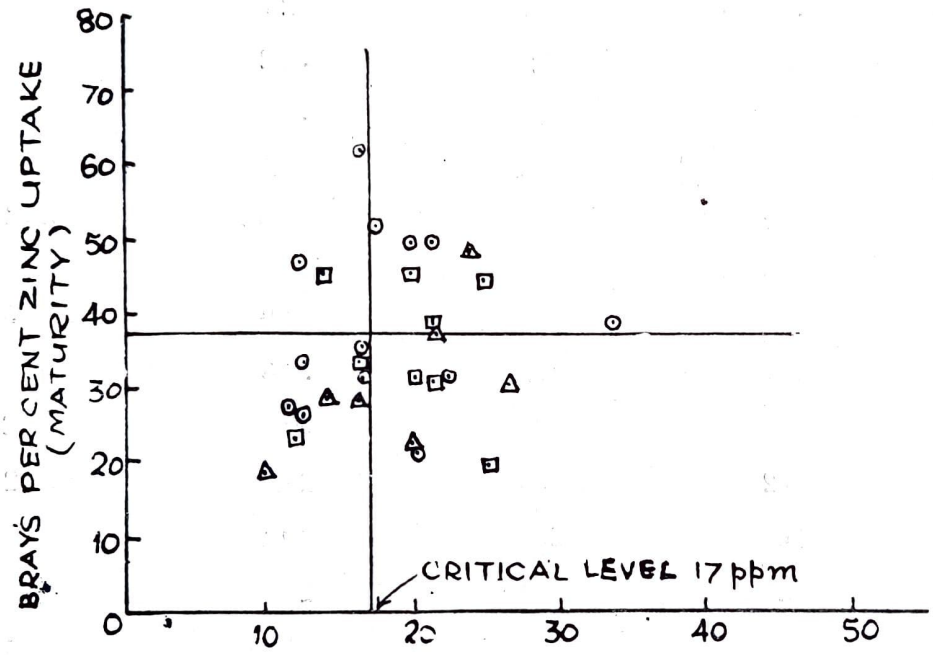

Fig. 2. ZINC CONTENT IN WHEAT. IN CONTROL POTS (ppm).

growth. The values of zinc content in plants in zinc untreated pots at 20 and 60 day's growth were also correlated with Bray's per cent dry matter yield. There was significant positive coefficient of correlation at 20 day's growth ($r = + 0.373^*$) and 60 days growth ($r = + 0.545^{**}$), suggesting that the critical concentration in the plant at these stages can be taken as a criterion for predicting the response of zinc fertilization to wheat. However, if further work in the field confirms these values, these could be adopted as a useful yard stick in the plant analysis laboratory for the diagnosis of zinc deficiencies in suspected areas.

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