Annals of Arid Zone 36(4): 335-340, 1997

Distribution of Available Micro-nutrients as Related to the Soil Characteristics of Older Alluvial Plain of Central Haryana

Kuldeep Singh, V.N. Garalapuri and S.K. Rana
Department of Soil Science, CCS Haryana Agricultural University, Hisar 125 004, India

Abstract: Profile distribution was investigated for DTPA-extractable Zn, Cu, Mn and Fe in relation to depth and important soil characteristics in eight representative soil profiles of older alluvial plain of central Haryana. There was no specific pattern of distribution of available Cu, Mn and Fe due to alluvial nature of soils; however, a decreasing trend for available Zn with increasing depth was observed. Mean values for available Zn, Cu, Mn and Fe were, 0.38, 0.92, 2.02 and 2.48 mg kg^{-1}, respectively. Distribution of Zn and Mn was influenced inversely by soil pH and $CaCO_3$ content. Organic carbon content controlled dominantly the available Cu and Mn. Multiple regression equations revealed 47, 35, 47 and 45% variations in available Zn, Cu, Mn and Fe, respectively, were due to the combined effect of all the soil characteristics. However, no single soil property influenced the distribution of all the four micro-nutrients. All the soil samples were deficient in available Zn, sufficient in Cu and low to medium in Mn and Fe status.

Key words: Available micro-nutrients distribution, soil characteristics, older alluvial plain.

The importance of fertilizer application, which is a common practice in modern agriculture in enhancing agricultural productivity and production on a sustainable basis, is now well established. Increased productivity has greatly increased the demands on the soil for nutrients. Among the soil fertility related constraints, available micro-nutrients have assumed added significance due to their widespread deficiencies in Indian soils (Katyal and Vlek, 1985). The distribution of available micro-nutrients within soil profiles has been considered useful for a better understanding of soil capacity to sustain an adequate supply of these nutrients to plants and their downward movement in soil. Micro-nutrient deficiencies in varying degrees of intensity have been reported in large areas representing different soil groups of Haryana State (Gupta *et al.,* 1994). Secondary micro-nutrient deficiencies are caused by soil factors reducing their availability to plants (Singh, 1995; Singh and Raj, 1996). The present study was taken up to evaluate the availability of Zn, Cu, Mn and Fe in alluvial soils, primarily representing older alluvial plain region of Central Haryana, in relation to some important soil characteristics.

Materials and Methods

Eight soil profiles were exposed in the northern part of Haryana after selecting representative sites based on the soil-landscape relationship (Table 1). The area under

Table 1. Description of profile sites

Location	Landform	Soil Taxonomy
Pur	Levelled plain	Typic Camborthids, coarse loamy
Lohari Jatu	Eroded plain	Typic Calciorthids, coarse loamy
Tigrana	Undulatory alluvial plain	Typic Calciorthids, coarse loamy
Gujran	Bevelled alluvial plain	Typic Torripsamments
Mundhana	Levelled alluvial plain	Typic Camborthids, coarse loamy
Bawani Khera	Alluvial plain	Typic Camborthids, fine loamy
Jamalpur	Aeolian plain	Typic Torripsamments
Maghadpur	Dunal plain	Typic Torripsamments

study lies between 28°50′ and 29°50′N, latitude, and between 75°35′ and 76°15′E longitude. The climate of the area is sub-tropical continental semi-arid and monsoon type. The normal annual rainfall is about 420 mm at Bhiwani and more than 300 mm at Siwani, out of which, 75% is received during monsoon. The dominant soils, with alluvium as parent material in association, are Typic Camborthids, Typic Calciorthids and Typic Torripsamment (Soil Survey Staff, 1975). Forty samples were collected from different horizons. The samples were air-dried, ground to pass through 2 mm stainless steel sieve, and analysed for particle size distribution, pH, EC, $CaCO_3$, organic carbon and CEC by following standard procedures. Diethylene triamine pentaacetic acid (DTPA) was used for extracting available micro-nutrient cations from the soil (Lindsay and Norvell, 1978) and estimated with the help of an atomic absorption spectrophotometer. Simple and multiple correlation studies of soil characteristics with micro-nutrient cations were worked out statistically.

