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MICRONUTRIENT STATUS OF SOME WHEAT AND RICE SOILS OF PUNJAB, PAKISTAN

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As a result of micronutrient survey of wheat and rice growing areas in some districts of the Punjab, the available Zn determined in wheat soils ranged from 0.22-1.56 ppm showing 26 % of the soils deficient while in rice soils, Zn ranged from 0.20-1.72 ppm and Cu from 0.27-4.71 ppm showing 82 and 7 % of the soils deficient in Zn and Cu respectively. However, Cu in wheat soils and Fe and Mn in both type of soils were sufficient.

Generally, there was a significant ($P < 0.05$) positive correlation among various micronutrients and soil clay, organic matter and carbonate contents but nonsignificant negative with pH. Multiple regression relationship obtained between DTPA extractable soil Zn and Cu and soil characteristics of either type of soils was limited to predict element availability in soils.

Key words: Micronutrients; Rice and Wheat; Punjab Soil.

INTRODUCTION

Plants need a number of nutrients for proper growth and performance of various other functions. Some are required in large while the others in small quantities. Due to intensive cropping and many years of exploitation of soils, the former, called macronutrients, become first deficient in soils, reducing yields measurably. Higher yield emphasis, however, resulted in their larger applications, specifically that of N and P. This practice failed to improve yields [1]. Soil status and response of micronutrient fertilizers became very much essential to know [2]. Since along the macronutrients' uptake by plants, simultaneous removal of micronutrients from soils is effected, the soils thus gradually become deficient in micronutrients [3]. Intensive and specialized cropping systems are also conducive to micronutrient deficiency in soils [4].

Though plants require micronutrients in small quantities their deficiencies depress yields drastically [5, 6]. Their excess, on the contrary, exerts strong toxic effects on crop growth [3, 4, 7]. Supplementation by fertilizers to ameliorate their deficiencies should be practised very judiciously. Prior to making an elaborate programme of micronutrient fertilization for crops, a knowledge of their available status in soils is prerequisite.

Survey of rice and wheat growing soils in some districts of the Punjab was carried out to determine micronutrient levels to develop maps indicating their deficiency areas.

MATERIALS AND METHODS

Composite soil samples (0 – 15 cm depth) from 50 and 39 sites in the wheat growing areas of Jhang, Muzaffar Garh, Dera Ghazi Khan and Vehari and in the rice growing areas of Gujrat, Sialkot and Sahiwal Districts respectively of the Punjab were collected. A kg. of the soils from each site was taken in the plastic bags. The samples were air-dried, ground with a wooden pestle in a mortar to a 40 mesh fine powder and stored for varius analyses.

Sand, silt and clay constituents of soils were determined by the Bouyoucos hydrometer method of Jackson [8]. The pH was measured on a pH-meter using a glass electrode and the salt contents (Ec, mmhos/cm) on a conductivity meter in 1:2, soil/water suspension [8]. Carbonate ($CaCO_3$) contents in soils were estimated by Puri's procedure [9].

Available Zn, Mn, Fe and Cu were measured on atomic absorption spectrophotometer in soil extracts obtained by shaking 10 g. of soils in plastic bottles for 2 hr. with 20 ml of 0.005 *M.* The DTPA (diethylene triamine pentaacetic acid) solution containing 0.1 *M.* triethanolamine and 0.01 *M.* $CaCl_2$ was finally adjusted to pH 7.3 as recommended by Lindsay and Norvell [10].

RESULTS AND DISCUSSION

Soils. Both wheat and rice areas were rich in clay occasionally containing more than 60 % (Table 1) which is conducive to the micronutrients' fixation [11, 12]. Soils, being saline in nature (having pH between 7 to 9), inhibited the micronutrient availability in soils and consequently their absorption by plants [13, 14]. Carbonates, depending on the type, particle size and amount in soils [15], check micronutrients, especially Zn uptake by plants [15, 16]. Organic matter in soils was apparently low (Table 1) but the effect, depending on various factors [13, 17 – 19], could have a strong bearing on the micronutrient availability in soils. Phosphorus particularly added as a fertilizers, due to interactive effects, could adversely affect the micronutrients availability in the soils [20 – 22]. It is evident that the characteristics of both type of soils may be conducive to low availability of micronutrients in soils.

Concentration. The concentration of Zn, Cu, Fe and Mn (Table 2 and 3) extracted by the DTPA method from soils [10] fall well within their respective ranges reported round the world [6, 7, 14, 23]. However, the minimum concentration levels of Zn, Cu and Mn, except Fe, in soils (Table 1) were higher while the maximum ones were quite lower than that known internationally [24]. The soil as well as the environmental factors [14, 23, 25] and agronomical practices [6, 7, 14] (as ferrous changes to ferric under aerated conditons resulting in its decreased availability and vice versa) are the causes for quantitative differences in the available amounts of micronutrients in soils that have evolved under various ecological zones of the world [25].

