



Nutrient distribution and relationship with soil properties in different watersheds of Haryana

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ABSTRACT

Nutrient distribution in profile depths is unclear due to large exploitation of nutrient in the top soil while neglecting sub soil, which is also important from crop production point of view. Therefore, the present investigation was carried out in CCS Haryana Agricultural University, Hisar, Haryana, during 2017–18 where eight typical pedons (P) representing micro watersheds, viz. Motipura (P1), Sainiwas (P3), Jhumpa (P5), Budhsheli (P7), Motipura (P2), Sainiwas (P4), Jhumpa (P6) and Budhsheli (P8) were studied to evaluate the stratification of nutrients. A gradual decreasing pattern of macronutrient content was observed throughout the profile depths, which may be ascribed to accrual of organic matter in surface horizon by biological processes linked with natural vegetation. Nitrogen (N) was found to be low (42–189 kg/ha), phosphorous (P) low to medium (4.2–17.10 kg/ha), while potassium (K) and sulphur (S) were low to high, ranging between 62.2–326.5 kg/ha and 0.4–19 mg/kg, respectively. A positive and significant correlation was observed in case of N with P, K and S and among micronutrients, which implicates synergism among these nutrients. In general, the values of extractable micronutrients in the soils decreased irregularly down the profile.

Key words: Correlation, Macronutrients, Micronutrients, Pedon, Watershed

Watershed is defined as a natural hydrologic entity that covers a specific area of land surface from which the runoff flows to a defined drain, channel, stream or river at any particular point (Rattan *et al.* 2015). The planners and agricultural scientists started to promote rainfed agriculture in India through watershed development in the 1980s and 1990s. Our aim of optimizing the utilization of watershed resources with intensification of agriculture resulted either in the fast depletion of nutrients or occasionally in their accumulation. It is therefore important to monitor the fertility status of watershed areas from time to time in order to monitor the health of the soil. Knowledge on the distribution of plant nutrients is therefore also important, as the roots of most plants reach beyond the surface layer and obtain part of their required nutrients from the soil's subsurface layers (Mishra *et al.* 2015).

The availability of macronutrients in natural uncultivated systems is not a limiting factor for growth due to rapid

recycling. Nevertheless, the use of modern agricultural practices may affect the availability of nutrients due to intensive cultivation (Kulcheski *et al.* 2015). The importance of macro and micronutrients are well recognized which adds to the necessity of knowledge regarding their variability in soil plant system. In soils the geographical distribution of micronutrients is intimately correlated to the make-up of the parent materials, in spite of the fact that soils show less variation in micronutrient content (Hodgson 1963) and soil forming processes might significantly influence the distribution of trace elements within the soil profile (Sharma *et al.* 2000). Keeping in view the present study was undertaken to determine the distribution of nutrients and their relationship with soil properties in semi-arid ecosystem of north-west Haryana.

MATERIALS AND METHODS

Study was conducted during 2017–18 in areas covering around 3000 ha of different micro watershed, viz. Motipura, Sainiwas, Jhumpa and Budhsheli, located at north-west Haryana (28° 46' to 28° 49' N latitudes and 75° 31' N to 75° 34' E longitudes; 225 m amsl). Broadly, the study area is a sandy (orthids and psammments types of soils), undulating plain. The climate of the study area is sub-tropical continental semi-arid. The normal annual rainfall is about 360.8 mm, out of which, 77% is received during months of June–September. The topographic maps of India (1:50,000) and aerial photographs were used for

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detailed reconnaissance soil survey and site selection and profile excavation. Based on geomorphic-soil relationship, thirty-nine samples were collected from eight profiles of different horizons. Particle size distribution of the soils was determined by International Pipette method (Piper 1950). The pH of the soils was measured with glass electrode using soil suspension of 1:2 (soil: water) and electrical conductivity in same supernatant. Cation exchange capacity (CEC) was determined by neutral normal ammonium acetate extraction (Jackson 1973). Organic carbon (OC), available N, P, K and S was determined by wet-oxidation method (Walkley and Black 1934), alkaline permanganate method (Subaiah and Asija 1956), Olsen *et al.* 1954 method, flame photometer (Jackson 1973) and 0.15% CaCl_2 method (Black 1965), respectively. Ten gram of soil (2-mm sieved) was used for extraction of Zn, Cu, Mn, and Fe with 20 ml of diethylenetriamine pentaacetic acid (DTPA) extractant (0.005M DTPA + 0.01 M CaCl_2 + 0.1 M triethanolamine, adjusted to pH 7.3) using atomic absorption spectrometer (Lindsay and Norvell 1978).

