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Distribution of micronutrient cations in relation to soil properties in Saproon Valley of Solan district in North Western Himalayas

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ABSTRACT

Vertical distribution of available micronutrient cations (Fe, Mn, Cu and Zn) and their relationship with various soil properties were studied in one hundred twenty six samples of twenty one villages of Saproon valley of Solan district in North Western Himalayas. The results revealed that the contents of available Fe, Mn, Cu and Zn were higher in surface horizons than those in sub-surface horizons and ranged from 7.03 to 36.46, 0.25 to 29.04, 1.15 to 12.75 and 0.01 to 4.23 mg kg^{-1}, respectively. Available Zn was found deficient in 19.0, marginal in 65.0 and sufficient 16.0 per cent of the soil samples, while, Fe, Mn and Cu were sufficient in all the soils of Saproon valley of Solan district, Himachal Pradesh. The pH ranged from 6.16 to 7.94 and EC of the surface and sub-surface soils ranged from 0.09 to 1.02 and 0.11 to 0.49 dS m^{-1}, respectively. The organic carbon content varied from 5.70 to 32.60 in the surface soils. Available Fe, Mn, Cu and Zn were influenced by pH, EC and organic carbon content of the soils.

Keywords- Fertility status, micronutrient, soil properties, Himachal Pradesh

INTRODUCTION

Soil plays a major role in determining the sustainable productivity of an agro-ecosystem. The sustainable productivity of a soil mainly depends upon its ability to supply essential nutrients to the growing plants. The deficiency of micronutrients has become major constraint to productivity, stability and sustainability of soils (Bell and Dell, 2008). Micronutrient contents of soil and their availability to plant are assessed by the mineral present and weathering processes. Uptake of micronutrient is affected by the presence of major nutrients due to either negative or positive interactions. High phosphate content of soils or high fertilization with phosphate may reduce the uptake of zinc and other nutrients (Dadhich and Somani, 2007). Thus, indiscriminate use of macronutrients may affect uptake of micronutrients. Plants take their nutrients mostly from soil. It is well known that the optimum plant growth and crop yield depends not only on the total amount of nutrients present in the soil at a particular time but also on their availability which in turn is controlled by physico-chemical properties like: soil texture, organic carbon and calcium carbonate, cation exchange capacity, pH and electrical conductivity of soil. The problem of micronutrient deficiency has been further aggravated due to introduction of heavy nutrient feeders and high yielding hybrid varieties in the valley. As the demand of nutrients for higher yields increases the plant's need for nutrients, nutrient deficiencies are likely to become more acute. As the limit of deficiency and toxicity in micronutrients is very narrow, the investment on a non-limiting nutrient is a waste and also has a deleterious effect on crops. In the present era of intensive agriculture, in view of sustainable crop production, it is being strongly felt that deficiency and sufficiency of nutrients must be assessed for different crops and locations. This valuable knowledge on the status of available micronutrients and their relationship with various soil properties is essential to formulate the strategies for amelioration of such deficiencies, timely and more precisely.

MATERIALS AND METHODS

The study area Saproon Valley is located between 30^{0}55$^'$ North latitude and 77^{0}9$^'$ East longitude with an altitude ranging from 1390 to 1500 meters above mean sea level. It represents sub-humid to sub-temperate climate with an average rainfall of 1300 mm and. The soils have been derived from red and grey gypsiferrous and calcareous shales, are medium deep and mostly sandy loam to sandy clay loam in texture. One hundred twenty six representative soil samples (6 surface and 6 sub surface) were collected

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from twenty one villages, spread over the whole valley following the random sampling technique. Samples were air dried, ground in wooden pestle and mortar. The ground samples were passed through 2 mm sieve and stored in properly labeled plastic containers for analysis. The soil reaction (pH) and electrical conductivity (EC) were determined in 1:2 soil: water suspension as per the procedure described by Jackson (1973). The soil organic carbon (OC) was determined by wet digestion method of Walkley and Black (1934). The content of DTPA extractable micronutrients *viz.* Fe, Mn, Cu and Zn in soil were estimated by using 1:2 soil: extractant ratio (Lindsay and Norvell, 1978) and determined on atomic absorption spectrophotometer. Soil Nutrient Indices (SNI) were also worked out by using the formula as proposed by Parker *et al.* (1951).

RESULTS AND DISCUSSION

Chemical properties of soils

The soil reaction ranged from neutral to slightly alkaline (pH 6.16 to 7.94 in surface and 6.69 to 7.88 in sub surface). The highest pH values of surface and sub surface soils were recorded in Bairtee and Chakli villages, respectively (Table 1).