Majority of the soils (Table 2 and 3), particularly those growing rice were noticed to be deficient in Zn like the ones marked out in different parts of the world [7, 14, 23, 24, 27] and occasionally in Cu due to soil characteristics [11, 12, 15, 16], environmental variables [24, 25], cultural

Table 1. Physico-chemical properties of soils.

Properties studied	Wheat soils		Rice soils	
	Ranges	Average	Ranges	Average
Sand (%)	13.4 – 76.4	43.4	18.4 – 71.8	38.3
Silt (%)	11.0 – 71.0	28.8	15.1 – 41.9	28.7
Clay (%)	9.6 – 64.0	36.5	13.1 – 53.6	33.5
Texture	*SL-C	–	*SL-C	–
pH (1:2)	8.0 – 9.1	8.5	7.0 – 9.2*	8.2
Ec.mmhos/cm (1:2)	0.28 – 9.50	1.40	0.12 – 1.00	0.35
Organic matter (%)	0.63 – 2.16	1.35	0.10 – 1.79	0.95
$CaCO_3$ (%)	3.33 – 11.45	6.62	0.00 – 10.93	5.82
Olsen-P. ppm	0.14 – 11.18	4.82	0.14 – 8.87	3.23
DTPA-Zn, ppm	0.22 – 1.56	0.63	0.20 – 1.72	0.45
DTPA-Cu, ppm	0.50 – 3.17	1.59	0.27 – 4.71	1.91
DTPA-Fe, ppm	5.5 – 28.0	14.0	5.5 – 95.4	49.9
DTPA-Mn, ppm	12.0 – 40.0	23.0	7.5 – 21.9	13.9

*SL = sandy loam and C = clay.

Table 2. Zinc, Cu, Fe and Mn concentrations of soils sampled from wheat areas.

Soil sites	Concentration (ppm) Zn	Cu	Fe	Mn
1. Rajoa, Jhang	0.52	1.67	10.0	40.0
2. Chiniot-I, Jhang	0.52	0.83	10.0	15.6
3. Chiniot-II	0.69	1.83	13.5	25.2
4. Rabwah, Jhang	0.56	1.67	12.5	15.2
5. Khewa, Jhang	0.69	2.67	21.0	28.8
6. Lalian, Jhang	0.78	1.50	8.0	26.4
7. Bukhari-I, Jhang	0.35	0.58	7.5	12.4
8. Bukhari-II, Jhang	0.43	0.50	5.5	18.4
9. Rangpur, Jhang	0.52	1.50	10.0	28.0
10. Doratta, Jhang	0.35	1.17	10.0	28.0
11. Suleman, Jhang	0.35	1.17	9.5	24.8
12. Mekhiana, Jhang	0.52	0.83	8.5	21.6
13. Athara Hazari-I, Jhang	0.35	1.17	7.5	14.0
14. Athara Hazari-II, Jhang	0.43	0.92	6.0	21.6
15. Athara Hazari-III, Jhang	0.69	1.00	10.0	16.8
16. Ahmedpur, Jhang	0.52	0.67	5.5	24.4
17. Lungar Sarai, M. Garh	0.69	0.67	8.0	34.4
18. M. Garh-I, M. Garh	0.43	0.50	7.5	16.0
19. M. Garh-II, M. Garh	0.48	1.83	21.5	13.6
20. M. Garh-III, M. Garh	0.69	1.42	13.5	20.0
21. Shah Model Farm, M. Garh	0.69	1.50	15.0	13.5
22. Samnawala, M. Garh	0.22	0.50	6.0	18.8
23. Khan Garh-I, M. Garh	0.52	1.83	8.0	14.4
24. Khan Garh-II, M. Garh	0.69	1.50	12.0	25.6
25. Pirwala, M. Garh	0.78	1.33	14.0	35.2
26. Shahr Sultan-I, M. Garh	0.69	2.50	14.0	16.8
27. Shahr Sultan-II, M. Garh	0.52	1.17	7.5	27.2
28. Kot Addu, M. Garh	0.52	1.67	16.0	12.8
29. Kot Chutta-I, D.G. Khan	0.87	2.67	30.0	27.2
30. Kot Chutta-II, D.G. Khan	0.69	2.33	26.0	19.2
31. Jampur, D.G. Khan	0.95	1.83	15.0	34.4
32. Dajal, D.G. Khan	0.52	1.83	15.0	22.4
33. Dandi, D.G. Khan	0.69	1.75	13.0	19.2
34. Hajipur, D.G. Khan	1.13	2.33	28.0	25.6
35. Kotla Lunden, D.G. Khan	0.95	3.17	25.0	32.0
36. Rajanpur, D.G. Khan	1.22	2.33	24.0	32.0
37. Kotla Nur Mohd, D.G. Khan	0.61	1.08	18.0	20.0
38. Vehari-I, Vehari	0.69	2.50	13.0	32.4
39. Ludden-I, Vehari	0.69	1.75	14.0	32.8
40. Ludden-II, Vehari	0.43	2.00	14.0	20.8
41. Ludden-III, Vehari	0.52	1.17	10.0	28.8
42. Ludden-IV, Vehari	1.22	1.17	11.5	20.0
43. Ludden-V, Vehari	1.56	2.67	20.0	38.4
44. Vehari-II, Vehari	0.35	1.33	10.0	20.0
45. Nurshah-I, Vehari	0.65	3.17	24.0	20.0
46. Nurshah-II, Vehari	0.65	1.50	18.0	24.0
47. Melsi-I, Vehari	0.35	1.75	20.0	22.0
48. Melsi-II, Vehari	0.69	1.83	15.0	32.0
49. Machianwala, Vehari	0.43	1.67	14.0	18.0
50. Burewala, Vehari	0.61	1.50	15.5	12.0
*No. of deficient sites	(13 (26%)	None	None	None