RESULTS AND DISCUSSION

The horization as well as physico-chemical properties of different soil profiles are shown in Table 1. The soils of the study area were classified into two soil orders, i.e. Entisols and Aridisols. The land use, by and large, included forest crops like Kikar, Neem, Shisham, Janti, Eucalyptus and leafless Kair and Jaal and field crops like bajra, cotton, wheat, gram and oilseeds etc.

Physico-chemical properties: The soils of pedons P1, P4, P6 and P8 in all horizons were sand in texture, whereas pedons P2, P3, P5 and P7 were sand (surface horizon) to loamy sand (subsurface horizon). Sand constitutes the bulk of the mechanical fractions, which may be assigned to dominance of physical weathering and siliceous nature of parent material (Ahuja *et al.* 1997). The results reveal that the soils varied from neutral to alkaline (pH 7.3–8.5) in reaction. The electrical conductivity (1:2) of the soils was non-saline (0.02–0.61 dS/m). The CEC of the study area was found to be low (3.82 to 7.85 cmol (p+)/kg) which was attributed to the dominance of illite mineral and low organic matter content. The OC content of soils varied from 0.06–0.27%, which decreased down the depth in the profiles, may be due to the prevailing high temperature that is responsible for rapid mineralization of organic matter, as it is expected in subtropical and tropical climates (Bhat *et al.* 2017).

Available major and micronutrients

Available macro (N, P, K and S) and DTPA extractable micronutrients, viz. Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) are important to plant from fertility point of view. Status of macro and micronutrients is shown in Fig 1 and 2, respectively and their linear correlation studies with soil properties and among them are presented in Table 2.

Macronutrients: Available nitrogen (N), phosphorous (P), potassium (K) and sulphur (S) were found to be low

(42–189 kg/ha), low to medium (4.2–17.10 kg/ha), low to high (62.2–326.5 kg/ha) and low to high (0.4–19 mg/kg) in the studied pedons, respectively. A positive and significant correlation was observed between N and P ($r = 0.71^{**}$), N and K ($r = 0.70^{**}$) and N and S ($r = 0.74^{**}$) which shows the presence of synergistic effects among these nutrients. Available nitrogen was found maximum in surface layer and decreased down the profiles, which may be ascribed to the decreasing trend of OC with depth and prevailing high temperature. A significant and positive correlation was observed between N and OC ($r = 0.89^{**}$) suggesting that N is closely associated with organic matter. Hailu *et al.* (2015) ascertained that the trends of total N, in general, followed that of the soil OM showing a strong relationship between OM and total N as indicated by the positive and highly significant correlation with OM.

Available phosphorous was found to be positively and significantly correlated with OC content ($r = 0.89^{**}$) showing that higher available P is associated with higher OM (Sharma *et al.* 2013). It was insignificantly correlated with pH and EC. OM increases P by anion replacement of H_2PO_4^- ion on adsorption sites thereby increasing the quantity of organic P mineralized to inorganic P (Havlin *et al.* 2016, Bhat *et al.* 2017). Available potassium had positive and significant correlation with OC ($r = 0.56^{**}$), owing to presence of potassium bearing minerals like feldspars, illite, mica in clay and silt fractions (Deka *et al.* 1995, Reza *et al.* 2014). However, potassium was negatively correlated with sand ($r = -0.04$) which may be due to presence of quartz which is the dominant mineral in the sand fraction and does not retain K, therefore, affirmed the results of Reza *et al.* (2014). Available sulphur showed a negative correlation with pH ($r = -0.32^*$) which indicates that increase in soil pH would result in a concomitant decrease in the amount of S, attributing it to the reduced adsorption of sulphate in soils and its consequent losses through leaching. However it had a positive correlation with OC ($r = 0.71^{**}$) indicating that the organic matter serves as a reservoir of sulphur (Paul and Mukhopadhyay 2015).