Table 1: Physico-chemical properties of soils

Village's Name	pH		EC (dS m^{-1})		Organic Carbon (g kg^{-1})	
	Depth (cm)					
	0-15	15-30	0-15	15-30	0-15	15-30
Saproon	6.43 (6.16-6.57)	6.74 (6.69-6.76)	0.38 (0.32-0.45)	0.33 (0.30-0.35)	8.0 (14.9-20.6)	6.6 (6.3-6.9)
Kailar	7.15 (7.02-7.30)	7.19 (7.16-7.20)	0.33 (0.30-0.35)	0.31 (0.25-0.34)	2.9 (18.8-29.3)	3.0 (8.6-18.7)
Bajrol Khurd	6.55 (6.40-6.62)	7.07 (6.76-7.24)	0.35 (0.28-0.38)	0.30 (0.29-0.32)	10.2 (7.2-13.6)	4.6 (3.2-6.5)
Lavi Khurd	7.44 (7.32-7.55)	7.56 (7.44-7.66)	0.28 (0.25-0.31)	0.27 (0.23-0.29)	20.1 (19.2-21.1)	5.0 (13.3-16.7)
Lavi Kalan	7.08 (6.70-7.32)	7.02 (6.72-7.51)	0.42 (0.38-0.45)	0.38 (0.31-0.48)	24.8 (19.0-32.6)	3.2 (12.8-13.4)
Bajrol Kalan	7.29 (7.12-7.59)	7.37 (6.73-7.74)	0.31 (0.25-0.36)	0.23 (0.11-0.37)	20.7 (16.6-27.1)	1.0 (7.8-16.6)
Sandrol	7.49 (7.34-7.65)	7.57 (7.44-7.72)	0.31 (0.26-0.34)	0.26 (0.23-0.31)	16.3 (14.5-18.1)	3.5 (1.8-3.6)
Sheel I	7.39 (7.30-7.47)	7.57 (7.52-7.63)	0.29 (0.25-0.35)	0.24 (0.18-0.29)	14.9 (14.8-15.1)	2.8 (11.2-14.2)
Sheel II	7.30 (7.18-7.44)	7.38 (7.26-7.55)	0.16 (0.15-0.17)	0.15 (0.11-0.20)	8.1 (7.2-8.7)	4.3 (3.9-4.5)
Bairtee I	7.66 (7.52-7.77)	7.58 (7.41-7.69)	0.18 (0.09-0.28)	0.22 (0.19-0.26)	12.9 (8.4-16.9)	9.6 (3.9-12.7)
Bairtee II	7.45 (7.20-7.59)	7.53 (7.38-7.65)	0.49 (0.19-1.02)	0.25 (0.22-0.33)	14.2 (12.7-16.9)	1.1 (8.1-15.4)
Kothi Deora I	6.95 (6.90-6.97)	7.02 (6.85-7.12)	0.25 (0.20-0.30)	0.30 (0.20-0.49)	7.3 (6.3-9.0)	3.5 (0.3-8.4)
Kothi Deora II	7.28 (7.20-7.33)	7.32 (7.20-7.46)	0.19 (0.15-0.23)	0.25 (0.20-0.35)	11.60 (9.90-14.50)	7.4 (4.2-12.4)
Top Ki Ber	7.37 (7.30-7.42)	7.39 (7.29-7.52)	0.35 (0.26-0.47)	0.27 (0.28-0.31)	22.0 (18.7-25.0)	4.4 (11.5-16.9)
Ghatti	7.52 (7.49-7.57)	7.54 (7.45-7.63)	0.27 (0.20-0.39)	0.23 (0.19-0.26)	22.8 (19.0-26.8)	7.7 (14.5-20.5)
Bhannat	7.52 (7.41-7.60)	7.52 (7.40-7.65)	0.30 (0.22-0.36)	0.21 (0.17-0.23)	7.2 (5.7-9.6)	20 (0.60-3.90)
Loharon	7.18 (7.03-7.42)	7.31 (7.02-7.64)	0.21 (0.18-0.26)	0.16 (0.13-0.18)	8.5 (4.2-13.0)	60 (0.60-9.03)
Jagaat Khana	7.00 (6.64-7.11)	7.27 (7.17-7.40)	0.18 (0.15-0.22)	0.24 (0.11-0.35)	14.8 (8.1-19.0)	3.5 (7.5-16.6)
Chakli	7.40 (7.42-7.94)	7.76 (7.69-7.88)	0.23 (0.20-0.24)	0.24 (0.21-0.27)	13.6 (7.2-18.7)	1.5 (5.7-15.1)
Deothi	7.47 (7.36-7.52)	7.54 (7.44-7.59)	0.20 (0.18-0.22)	0.19 (0.16-0.21)	16.1 (11.2-20.8)	0.7 (8.4-15.1)
Kiartoo	7.61 (7.32-7.80)	7.66 (7.49-7.77)	0.18 (0.14-0.21)	0.17 (0.14-0.20)	8.9 (5.7-14.8)	7.3 (4.8-11.5)