Results and Discussion

The range and mean values of some selected soil properties in respect of all the eight soil profiles are given in Table 2. These soils are slightly alkaline as pH values ranged from 7.6 to 8.8. Salinity level in all the profiles is less than 4 dS m^{-1}, and varied from 0.13 to 0.25 dS m^{-1}. The soils are characterised as non-saline. The organic carbon content of majority of these soils was very low to medium, and ranged from 1.8 to 4.5 g kg^{-1}, with an average value of 3.0 g kg^{-1}. The calcium carbonate equivalent varied from traces to 15.7 g kg^{-1}. The clay distribution was between 44 and 241 g kg^{-1}, with a mean value of 103 g kg^{-1}. The cation exchange capacity varied from 7.04 to 12.48 c mol (p+) kg^{-1}, which increased with depth and followed the pattern of clay distribution. Majority of the soils had sand or loamy sand texture and thus, the soils were classified as very light to light.

Distribution of available micro-nutrients

The DTPA-extractable Zn in all the profiles and horizons varied from 0.24 to 0.56 mg kg^{-1}, with a mean value of 0.38 mg kg^{-1}. Sangwan and Singh (1993) also reported similar results in semi-arid soils of Haryana. Based on the critical limit of 0.60 mg kg^{-1} (Singh and Shukla, 1985), all the soil samples fall in the category of low

Table 2. Some important soil properties

Location	Depth	pH	EC (dS m^{-1})	Org. C (g kg^{-1})	$CaCO_3$ (g kg^{-1})	Clay (g kg^{-1})	CEC (c mol(P$^+$) kg^{-1})
Pur	0-200	7.7-8.2	0.15-0.25	2.2-4.5	Traces	88-198	8.2-10.2
			(0.17)	(3.1)	–	(134)	(8.9)
Jatu	0-166	7.9-8.6	0.15-0.25	1.8-4.5	4-157	75-143	8.5-12.5
			(0.19)	(3.1)	(68)	(99)	(10.5)
Tigrana	0-136	7.9-8.5	0.14-0.17	2.2-4.2	4-100	74-126	8.2-10.6
			(0.15)	(3.1)	(37)	(87)	(9.4)
Gujran	0-220	8.0-8.7	0.13-0.22	2.2-4.4	7-72	68-88	7.0-8.8
			(0.16)	(3.0)	(41)	(75)	(8.0)
Mundhana	0-160	8.2-8.5	0.17-0.22	2.7-4.2	0-37	62-124	8.5-9.6
			(0.19)	(3.1)	(12)	(93)	(9.1)
Bawani Khera	0-183	7.6-8.2	0.16-0.25	2.4-3.4	1-32	124-241	10.0-12.1
			(0.21)	(2.8)	(14)	(176)	(10.8)
Jamalpur	0-170	8.2-8.4	0.15-0.23	2.2-3.8	Traces	44-76	7.6-7.9
			(0.19)	(2.9)	–	(66)	(7.7)
Majhadpur	0-180	8.2-8.9	0.17-0.25	2.6-3.4	Traces	64-97	8.6-9.0
			(0.21)	(2.9)	–	(80)	(8.8)

Note: Figures within parenthesis indicate mean values.

Zn status and would require Zn fertilization for better crop production. This is in line with the finding of Singh (1995) and Singh and Raj (1996), who reported widespread Zn deficiency in the soils of Haryana State. The deficiency of Zn could be due to poor inherent supply of this nutrient from soil. In general, the available Zn decreased with depth, except in profile 3, and followed the trend of clay accumulation. Zinc content was less in calcic horizons, which suggest that calcium carbonate reduces the availability of Zn.