DTPA-extractable micronutrients: The DTPA extractable Fe, Mn, Cu, Zn content in soils ranged from 0.87–6.49 mg/kg, 1.03–4.99 mg/kg, 0.13–0.72 mg/kg, 0.15–0.92 mg/kg, respectively. Considering the critical limits for DTPA extractable Fe, Mn, Cu and Zn content, it can be inferred that soils of the study area were by and large, deficient, marginal to sufficient, sufficient and deficient, respectively. Irregular trend of vertical distribution through depth of pedons was reported.

Iron showed a negative correlation with pH ($r = -0.51^{**}$) which might be due to precipitation of Fe as insoluble iron hydroxides. From this, it can be inferred that availability of Fe will be a serious problem in alkaline soils. Manganese was also positively correlated with clay ($r = 0.30$) indicating that fine textured soils had ample Mn compared to coarse textures soil which may be due to higher adsorption and retention of Mn by finer soil separates. Mishra *et al.* (2007) also reported similar positive relationship between clay and

Table 1 Physico-chemical properties of the soils

Horizon	Depth (cm)	Sand (%) (2.0–0.05 mm)	Silt (%) (0.05–0.002 mm)	Clay (%) (<0.002mm)	Texture	pH (1:2)	EC (dS/m)	OC (%)	CEC cmol (p+)/kg
<i>Motipura</i>									
<i>P1 (Sandy, Mixed, Hyperthermic, Typic Ustipsamments)</i>									
Ap	0-14	88.80	7.10	4.10	s	7.85	0.04	0.22	5.28
C1	14-53	88.80	8.80	2.40	s	7.73	0.03	0.21	4.89
C2	53-79	90.50	5.70	3.80	s	7.75	0.24	0.16	4.93
C3	79-142	89.40	3.70	5.90	s	7.70	0.14	0.12	6.09
C4	142-177+	92.15	1.85	6.00	s	7.52	0.03	0.08	5.71
<i>P2 (Coarse loamy, Mixed, Hyperthermic, Typic Ustipsamments)</i>									
Ap	0-25	93.90	3.80	2.30	s	7.61	0.04	0.27	4.81
C1	25-58	90.45	5.55	4.00	s	7.78	0.04	0.18	5.10
C2	58-86	83.60	10.40	6.00	ls	7.56	0.04	0.14	5.70
C3k	86-119	81.10	8.90	10.00	ls	7.50	0.05	0.11	7.81
C4	119-135+	82.00	7.50	10.50	ls	7.64	0.05	0.10	7.85
<i>Sainiwas</i>									
