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Full Length Research Paper

Distribution of available micronutrients as related to the soil characteristics of Hissar; Haryana (India)

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Profile distribution was investigated for DTPA-extractable Zn, Cu, Mn and Fe in relation to depth and important soil characteristics in ten representative soil profiles of Hissar. There was specific pattern of distribution of available Cu, Mn and Fe due to alluvial nature of soils. A decreasing trend for available Zn with increasing depth was observed. Mean values for available Zn, Cu, Mn and Fe were 27, 81, 4.38 and 2.98 ppm, respectively. Distribution of Mn was influenced inversely by soil pH, electrical conductivity (EC), exchangeable sodium percentage (ESP) and $CaCO_3$ content. Distribution of Fe and Cu also were influenced inversely by ESP. Distribution of Cu was influenced inversely by $CaCO_3$. Organic carbon content controlled dominantly of all the four micro nutrients. Cation exchange capacity (CEC) content controlled dominantly only the available Cu. Four multiple regression models to predict the available micro nutrients (Zn, Cu, Mn and Fe) of a soil from organic carbon and CEC are also presented. The amount of correlation was 46, 53, 42 and 41 in respect to Zn, Cu, Mn and Fe respectively. All the soil samples were deficient in available Zn, medium in Cu and low to medium in Mn and Fe.

Key words: Diethylene triamine pentaacetic acid, iron, zinc, copper, manganese, cation exchange capacity.

INTRODUCTION

Investigation of trace elements in soils mostly carried out for two purposes: 1) to explain crop failures and 2) to determine the effects on plant growth of elements other than those already recognized as essential. As a consequence of (1), much practical data has been collected regarding the effects of trace elements on crops, but relatively little information has been found pertaining to their roles in the intricacies of plant growth. 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. The present study was taken up to evaluate the availability of Zn, Cu, Mn and Fe in alluvial soils of Hissar in relation to some important soil characteristics.

MATERIALS AND METHODS

The area under study lies between 28° 59' to 29º 49' N latitude and 75º 11' to 76º 18' E longitude (2005). The climate of the area is sub-tropical continental secondary, monsoonal type of climate with prolonged hot period from March to October and fairly cool winters. The average annual rainfall varies from about 353 mm in Hansi to 447.1 mm in Tohanatehsils. Roughly much needed (75 to 80%) of the annual rainfall is received during the SW monsoon season (June to September) with C.V. of nearly 50% (Bishnoi, 1982). In the post monsoon winter season few light showers that is 10 to 15% of the annual rainfall, are received from waste rely depressions. The representative sites included in the present studies belong to 10 different soil series. Simple and multiple correlation studies of soil characteristics with micro nutrient cations were worked out statistically from the analytical data of 50 samples collected from 10 profiles in the south-western part of Haryana and worked out by Ahuja and Singh (1983). Air-dried bulk samples were crushed to pass through a 2 mm sieve. Particle-size distribution, pH, EC,

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Table 1. Soil landscape relationship of soil profiles.

Soil series	Parent material	Physiography	Soil taxonomy
Behal	Aeolin sand	Sand dunes unstabilized	Typic torripsamments
Rawalwas	Alluvium with aeolian cover	Aeolian covered upland plain	Typic ustripsamments
Nindana	Alluvium covered with aeolian	Aeolian covered slightly leveled plain	Typic ustochrepts
Jallopur	Alluvium ghaggar	Ghaggar plain leveled &cultivated	Udic ustochrepts
Ladwa	Alluvium drishdawati	Low lying alluvial plain	Typic ustochrepts
Joytisar	Alluvium	Drishdavati channel-relictcourse	Apuic ustochrepts
Kaul	Alluvium	Old basin	Vertic haplaquents
Shamri	Alluvium	Drishdawati saltaffected plain	Aquic ustochrepts (strongly saline)
Kaithal	Alluvium	Relict course salt affected	Aquic ustochrepts (moderately saline)
Zarifa Viran	Alluvium	Salt affected plain in the Ghaggar river	Typic natrustalfs

$CaCO_3$, organic carbon and CEC were determined on the fine earth fraction by standard procedures (Horwiz, 2005). DTPA are the methods or procedures you actually used to analyze these nutrient elements.

RESULTS AND DISCUSSION

The range and mean values of some selected soil properties in respect of all ten soil profiles are given in Table 1. Out of ten soil series established in the Hissar district, seven series, Behal, Rawalwas, Joytisar, Kaul, Shmri, Kaithal and Zarifa Viran have major problems and need immediate special attention to check their problems and to make them more suitable for crop production. Four soil series named Nindana, Jallopur and Ladwa have same problems and need only the protective measures and planning to save them from the hazards of damage (Ahuja and Singh, 1983). In these soils pH value range from 7.60 to 9.40 EC values range from 9 to 24 dS/m with mean 2.59 dS/m and ESP values range from 2 to 62.9 with mean 17.92% (Table 2). The organic carbon content of the majority of these soils is very low to medium and ranged from 0.01 to 0.64% with an average value of 0.16%. The calcium carbonate equivalent varies from trace to 13.50%. The clay distribution is between 4.50 to 46.80% with a mean value of 19.55%. The cation exchange capacity varies from 0.70 to 19.50 meq/100 g, which in creases with depth and follows the pattern of clay distribution. Majority of the soils have sand or loamy sand texture and thus, the soils were classified as very light to light (Table 2).