*Categorized on soil critical limits of Zn = 0.5, Cu = 0.4, Fe = 2.5 and Mn = 1.0 ppm (bracket denote percent sites deficient in elements).

Table 3. Zinc, Cu, Fe, and Mn concentrations of soils sampled from rice areas.

Soils sites	Concentration (ppm) Zn	Cu	Fe	Mn
1. Chak Alawal, Sahiwal	0.36	2.49	14.0	16.3
2. Chak Maisoor, Sahiwal	0.32	1.42	16.0	10.6
3. Ratti Tibbi, Sahiwal	1.72	3.46	78.5	14.4
4. Chak 88-A/6-R, Sahiwal	0.68	2.93	94.6	13.1
5. Sahiwal, Sahiwal	0.36	2.09	24.0	16.3
6. Chak 34/EB, Sahiwal	0.28	1.78	17.5	8.7
7. Jewan Shah, Sahiwal	0.36	2.62	61.5	15.0
8. Chak 57/EB, Sahiwal	0.48	3.20	83.0	13.7
9. Arifwala, Sahiwal	0.36	1.24	17.5	8.7
10. 14 m from Arifwala, Sahiwal	0.40	4.26	83.0	15.0
11. Sidhar, Sahiwal	0.40	3.06	72.3	11.2
12. Pakpatan, Sahiwal	0.48	4.71	89.2	15.0
13. Chak 48/2-L, Sahiwal	0.32	1.82	26.0	13.1
14. Kot Bhattian, Sahiwal	0.40	1.95	46.1	13.1
15. Mazharabad, Sahiwal	0.28	2.44	58.5	14.4
16. Kot Pathanan, Sahiwal	0.24	2.04	22.0	12.5
17. Naqi Nagar, Sahiwal	0.20	1.55	22.0	11.2
18. Qila Dewan Singh, Sahiwal	0.20	1.55	14.0	8.7
19. B.S. Link, Sahiwal	0.40	1.95	25.0	12.5
20. Meer Kot, Sahiwal	0.60	2.58	68.5	7.5
21. Chak Wattuan, Gujrat	0.52	1.86	52.3	12.5
22. Kunjah, Gujrat	0.40	1.38	21.0	10.0
23. Maggowal, Gujrat	0.36	1.82	46.2	10.0
24. 6 m from Gujrat	0.28	1.02	43.1	10.0
25. Kothala, Gujrat	0.80	0.31	6.5	21.2
26. Tanda, Gujrat	0.24	0.27	5.5	10.0
27. Bagowal, Gujrat	0.20	0.31	8.5	20.6
28. Gondal, Gujrat	0.32	0.84	20.0	7.5
29. Dhaley Wali, Gujrat	0.24	2.09	83.1	20.6
30. Kotli Loharan, Sialkot	0.32	1.33	61.5	15.0
31. Sialkot, Sialkot	0.36	1.33	60.0	21.9
32. Pakki Kotli, Sialkot	1.32	1.95	59.2	15.6
33. Daska, Sialkot	0.32	1.33	74.6	15.6
34. Ghoinke, Sialkot	1.32	1.20	70.8	13.1
35. Chak Gillan, Sialkot	0.24	1.47	46.2	11.2
36. Kanwanlit-I, Sialkot	0.36	2.49	60.0	12.5
37. Kanwanlit-II, Sialkot	0.40	0.98	95.4	17.5
38. Ranijhi, Sialkot	0.32	1.82	53.8	12.5
39. Babakwala, Sialkot	0.24	1.73	73.8	15.0
*No. of deficient sites	32 (82%)	3 (7%)	None	None