<i>P3 (Coarse loamy, Mixed, Hyperthermic, Typic Ustipsamments)</i>									
Ap	0-36	87.85	6.35	5.80	s	7.73	0.04	0.27	5.69
AC	36-89	83.20	10.65	6.15	ls	7.49	0.05	0.24	5.72
C1	89-133	82.60	11.60	5.80	ls	7.58	0.06	0.17	5.67
C2	133-152	84.80	11.00	4.20	ls	7.60	0.09	0.15	5.34
C3	152+	82.55	13.35	4.10	ls	7.60	0.08	0.12	5.31
<i>P4 (Sandy, Mixed, Hyperthermic, Typic Torripsamments)</i>									
Ap	0-27	95.65	2.35	2.00	s	7.46	0.03	0.27	3.89
C1	27-115	97.05	1.05	1.90	s	7.33	0.02	0.21	3.82
C2	115-165	95.85	2.10	2.05	s	7.61	0.02	0.16	4.10
C3	165+	92.70	3.70	3.60	s	7.56	0.05	0.10	4.86
<i>Jhumpa</i>									
<i>P5 (Coarse loamy, Mixed, Hyperthermic, Typic Cambiorchids)</i>									
Ap	0-17	93.20	2.90	3.90	s	8.10	0.26	0.24	7.08
AB	17-60	90.70	7.10	2.20	ls	8.20	0.17	0.16	5.89
B1k	60-82	87.50	8.60	3.90	ls	8.30	0.18	0.14	6.09
C1k	82-164	84.45	11.35	4.20	ls	8.00	0.21	0.11	5.79
C2k	164-202	81.65	12.45	5.90	ls	8.10	0.32	0.08	6.98
<i>P6 (Coarse loamy, Mixed, Hyperthermic, Typic Torripsamments)</i>									
Ap	0-19	94.15	4.65	1.20	s	7.90	0.19	0.27	4.21
C1	19-80	93.25	4.75	2.00	s	7.50	0.20	0.19	4.89
C2	80-126	93.00	4.70	2.30	s	8.10	0.14	0.13	4.90
C3	126-224	93.85	3.25	2.90	s	8.20	0.18	0.11	5.10
C4	224+	94.55	3.45	2.00	s	8.40	0.08	0.06	4.92
<i>Budhsheli</i>									
<i>P7 (Coarse loamy, Mixed, Hyperthermic, Typic Calciorchids)</i>									
Ap	0-17	88.80	6.59	4.61	s	7.80	0.12	0.19	7.00
AC	17-55	83.20	11.26	5.54	ls	8.10	0.10	0.14	6.21
C1	55-129	80.42	10.32	9.26	ls	8.50	0.16	0.13	7.82
C2k	129-169	84.77	9.81	5.42	ls	8.50	0.20	0.08	6.14
C3	169-207	92.04	4.80	3.16	s	8.50	0.18	0.06	5.35
C4	207+	92.70	3.93	3.37	s	8.30	0.19	0.06	5.30
<i>P8 (Sandy, Mixed, Hyperthermic, Typic Torripsamments)</i>									
Ap	0-24	93.20	5.20	1.60	s	7.50	0.12	0.22	4.84
AC	24-62	92.10	5.70	2.20	s	7.30	0.10	0.19	5.78
C1	62-155	90.20	6.30	3.50	s	7.30	0.08	0.14	5.82
C2	155+	89.90	4.90	5.20	s	7.80	0.08	0.10	6.56

