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Critical limit of copper in soil and plant for predicting response of oat (*Avena sativa*) in soils of Haryana

NARENDER[1], R S MALIK[2] and R P NARWAL[3]

CCS Haryana Agricultural University, Hisar, Haryana 125 004

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ABSTRACT

In order to evaluate critical level in oat (*Avena sativa* L.), laboratory and a screen house experiment was conducted at CCS HAU, Hisar. Bulk surface soil samples (0-15 cm) were collected from eighteen (18) different locations, in the state representing major soil groups of Haryana. The results of the study revealed that the relationship between Bray's per cent yield against DTPA-Cu in soil and Cu concentration in plants indicated critical deficiency level of Cu in soil as 0.30 mg/kgand for oat plant it was 11.7 mg/kg which was statistically also at par.

Key words: Bray's % yield, Copper, Critical limit, Haryana soils, Oat

Copper is one of the essential micronutrient for fodder crop production. Its deficiency in crop plants particularly to that of fodder is a widespread nutritional disorder in many countries of the world (Reuter *et al*. 1988) and often results in decreased crop yield. Oat (*Avena sativa* L.) an important fodder crop of the country in general and Haryana in particular and is grown in diversified agro-ecological conditions and soils. About 70 per cent of the Cu in plants is found in chlorophyll. Copper deficiency can result an early aging or lowered levels of chlorophyll, which leads to yield reduction that goes unnoticed if the deficiency is not severe. This fodder crop has higher Cu requirement and is sensitive to its deficiency. For predicting response of oat to applied Cu in soils of Haryana, some extractants have been tried in soils having limited variability in the characteristics. The critical limits of available Cu in Indian soils have been established using various extractants and methods of estimation for few selected soils and crops. However, no work has been done so far to predict a relationship between available copper in soil and oat crop response to its application in Haryana soils. Therefore, the present work was planned to establish the critical level of Cu for oat in soil and plant.

MATERIALS AND METHODS

Bulk surface soil samples (0-15 cm) were collected from eighteen (18) different locations, representing the major soil groups in the state. The physical and chemical properties of soils (Table 1) were determined following standard procedures as outlined by Jackson (1973). The experiment soils (Table 1) are neutral in reaction with pH ranging from 7.0 to 8.6 and EC from 0.30 to 1.71 dS/m with an average of 0.70 dS/m. Organic carbon of the soil was found to range from 0.20 to 0.69 %, non-calcareous in nature and texturally varied from sand to loam.

The DTPA-extractable Cu was determined by the method of Lindsay and Norvell (1978) using Atomic Absorption Spectrophotometer (Varian-Spectrophotometer AA-20 plus). The critical deficiency level of Cu in soil and plant was determined by the procedures of Cate and Nelson (1965, 1971). The pots were arranged in completely randomized design in the screen house according to Steel and Torrie (1980). In the screen house study, four kg thoroughly mixed soil collected from eighteen (18) different locations in the state was filled in plastic pots. A basal application of recommended doses of N, P and K was applied using 50 mg N/kg soil as urea, 50 mg P/kg soil as potassium dihydrogen phosphate (KH_2PO_4) and 15 mg K/kg soil as potassium sulphate (K_2SO_4) in each pot. Copper @ 0, 5, 10, 15 and 20 mg/kg soil through $CuSO_4.5H_2O$ was applied at the time of sowing of oat. In all the pots soil was moistened with distilled water, dried and thoroughly mixed for equilibration.

RESULTS AND DISCUSSION

Plots of Bray's per cent yield against DTPA-Cu in soil and Cu concentration in plants by the graphical method of Cate and Nelson (1965) revealed that soils containing DTPA-Cu ranging from 0.18 to 0.56 mg/kg and dry matter yield varies from 53.0 to 91.4 per cent. The DTPA-extractable Cu was correlated with Bray's per cent yield to find out the critical limit of copper in soil. The critical limit for DTPA-Cu is 0.30 mg/kg in soil which was also at par to that of

[1] Senior Research Fellow (e mail: narenderhisar@gmail.com), [2] Senior Soil Scientist (e mail: ranbirsinghmalik@gmail.com), [3] Professor (e mail: rpnarwal@gmail.com), Department of Soil Science