*See Table 2 for deficiency categorization.

practices [23, 27] (as rice is grown under submergence) and N as well as P fertilization [20 – 20, 29]. Though Fe and Mn apparently seemed to be adequately present in soils (Table 2 and 3), some crops grown thereon might still show their deficiencies [5, 6, 28], due probably to genetic variability [23, 39] and other factors [12, 14, 23], thus indicating their hidden deficiencies [7]. However, a soil cannot actually be designated as deficient or adequate in micronutrients unless the correlation between soil and plant contents as well as yield responses may be studied since sometimes an element, that a soil test is showing to be adequate in a soil, may not fulfil its own crop requirements and vice versa.

Correlation. The contents of nutrient elements in soils may depend on the materials they are derived from [4, 32] but their availabilities depend on the total contents [24] and particularly the changes due to environmental factors [14, 24, 25] the soils have been put to. With no frequent changes occurring in the environments of a region, knowledge about certain soil components having natural relationship with elements could help to somewhat quantitatively know the amounts of elements including the micronutrient elements in the soils [32].

Significant correlation between DTPA-extractable soil Zn or Cu and Zn or Cu contents as well as yield responses in different plants has been established and the test thus has been commonly used for accurately predicting the availability of Zn or Cu in soils [4, 10, 13, 24, 32, 33]. Correlation coefficients studied (Table 4) showed a significant relationship ($P < 0.05$) between some of the rice or wheat soil characteristics and the micronutrients removed by DTPA extractant from the soils. Therefore, multiple regression equations relating soil chemical characteristics to DTPA-extractable soil Zn and Cu values (Fe and Mn are excluded because of their being adequately present in soils) were studied to ascertain if, with the help of data on the physicochemical characteristics of soil available, Zn or Cu amounts could be precisely predicted to delineate the deficiency areas. Soil values of clay (%), pH, organic matter (%) and carbonates (%) were used together to predict the extractable Zn and Cu values. It has been shown (Table 5) that extractable Zn and Cu values could not most accurately be predicted in this way since the best $r^2 \times 100$ were generally less than 75%. This shows that the available Zn and Cu in our soils may not only be dependent on these

Table 4. Correlation of DTPA-Zn, -Cu, -Fe and -Mn in soils with clay, O.M., CO_3 and pH of soils.

Soil variables	'r' values: Wheat soils Zn	Cu	Fe	Mn	Rice soils Zn	Cu	Fe	Mn
Clay	.46**	.51**	.60**	.31**	–.008	.43**	.31	–.21
O.M.	.64*	.21	.41*	.58**	.38*	.62**	.54**	.06
CO_3	.28*	.39**	.43**	.16	–.21	–.14	–.24	–.53**
pH	–.19	–.17	–.06	–.39	–.09	–.05	–.33*	–.24

*–significant at 5% level, **–significant at 1% level and unstarred figures are not significant.

Table 5. Multiple regression equations relating soil physico-chemical characteristics to DTPA-extractable Zn and Cu values in wheat and rice soils.

	Wheat soils	$r^2 \times 100$
DTPA-extractable Zn =	$-0.371 + 0.001$ clay $+ 0.435$ O.M. $+ 0.017\ CO_3 + 0.037$ pH	43.9
DTPA-extractable Cu =	$-0.730 + 0.011$ clay $+ 0.764$ O.M. $+ 0.971\ CO_3 + 0.069$ pH	37.4
	Rice soils	$r^2 \times 100$
DTPA-extractable Zn =	$-0.953 - 0.006$ clay $+ 0.519$ O.M. $- 0.037\ CO_3 + 0.155$ pH	27.4
DTPA-extractable Cu =	$0.845 + 0.030$ clay $+ 1.546$ O.M. $+ 0.003\ CO_3 - 0.173$ pH	45.2

soil characteristics but on others also. However, systematically including other possible soil variables in the regression equation and as much eliminating experimental errors as possible might enable us to reach a stage to ultimately precisely predict their available amounts in soils. These points will specially be taken into consideration during the following investigations being carried out in a comparatively small area with more detailed soil sampling.