The sand distribution was between 9 to 91.8% with a mean value of 57.88% and the silt distribution was between 1.60 to 46% with mean value of 21.91%.

Distribution of available micronutrients

The DTPA-extractable Zn in all the profiles and horizons varied from 0.12 to 0.94 ppm with a mean vale of 0.27 ppm. Sangwan and Singh (1993) also reported similar results in semi-arid soils of Haryana. Based on the critical limit of 0.60 ppm (Singh and Shukla, 1985), most of the soil samples fall in the category of low Zn status and would require Zn fertilization for better crop production. In general, in most of the profiles the available Zn decreased with depth and followed the trend of organic carbon accumulation. Indifferent profiles the amount of Cu , Mn and Fe extracted by DTPA solution ranged from 0.10 to 2.10 , 0.66 to 12 and 0.51 to 10.8 ppm, with the corresponding mean values of 0.819, 4.38 and 2.98 ppm, respectively (Table 3). According to the criterion for DTPA-extractable micro nutrients preferred by Gupta et al. (1994), all the soils were medium in Cu and low to medium in Mn and Fe status. Distribution of Zn, Cu, Mn and Fe in all profiles followed specific pattern with organic carbon. The distribution of available micro nutrients depends on some important soil characteristics which are exhibited by significant coefficient of correlation between them (Table 2). There exists a positive relationship between available Zn with organic carbon (r = 0.46**). Soil cations like Mn, Cu and Fe have significant positive correlation with available Zn, suggesting variation in their distribution dependent upon common soil factors (Follect and Lindsay, 1970). Available Cu is significantly and positively correlated with organic carbon (r = 0.40**) and cation exchange capacity (CEC) (r = 0.40**) and negative relationship with $CaCO_3$ (r = -0.37**) (Table 4). Soil cations like Mn, Zn and Fe have significant positive correlation with available Cu. However, the partial regression coefficients indicates the dominate role of CEC only on available Cu.

Available Mn has significant negative relationship with pH (r = -0.34*), EC (r = -.29*), $CaCO_3$ (r = -0.53**) and ESP (r = -0.50**) and positive with organic carbon content (r = 0.40**) and soil cations like Zn (r = 0.51**) < Cu (r =. 78**) and Fe (r = 0.62**). Available Fe has significant negative relationship with ESP (r = -0.29*) and positive with organic carbon content (r = 0.37**) and soil

Table 2. Soil properties of experimental sites.

Location	Depth (cm)	pH	EC dS/m	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)	CEC meq/100 g	ESP (%)
Behal	0-200	7.8-7.9	0.09-0.13 (0.10)	0.00-0.04 (0.025)	1.4-1.5 (1.45)	90.4-91.8 (91.2)	1.6-3.6 (2.7)	5.2-6.6 (5.85)	4.1-5.0 (4.6)	3.4-6.3 (4.97)
Rawalwas	0-160	7.6-8.3 (8.06)	0.15-0.18 (0.16)	0.05-0.12 (0.10)	3.3-5.6 (4.3)	70.5-83.3 (77.54)	12.1-15.2 (13.72)	4.5-10 (7.34)	0.7-6.7 (4.96)	3-7.2 (6.18)
Nindana	0-160	7.7-8.2 (7.97)	0.15-0.19 (0.17)	0.11-0.27 (0.18)	0.8-2 (1.4)	50.6-80 (67.1)	11.2-32.2 (20.35)	8.2-17.2 (12.4)	8.8-13.9 (11.12)	2.7-4.5 (3.57)
Jallopur	0-225	8-8.7 (8.24)	0.12-0.56 (0.27)	0.14-0.41 (0.22)	6.2-6.2 (6.2)	39.1-76.6 (61.12)	11-38 (22.52)	9.4-22.9 (15.76)	7.5-15 (12.10)	2-11.3 (5.58)
Ladwa	0-170	7.9-8.4 (8.21)	0.14-0.60 (0.21)	0.18-.50 (0.26)	0.1-.2 (0.15)	50-69 (55.57)	15-22 (19.42)	16-30 (25)	11.4-19.5 (15.74)	2.4-4.2 (3.07)
Joytisar	0-175	7.9-8.2 (8.02)	0.40-0.57 (0.48)	0.08-0.19 (0.12)	------	33-43.4 (39.4)	29.6-37 (32.95)	23-32.4 (27.7)	12.8-13.2 (13.02)	10.1-11.9 (10.9)
Kaul	0-175	8.1-8.2 (8.17)	0.45-0.50 (0.47)	0.09-0.19 (0.135)	-------	9-30 (16.12)	38-46 (41.8)	32-46.8 (42.07)	14-19 (16.70)	2-4 (2.9)
Shamri	0-175	8.9-9.3 (9.14)	6.4-14.1 (11.72)	0.08-0.21 (0.144)	1.5-13.5 (8.26)	59.6-80 (69.84)	10-21.7 (16.44)	9-18.7 (13.52)	5.3-10.6 (8.58)	30.4-56.1 (40.3)
Kaithal	0-160	8.3-8.7 (8.53)	4-24 (9.86)	0.04-0.64 (.20)	3.5-12.5 (8.23)	42.5-79.4 (58.11)	12.5-33.8 (23.41)	8.1-30.6 (18.46)	8.9-15.3 (12.80)	24.7-43.7 (38.5)
Zarifa Viran	0-160	8.4-9.4 (9.08)	0.31-0.86 (0.53)	0.08-0.26 (0.13)	0.5-5.5 (2.3)	27.6-60 (43.13)	4.2-39.8 (27.4)	14.4-33.8 (26.13)	8.6-16.8 (12.10)	28-62.9 (48.9)