Table 1 Physico-chemical characteristics of experimental soils

Locations of Soil Sampling	pH (1:2)	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	Particle Size (%)			Textural Class
					Sand	Silt	Clay	
Sadalpur	8.40	0.30	0.27	1.50	92	04	04	Sand
Shahnal	8.20	0.75	0.66	2.05	94	02	04	Sand
Sagwan	8.30	0.36	0.20	2.60	96	02	02	Sand
Narwana	7.60	0.47	0.67		80	12	08	Loamy sand
Dhani lamba	8.30	0.44	0.43	3.05	78	18	04	Loamy sand
Kalawali	8.60	0.62	0.40	2.55	90	04	06	Sand
Lakhan Mazra	7.00	1.18	0.69		80	06	14	Sandy loam
Dharsul Bhuna	8.10	0.42	0.36		82	02	16	Sandy loam
Siser Khurd	8.40	0.47	0.37		82	12	06	Loamy sand
Kourk	8.35	0.36	0.51		83	04	12	Sandy loam
Kalayat	8.05	1.71	0.48	1.00	82	06	12	Sandy loam
Butana	8.30	0.60	0.31	1.05	66	20	14	Loam
Nidani	8.00	0.82	0.43	3.12	62	22	16	Loam
Madanheri	8.30	0.83	0.69		80	04	16	Sandy loam
Kurkawali	8.25	0.93	0.27	3.50	78	06	16	Sandy loam
Kharakheri	8.40	0.40	0.25		72	20	08	Loamy sand
Kaul	8.10	0.41	0.66		68	18	14	Loam
Damla	7.70	1.70	0.33		82	06	12	Sandy loam
Range	7.00-8.60	0.30-1.71	0.20-0.69	Nil-3.50	62-96	02-22	02-16	Sand-Loam
Mean	8.13	0.70	0.44	2.26	80.38	9.33	10.22	Sandy loam
CV	4.55	61.42	36.36	40.70	11.49	76.74	48.33	

statistical method of Cate and Nelson (1971) as presented in Fig 1 and Table 2. All the soils with DTPA-Cu below the critical limit of 0.30 mg/kg was found to respond significantly to Cu application and the soils having more than 0.30 mg/kg Cu showed a little response. These findings are in agreement with those reported by Rathore *et al.* (1978) and Rawat (1981) for alluvial and hill soils, respectively. Considering the already established critical limits of Cu as 0.2 mg/kg (Anonymous 1990), all the soils used in the study were found adequate in Cu contents.

The normal range of Cu in many plants is fairly narrow ranging from 5 to 20 µg/g soil. When the Cu concentration in plants is less than 5.0 µg/g dry matters, the deficiencies are likely to occur in plants. The plant Cu content was found to increase from 9.17 to 17.83 mg/kg with the application of 20 mg Cu/kg and dry matter yield was found to vary from 53.0 to 91.4 per cent. They were correlated for computing the critical limit of copper in oat plant. The critical limit of Cu is 11.7 mg/kg in plant which was

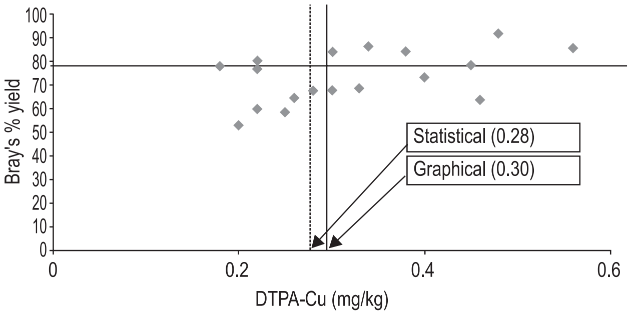

Fig 1 Relationship between Bray's% yield and DTPA

statistically also at par as presented in Table 3. Similar results were obtained by Singh and Nongkynrih (2000) studied copper deficiency in rice is expected in wetland rice soils of Meghalaya due to inherently high organic matter