In different profiles, the amount of Cu, Mn and Fe extracted by DTPA solution ranged from 0.54 to 1.80, 1.04 to 2.83 and 1.63 to 3.31 mg kg^{-1}, with the corresponding mean values of 0.92, 2.02 and 2.48 mg kg^{-1}, respectively. According to the criterion for DTPA-extractable micro-nutrients preferred by Gupta *et al.* (1994) all the soils were sufficient in Cu and low to medium in Mn and Fe status. Distribution of Cu, Mn and Fe in various profiles did not follow any specific pattern. The results are at variance with the observations of Lal and Biswas (1974) and Singh *et al.* (1988), who reported uniform distribution of Mn, Fe and Cu in old alluvial soil of Rajasthan and of Zn, Cu and Fe in alluvial plains of Haryana, respectively. The irregular pattern of micro-nutrient distribution observed in the present investigation might be related to the weak pedogenic manifestation and alluvial nature of these soils. The variations in the pattern of clay, organic matter and calcium carbonate content distribution might have caused the irregular pattern of available micro-nutrient distribution.

Table 3. Range and mean values of available micro-nutrients

Profile No.	Location	Zn	Cu	Mn	Fe
		mg kg^{-1}			
1.	Pur	0.32-0.44 (0.36)	0.18-0.48 (0.41)	1.60-2.60 (2.04)	1.63-2.28 (1.97)
2.	Jatu	0.24-0.48 (0.35)	0.54-1.26 (0.93)	1.60-2.68 (2.12)	2.09-3.31 (2.67)
3.	Tigrana	0.25-0.40 (0.33)	0.72-1.44 (1.21)	1.41-2.83 (2.18)	2.08-2.96 (2.69)
4.	Gujran	0.32-0.48 (0.41)	0.99-1.44 (1.17)	1.04-2.72 (1.95)	2.26-3.13 (2.64)
5.	Mundhana	0.32-0.40 (0.38)	1.08-1.44 (1.29)	2.00-2.63 (2.37)	2.20-2.78 (2.46)
6.	Bawani Khera	0.40-0.64 (0.50)	0.46-1.80 (0.92)	1.56-2.60 (1.96)	2.78-3.31 (3.15)
7.	Jamalpur	0.28-0.44 (0.36)	0.54-0.72 (0.67)	1.06-2.12 (1.70)	1.97-2.32 (2.17)
8.	Maghadpur	0.32-0.44 (0.39)	0.63-1.08 (0.79)	1.32-1.86 (1.64)	1.97-2.32 (2.07)

Note: Figures within brackets indicate mean values.

Influence of soil characteristics on distribution of micro-nutrients

The distribution of available micronutrients depends on some important soil characteristics, which is exhibited by significant coefficient of correlation between them (Table 3). There exists a negative relationship of available Zn with pH (r = -0.34*) and $CaCO_3$ (= -0.39**), and positive with EC (r = 0.40**) and clay content (r = 0.31*). Soil cations like Mn and Fe bear significant positive correlation with available Zn, suggesting variation in their distribution dependent upon common soil factors (Follect and Lindsay, 1970). Multiple regression equations reveal that 47% variation in available Zn is due to the integrated effect of all the soil characteristics included in the study.

Available Cu is significantly and positively correlated with organic carbon (r = 0.30*) and is not influenced significantly by any other soil character. The joint effect of all these soil factors account for 35% of the variation in available Cu. These results are contrary to the findings of Singh and Raj (1994).