REFERENCES

1. Ann. Progr. Rep., Accelerated rice research programme of West Pakistan (1966).
2. S. Yashida and A. Tanaka, Soil Sci. Plant Nutr., **15**, 75 (1969).
3. E.W. Russell, *"Soil Conditions and Plant Growth"* Longmans, Green, and Co., London, (1961).
4. J.J. Mortvedt, P.M. Giordano and W.L. Linsay, Micronutrients in Agriculture, Soil Sci. Soc. Am. Inc., Madison, U.S.A.(1972).
5. M. Tahir, Review Papers on Potash, Micronutrients and Rhizobium, Pakistan Agr. Res. Counc., Islamabad, Tech. Bull., p. 57 (1978).
6. M. Tahir, Availability status of micronutrients in the soils of West Pakistan and the role and behaviour of selected micronutrients in the nutrition of crops, PL-480 Project No. PK-ARS-3/Fg-Pa-221, Final Techn. Rep. (1981).
7. P.N. Takkar and N.S. Randhawa, Fertilizer News (India), 3 (1978).
8. M.A. Jackson, *"Soil Chemical Analysis"* (Prentice-Hall, Englewood Cliffs, New York, 1965).
9. A.N. Puri, A New Method of Estimating Total Carbonates in Soils, Pusa (India) Bull., 206.
10. W.L. Lindsay and W.A. Norvell, Soil Sci. Soc. Am. J., **42**, 421 (1978).
11. H.L. Barrow, M.S. Neff and N. Gammon, Soil Sci. Soc. Am. Proc., **24**, 367 (1960).
12. M.R. Reddy and H. Perkins, Soil Sci. Soc. Am. Proc., **38**, 229 (1974).
13. W.L. Lindsay, Adv. Agron., **24**, 147 (1972).
14. A. Tanaka and S. Yoshida, Intern. Rice Res. Inst. (IRRI), Los Banos, Philippines, Tech. Bull. No. 10 (1970).
15. J. Navrot and S. Ravikovitch, Soil Sci., **108**, 30 (1969).
16. E.J. Udo, H.I. Bohn and T.C. Tucker, Soil Sci. Soc. Am. Proc., **34**, 405 (1970).
17. J.F. Hodgson, H.R. Geering and W.A. Norvell, Soil Sci. Soc. Am. Proc., **29**, 665 (1965).
18. K. Matsuda, Soil Sci. Plant Nutr., **15**, 202 (1969).
19. F.J. Stevenson and M.S. Ardakani, in *"Micronutrients in Agriculture"* ed. Mortvedt *et al.*, Soil Sci. Soc. Am. Inc., Madison, U.S.A., p. 79 (1972).
20. F.T. Bingham and M.J. Garber, Soil Sci. Soc. Am. Proc., **24**, 209 (1960).
21. R.F. Keefer and R.N. Singh, 8th Intern. Congr. Soil Sci. Trans (Adelaide), 2, 367 (1968).
22. J.R. Melton, B.G. Ellis and E.C. Doll, Soil Sci. Soc. Am. Proc., **34**, 91 (1970).
23. G.W. McLean, *Report on Rice Research in Pakistan,* IRRI, Los Banos, Philippines (1969).
24. M. Sillanpaa, Micronutrients and the Nutrient Status of Soils a Global Study, FAO Soils Bull. **48** (1982).
25. R.E. Lucas and B.D. Knezek, in 'Micronutrients in Agriculture', Soil Sci. Soc. Am. Inc., Madison, U.S.A., p. 265 (1972).
26. M. Tahir, F. Hussain and A.S. Bhatti, Proc. Nat. Semin. Wheat Res. Prod., Islamabad, **2**, 213 (1979).
27. S. Yashida, 11th Sess. of FAO/IRC Working party on rice soils, water and fertilizer practices, Kandy, Ceylon, Sept. 2 – 5 (1968).
28. M. Tahir, A. Rashid, A. Latif and A.S. Bhatti, Proc. Nat. Semin., Rice Res. Prod., Islamabad, Feb. 18 – 22 (1979).
29. P.G. Ozanne, Austr. J. Soil Biol., **8**, 47 (1955).
30. P.B. Vose, Herb. Abstr., **33**, 1 (1963).
31. F.E. Bear, *"Chemistry of the Soils"* Am. Chem. Soc. Monograph Ser. No. 160, (Reinhold Publishing Corp., U.S.A. 1965).
32. J.W.B. Stewart and M. Tahir, Proc. Intern. Symp. Soil Fert. Evaln., New Delhi **1**, 983 (1971).
33. M. Tahir, A. Rashid and A.S. Bhatti, Pakistan J. Sci. Ind. Res., **25**, 184 (1982).