s, sand; ls, loamy sand.

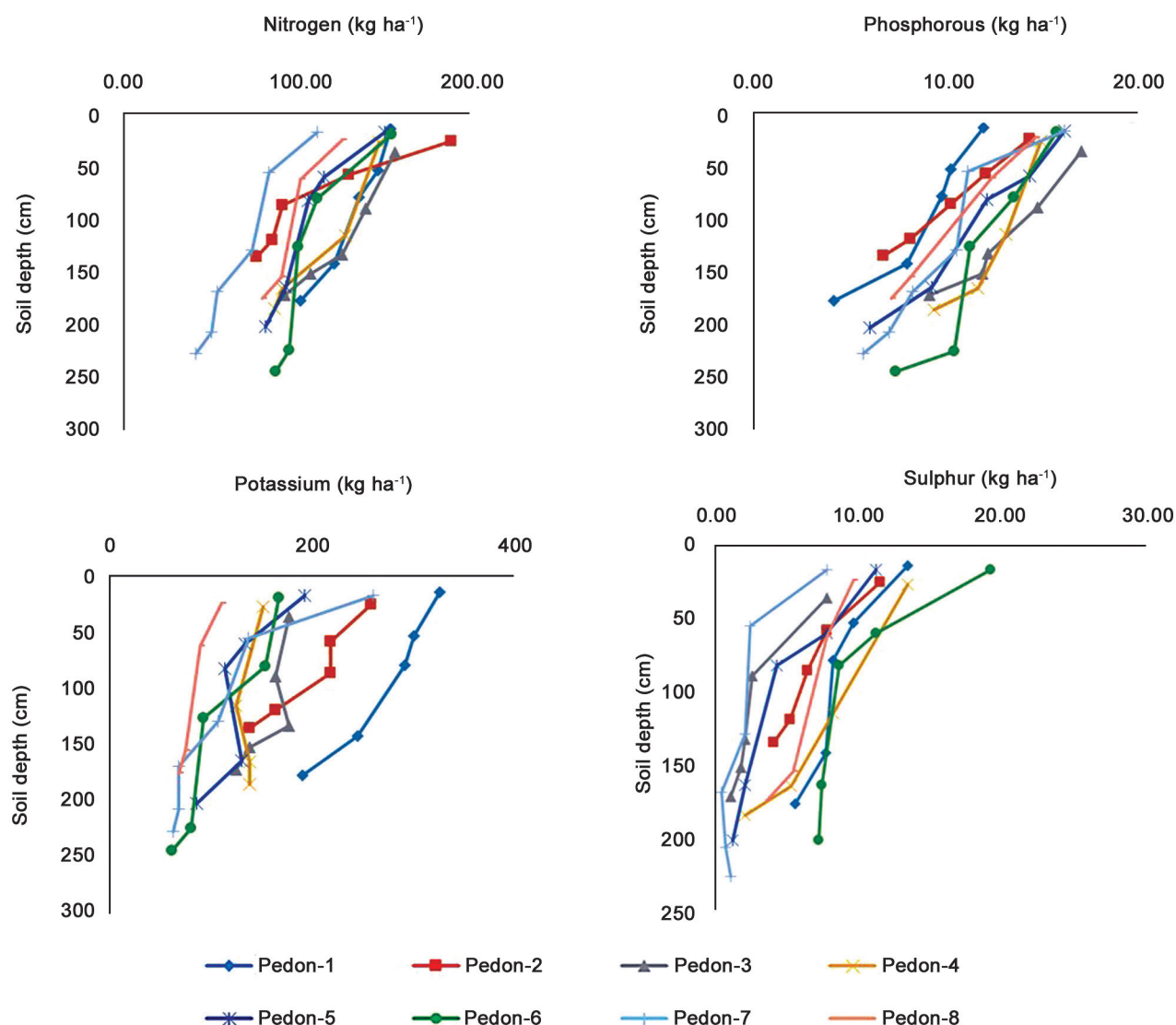


Fig 1 Vertical distribution of macronutrients in different pedons.

Table 2 Correlation among nutrients and physico-chemical properties

Parameter	pH	EC	OC	N	P	K	S	Zn	Fe	Mn	Cu	CEC	Sand	Silt	Clay
pH	1														
EC	0.54**	1													
OC	-0.37*	-0.25	1												
N	-0.47**	-0.24	0.89**	1											
P	-0.05	-0.08	0.89**	0.71**	1										
K	-0.54**	-0.31	0.56**	0.70**	0.37*	1									
S	-0.32*	-0.08	0.71**	0.74**	0.57**	0.49**	1								
Zn	-0.46**	-0.24	0.01	0.27	-0.19	0.42**	0.11	1							
Fe	-0.51**	-0.23	0.11	0.42**	-0.20	0.66**	0.34*	0.47**	1						
Mn	-0.56**	-0.30	0.02	0.23	-0.22	0.57**	0.14	0.47**	0.64**	1					
Cu	-0.39*	-0.24	0.03	0.25	-0.23	0.47**	0.09	0.62**	0.69**	0.58**	1				
CEC	0.24	0.25	-0.34*	-0.35*	-0.26	-0.07	-0.41**	0.11	-0.14	0.04	0.13	1			
Sand	-0.11	-0.06	0.26	0.28	0.23	-0.04	0.57**	-0.12	0.12	-0.21	-0.14	-0.70**	1		
Silt	0.16	0.14	-0.16	-0.20	-0.09	0.02	-0.51**	-0.02	-0.19	0.10	-0.05	0.45**	-0.90**	1	
Clay	0.01	-0.08	-0.32	-0.31	-0.36*	0.04	-0.47**	0.26	0.01	0.30	0.37*	0.82**	-0.79**	0.47**	1

*, ** significant at 0.05 and 0.01 probability level, respectively.