**Values in parenthesis indicate range*

This indicates that soils are quite young and have not been leached out of the bases even under sub-humid to sub-temperate conditions. The neutral to slightly alkaline pH may also be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in retention of basic cations on the exchangeable complex of the soil. Similar trends were also reported by Sharma *et al.* (2002) and Kumar *et al.* (2011) for the soils of Punjab and Rajasthan, respectively. In general, the EC values were high in surface soils and decreased with depth. The higher EC values in surface soils may be attributed to the addition of fertilizers and other nutrient management practices in the surface soils. Organic carbon content of the soils ranged from 5.70 to 32.60 g kg^{-1} in surface soils and 0.30 to 20.5 g kg^{-1} in sub-surface soils with mean values of 15.07 and 9.36 g kg^{-1}, respectively indicating that the soils of the Saproon valley are medium to high in organic carbon content. The continuous addition of higher amounts of leaf litter and consciousness of the farmers for maintaining higher levels of organic matter in their fields through the addition of organic manures might be the reason for higher organic carbon content in surface layers. These results are in line with the results of Sharma and Kanwar (2010) and Rajendiran *et al.* (2018).

Available micronutrients

Range and mean values of DTPA extractable cationic micronutrients are given in Table 2. The DTPA- Fe ranged from 7.03 to 36.46 mg kg^{-1} and 6.36 to 24.16 mg kg^{-1} in surface and sub surface soils, with mean values of 30.99 and 14.27 mg kg^{-1} respectively. The nutrient index value (Table 3) of 3.00 with 100 per cent samples in high nutrient range showed very high availability of Fe. Similar results were also reported by Sharma and Chaudhary (2007) for the soils of Himachal Pradesh. The content of DTPA-Mn ranged from 0.25 to 29.04 mg kg^{-1} with a mean value of 6.54 mg kg^{-1} (Table 2).

Table 2: Status of DTPA extractable iron, manganese, copper and zinc (mg kg^{-1}) in the soils of Saproon valley

Name of the Village	Iron		Manganese		Copper		Zinc	
	Depth (cm)							
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Saproon	26.36-36.46	9.22-18.17	1.95-6.44	9.37-11.22	5.58-8.10	2.62-4.42	3.02-3.63	1.01-1.68
Kailar	10.46-22.08	13.69-19.98	4.35-5.24	2.42-4.97	6.34-9.31	3.23-9.21	0.11-4.23	1.96-4.05
Bajrol Khurd	18.45-27.50	11.03-23.12	4.24-17.45	1.57-9.64	3.13-9.92	1.25-3.79	0.92-3.20	0.49-1.46
Lavi Khurd	14.46-16.36	13.56-13.98	0.25-4.27	0.23-3.35	2.70-4.25	2.16-3.99	1.88-3.12	0.62-2.70
Lavi Kalan	15.69-35.50	16.17-23.12	2.15-29.04	12.66-28.84	4.42-8.45	4.15-6.74	2.92-3.39	1.48-2.30
Bajrol Kalan	12.08-22.26	10.65-13.79	0.53-28.12	14.09-22.36	5.28-9.16	3.55-6.34	1.07-3.19	1.75-1.85
Sandrol	13.88-15.22	11.41-11.79	22.44-26.22	10.26-17.45	5.88-10.01	3.34-4.46	0.01-3.38	0.71-1.81
Sheel I	13.03-14.93	13.22-15.88	1.84-10.26	8.14-16.44	1.15-12.75	4.77-11.52	2.39-2.71	1.49-2.86
Sheel II	12.84-21.60	10.17-18.36	2.03-5.24	0.76-2.34	1.33-2.24	1.05-1.72	0.89-1.45	0.30-0.66
Bairtee I	9.41-10.55	7.50-10.27	2.38-3.62	0.41-3.46	2.74-9.70	2.33-8.66	0.31-3.32	0.49-2.95
Bairtee II	9.22-11.31	8.08-9.03	1.49-3.04	2.61-4.58	8.95-9.56	5.01-10.30	2.05-3.77	1.54-3.19
Kothi Deora I	15.50-16.55	10.17-15.03	5.90-6.55	5.59-8.10	4.07-13.70	2.09-8.22	0.89-2.13	0.80-2.39
Kothi Deora II	11.79-13.60	11.31-14.65	2.50-4.89	2.77-6.82	1.66-3.91	1.43-3.01	0.59-1.28	1.38-2.26
Top Ki Ber	9.69-17.69	8.46-17.31	2.11-3.85	2.11-5.28	2.52-4.83	2.86-4.53	2.80-3.63	0.10-2.58
Ghatti	10.55-18.55	6.36-14.55	5.20-6.82	2.77-6.20	4.09-12.85	7.51-12.43	1.87-2.43	2.56-3.43
Bhannat	8.36-10.17	8.08-9.41	3.35-5.47	4.20-6.01	0.25-5.89	1.83-4.34	0.53-1.26	0.22-1.04
Loharon	12.27-13.88	8.08-12.65	3.42-6.59	3.31-4.35	2.40-6.49	3.07-5.60	2.82-3.78	1.71-2.77
Jagat Khana	15.22-22.26	14.96-24.16	4.85-7.71	5.62-7.63	1.67-4.28	1.82-3.87	1.32-2.56	1.19-2.52
Chakli	7.03-14.74	10.84-15.69	3.38-3.85	3.42-4.23	2.38-3.47	2.48-2.90	0.88-2.08	0.58-2.57
Deothi	14.65-18.74	12.46-18.74	3.11-3.65	3.15-3.62	2.33-2.91	1.87-2.49	1.56-2.37	1.19-1.71
Kiartoo	11.51-24.74	15.22-19.69	3.15-3.77	3.23-3.77	1.48-3.85	1.47-3.38	0.55-3.19	0.73-2.51