Table 3. Rang and values of available micro nutrients.

Profile No	location	Depth (cm)	**Zn** (ppm)	**Cu** (ppm)	**Mn** (ppm)	**Fe** (ppm)	Order
1	Behal	0-200	0.12-0.2 (0.16)	0.10-0.15 (0.125)	0.66-1.44 (1.035)	0.51-0.76 (0.61)	Entisols
2	Rawalwas	0-160	0.2-0.4 (0.28)	0.60-1.9 (0.94)	3.8-12.0 (6.52)	1.10-10.80 (4.13)	Entisols
3	Nindana	0-160	0.16-0.4 (0.3)	0.6-1.1 (0.87)	6.24-9.6 (7.68)	1.53-1.87 (1.70)	Inceptisols
4	Jallopur	0-225	0.16-0.28 (0.21)	0.60-1.1 (0.84)	2.50-6.0 (4.15)	2.50-6.0 (3.35)	Inceptisols
5	Ladwa	0-170	0.29-0.94 (0.49)	1.8-2.1 (1.94)	6.01-9.35 (7.49)	4.02-10.05 (6.03)	Inceptisols
6	Joytisar	0-175	0.12-0.21 (0.16)	0.35-0.90 (0.67)	3.25-5.2 (4.17)	2.40-3.20 (2.90)	Inceptisols
7	Kaul	0-175	0.15-0.20 (0.17)	0.50-0.80 (0.62)	3.2-5.0 (4.11)	2.50-3.50 (3.12)	Entisols
8	Shamri	0-175	0.16-0.30 (0.24)	0.40-0.68 (0.51)	1.3-3.60 (2.54)	1.75-2.75 (2.31)	Inceptisols
9	Kaithal	0-160	0.19-0.36 (0.25)	0.40-0.74 (0.54)	1.50-3.40 (2.45)	1.40-2.40 (1.85)	Entisols
10	Zarifa Viran	0-160	0.16-0.48 (0.29)	0.50-0.65 (0.57)	2.50-3.50 (2.90)	1.50-3.00 (2.25)	Alfisols

Table 4. Correlation coefficients (r) between micro nutrients and Soil physical and chemical properties.

Soil character	Zn	Cu	Mn	Fe
pH	0.069	-0.164	-0.347*	-0.183
Ec	-0.128	-0.245	-0.296*	-0.174
OC	0.462**	0.406**	0.403**	0.379**
CaCo3	-0.063	-0.392*	-0.530**	-0.338
ESP	-0.083	-0.378*	-0.502**	-0.293*

Table 4. Contd.

Clay	-0.105	0.161	-0.015	0.119
Silt	-0.213	0.029	0.021	0.073
Sand	0.161	-0.090	0.003	-0.091
CEC	0.059	0.404**	0.204	0.218
Zn	-	0.671**	0.517**	0.612**
Cu	0.671**	-	0.786**	0.696**
Mn	0.517**	0.786**	-	0.623**
Fe	0.612**	0.696**	0.623**	-

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level.

cation like Zn (r = 0.61**), Cu(r = 0.69**) and Mn (r = 0.62**). It is concluded that only organic carbon content significantly contributes 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). This could be partially confirmed from the present study, possibly because of the narrow range in these two soil characteristics. Between four multiple regression modeless to predict the available micro nutrients (Zn, Cu, Mn and Fe) of a soil from organic carbon and cation exchange capacity (CEC), the result show that the model of Cu is better for prediction of soil Cu available because in this model the amount of (r) is high (r = 0.53) as compared to the other models and also the partial regression coefficients indicates the dominant role of CEC only on available Cu (Table 4).

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