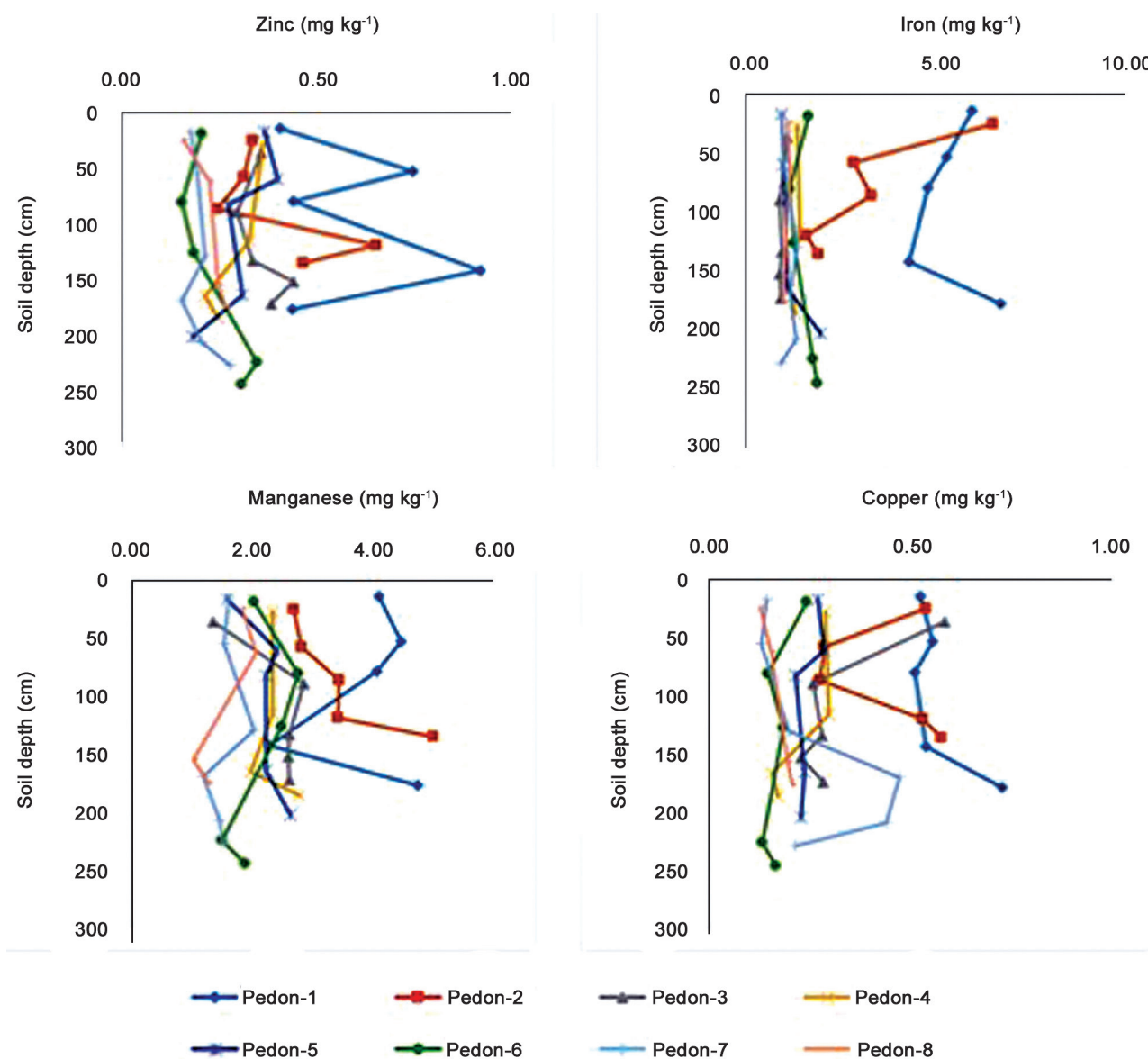


Fig 2 Vertical distribution of micronutrients in different pedons.

Mn. Manganese showed a negative correlation with pH ($r = -0.56^{**}$) which may be due to precipitation of Mn in form of hydroxides and carbonates that are water insoluble and thus unavailable to plants (Vijayakumar *et al.* 2011, Baruah *et al.* 2014).

The availability of Cu was found to be sufficient which may be ascribed to contribution of associated fluvial parent materials. In present study a positive correlation was found between Cu and clay ($r = 0.37^{**}$), whereas a negative correlation was observed to that of sand content ($r = -0.14$) which indicating that the availability of Cu in soils is anticipated to decrease as the texture becomes coarser thereby validating widespread incidence of Cu deficiency in sandy soils (Sharma *et al.* 2004). The coarse texture soils have less organic matter content, as a result, less of Cu remains bound to OM thus increasing its loss by leaching because of its less retention. Bassirani *et al.* (2011) reported deficiency of Zn in soils could be due to

poor inherent supply of this nutrient from soil. Zinc showed negative correlation with pH ($r = -0.46^{**}$) that leads to development of calcareous or alkaline soils which may be attributed to precipitation as $ZnCO_3$ or formation of insoluble calcium zincate thereby lowering availability of zinc (Rajput *et al.* 2015).

Thus, present study indicated that SOC content was found to be significantly correlated with available N, P, K and S and a positive correlation was observed among the micronutrients suggesting that these elements are functions of the same pedological factors. The growing demands for food owing to the increased population growth have resulted in an increased cultivation in the soils of semi-arid ecosystem north-west Haryana. Therefore, the fertility status of these soils was evaluated vertically down the profile and the distribution of various nutrients were analysed in relation to soil depth. This study will enable the farming community and policy makers to identify potential

fertility for the production of agricultural crops and design appropriate soil management strategies for sustainable crop production.

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