Available Mn has significant negative relationship with pH (r = -0.32*) and $CaCO_3$ (r = -0.30*) and positive with organic carbon content (r = 0.50**). Multiple regression analysis infers that 47% of the variation in content of Mn can be attributed to the simultaneous influence of all the soil factors. However, the partial regression coefficients indicates the dominant role of organic carbon only on available Mn. Basu *et al*. (1964) reported that Mn from humic acid fraction of soil was released more quickly, consequently increasing the availability of soil Mn. Available soil Fe was not influenced significantly by any of the soil factors,

Table 4. Correlation coefficients (r) between micro-nutrients and soil characteristics

Soil character	Zn	Cu	Mn	Fe
pH	-0.34*	-0.09	-0.32*	-0.28
EC	0.40**	0.26	0.23	0.18
OC	0.26	0.30*	0.50**	0.16
$CaCO_3$	-0.39**	0.03	-0.30*	0.05
Clay	0.31*	-0.09	0.10	0.24
CEC	-0.03	-0.05	-0.07	0.23
Zn	–	0.21	0.38*	0.47**
Cu	–	–	0.33*	0.44**
Mn	–	–	–	0.35*

*, ** Significant at 5 and 1% level, respectively.

presumably because of narrow variation in available Fe. The regression equation shows that about 45% variability in available Fe is due to the combined effect of all these soil factors. The present results corroborate the findings of Dhir *et al.* (1983) who showed that available Fe was not influenced by any soil parameter studied.

It is concluded that no single soil characteristic significantly contribute in the distribution of available Zn, Cu, Mn and Fe. An inverse relationship of soil pH and positive relationship of organic matter with available micro-nutrients have been reported (Katyal and Agarwala, 1982), which could be partially confirmed from the present study, possibly because of the narrow range in these two soil characteristics.

References

Basu, A.N., Mukherjee, D.C. and Mukherjee, S.K. 1964. Interaction between humic acid fractions of soil and trace element cations. *Journal of Indian Society of Soil Science* 12: 311-318.

Dhir, R.P., Sharma, B.K. and Joshi, D.C. 1983. Availability of iron, manganese, zinc and copper in some soils of western Rajasthan. *Annals of Arid Zone* 22: 343-347.

Follect, R.H. and Lindsay, W.L. 1970. Profile distribution of Zn, Fe, Mn and Cu in Colorado soil. *Technical Bulletin* 110 Colorado, 679 p.

Gupta, V.K., Gupta, S.P., Ram Kala, Potalia, B.S. and Kaushik, R.D. 1994. 25 years of micronutrient research in soils and crops of Haryana. *Technical Bulletin*, HAU, Hisar, 99 p.

Katyal, J.C. and Agarwala, S.C. 1982. Micro-nutrient research in India. *Fertilizer News* 27(2): 66-86.

Katyal, J.C. and Vlek, P.L.G. 1985. micro-nutrients problems in tropical Asia. *Fertilizer Resedrch* 7: 69-74.

Lal, F. and Biswas, T.D. 1974. Factors affecting the distribution and availability of micro-nutrient elements in major soil groups of Rajasthan. *Journal of Indian Society of Soil Science* 22: 333-346.

Lindsay, W.L. and Morvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42: 421-428.

Sangwan, B.S. and Singh, K. 1993. Vertical distribution of Zn, Mn, Cu and Fe in the semi-arid soils of Haryana and their relationships with soil properties. *Journal of the Indian Society of Soil Science* 41: 463-467.

Singh, K. 1995. Extractable micro-nutrient status of cation growing soils of Sirsa district. *Journal of Cotton Research and Development* 9: 115-120.

Singh, K., Ahuja, R.L. and Singh, M. 1988. Profile distribution of available micro-nutrients in relation to land forms and soil properties. *Journal of Indian Society of Soil Science* 36: 828- 832.

Singh, K. and Raj, H. 1994. DTPA-extractable Zn, Cu, Mn and Fe in Trans-Gangetic plains of northern India. *Annals of Arid Zone* 33: 295-297.

Singh, K. and Raj, H. 1996. Soil micro-nutrient status in some Inceptisols of Haryana and their relationship with soil characteristics. *Haryana Agricultural University Journal of Research* 26: 61-64.

Singh, K. and Shukla, U.C. 1985. Response of wheat to zinc application in different soils of semi-arid region. *Journal of Indian Society of Soil Science* 33: 831-835.

Soil Survey Staff 1975. *Soil Taxonomy*. Agriculture Handbook, U.S. Department of Agriculture, 436 p.