Table 2 Effect of copper application on dry matter yield in oat plants and soils

Soils	DTPA-Cu (mg/kg)	Dry matter yield (g/pot) at copper level (mg/kg)					Bray's % yield
		0	5	10	15	20	
1	0.20	2.23	2.69	4.20	3.25	3.36	53.0
2	1.02	3.12	3.36	4.02	3.82	3.86	77.6
3	0.18	2.78	2.83	3.55	3.48	3.47	78.1
4	1.22	3.09	3.20	3.28	3.70	3.27	83.6
5	0.26	2.12	2.15	3.28	2.96	3.23	64.5
6	0.22	3.48	3.76	5.79	4.63	4.18	60.0
7	1.80	3.22	3.42	3.82	3.75	3.75	84.2
8	0.43	2.97	4.33	3.42	3.48	3.67	68.6
9	0.38	3.16	3.21	3.55	3.52	3.75	84.1
10	0.46	2.74	4.29	3.70	3.01	3.53	63.6
11	0.30	2.28	2.50	3.37	3.14	2.80	67.5
12	0.88	2.62	2.86	2.70	2.72	2.74	91.4
13	0.66	2.41	2.58	2.82	2.66	2.70	85.5
14	0.25	2.10	2.68	2.96	3.58	3.02	58.6
15	0.74	3.88	4.14	4.51	4.44	4.22	86.1
16	0.28	2.34	2.48	3.45	2.82	2.98	67.8
17	0.45	3.57	4.56	4.13	3.64	3.82	78.3
18	0.40	3.73	3.92	5.10	4.82	4.08	73.2
Mean	0.56	2.88	3.28	3.76	3.52	3.47	
CD (P0.05)	Soil=0.37,		Cu-level= 0.19			Soil×Cu-level=0.84	

Table 3 Effect of copper application on copper concentration in oat plants and soils

Soils	DTPA-Cu (mg/kg)	Plant copper content (mg/kg) at copper level (mg/kg)					Bray's % yield
		0	5	10	15	20	
1	0.20	6.83	7.50	8.33	9.50	10.50	53.0
2	1.02	4.83	5.50	6.67	7.50	9.17	77.6
3	0.18	5.67	9.17	10.33	10.67	11.67	78.1
4	1.22	5.33	6.83	10.67	11.17	12.17	83.6
5	0.26	6.00	8.50	9.00	9.67	10.17	64.5
6	0.22	6.50	8.17	9.17	10.50	11.17	60.0
7	1.80	6.83	7.50	10.67	12.33	16.50	84.2
8	0.43	7.83	10.67	13.17	16.17	17.00	68.6
9	0.38	5.50	7.00	10.67	15.17	17.83	84.1
10	0.46	7.17	7.50	8.00	10.17	11.67	63.6
11	0.30	7.50	8.50	9.83	10.17	10.83	67.5
12	0.88	7.17	8.00	8.83	10.17	10.67	91.4
13	0.66	7.33	11.00	12.67	14.83	15.67	85.5
14	0.25	6.33	7.83	8.83	9.17	9.67	58.6
15	0.74	9.50	10.83	13.33	14.17	17.50	86.1
16	0.28	8.83	9.50	10.83	12.50	15.33	67.8
17	0.45	5.67	6.00	6.17	6.33	8.33	78.3
18	0.40	5.67	6.33	7.50	8.17	9.67	73.2
Mean	0.56	6.69	8.13	9.70	11.02	12.53	
CD (P0.05)	Soil=1.51,	Cu-level=0.79		Soil×Cu-level=NS			

content, intensive cultivation, judicious application of manures and NPK fertilizers.

Thus the results indicate that for oat crop, the critical deficiency level of Cu for oat in soil is 0.30 mg/kg and for plant it was found 11.7 mg/kg which was graphically also at par. All the eighteen soils with DTPA-Cu below the critical limit of 0.30 mg/kg Cu showed a little response. Based on the critical limit of Cu obtained in the present studies (<0.30 mg/kg Cu), about 40% samples were found deficient. Hence, it can be concluded that Cu deficiency in these soils is a major yield limiting factor in fodder crops. Therefore, there is a dire need for balanced fertilization to avoid nutrient deficiency. The critical values for both soil and plant observed here would be helpful in predicting the Cu fertilization programme.

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