The nutrient index value (Table 3) of 2.68 and 64.0 per cent samples in high range puts the majority of soils in the sufficient range. Considering 4.5 mg kg^{-1} as critical limit for Fe and 2.0 mg kg^{-1} for Mn (Lindsay and Norvell, 1978). These soil samples were well supplied with Fe and Mn content. This may be due to sufficient content of organic matter in the soil. Similar results were also reported by Kumar *et al.* (2011). The average DTPA-Cu content of surface and sub-surface soil samples was recorded as 5.33 and 4.18 mg kg^{-1}, respectively with all the samples in high range. This may be due to the fact that farmers of the area are using blue copper in their fields in order to maintain the flowers. These observations are in line with those of Sharma and Chaudhary (2007). The average DTPA extractable Zn content of surface soils ranged from 0.01 to 4.23 mg kg^{-1}. Considering the critical limit for Zn as 0.6 mg kg^{-1} (Lindsay and Norvell, 1978) about 19 per cent samples were found to be deficient, giving nutrient index value of 1.97 and accordingly medium status of the soil with respect to DTPA-Zn content. Like available macronutrient elements, micronutrient elements were also found to decrease with soil depth. The micronutrient content was comparatively high except Zn which is medium in availability, mainly due to consciousness of vegetable growers towards importance of FYM and micronutrient fertilizers.

Correlation with soil properties

The correlations were worked out to ascribe the degree of relationship among the soil characteristics (Table 4). A significant and negative correlation was observed between pH and DTPA-Fe (r=-0.66**), which can be attributed to the decrease in solubility and availability of micronutrient cations at neutral and higher pH. Similar results were worked out by Verma *et al.* (2007) and Sharma and Kanwar (2011). The availability of DTPA-Fe (r=0.34**), Cu (r=0.48**) and Zn (r=0.65**) was significantly and positively related with organic carbon (Sharma and Chaudhary, 2007).

Table 3: Nutrient Indices of the soils of Saproon Valley

Nutrient	Percentage of samples rating			Nutrient Index	Nutrient Status
	Low	Medium	High		
Iron	-	-	100	3.00	High
Manganese	6.00	30.00	64.00	2.68	High
Copper	-	0.80	99.20	2.99	High
Zinc	19.05	65.08	15.87	1.97	Medium

This is understandable as organic matter is one of the major sources of nutrient supplies in the soil. The availability of Fe increased with the increased organic matter content because Fe is held in the chelates as soluble complex. This result finds support from Behra and Shukla (2013) which explain that complexing agents generated by organic matter decomposition promote availability of these nutrients in soil by chelating these nutrients and making them available to the plant roots in soluble and absorbable form. These results are in conformity with the results of Singh *et al.* (2006), Kumar *et al.* (2011) and Singh and Singh (2017).

Table 4: Simple correlation coefficient (r) among different soil characteristics

Soil Parameters	pH	EC	OC	Fe	Mn	Cu	Zn
pH	**1**						
EC	-0.44**	1					
OC	-0.03	0.44**	**1**				
Fe	-0.66**	0.30	0.33*	1			
Mn	-0.20	0.33*	0.14	0.22	1		
Cu	-0.11	0.48**	0.48**	0.03	0.28	1	
Zn	-0.20	0.50**	0.65**	0.27	0.03	0.60**	1

*** Significant at 0.01 level*
*** Significant at 0.05 level*

From the results, it may be concluded that the available micronutrient elements were found to decrease with soil depth. The status of micronutrients of the soils of Saproon valley was comparatively higher except that of Zn which is medium in availability, mainly due to consciousness of vegetable growers towards importance of FYM and micronutrient fertilizers. pH and organic carbon play major role in controlling the availability of these micronutrient cations.

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