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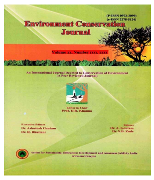

Assessment of block-wise status of micro nutrients in some soils of Shivalik hills of Himachal Pradesh

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ABSTRACT

The investigation was undertaken and micro nutrients status of the area was assessed. During February-March 2020, 50 soil sampling locations from tomato growing areas were selected at random and 100 representative surface (0-15 cm) and sub-surface (15-30 cm) soil samples were collected. Various micronutrients, *i.e.* DTPA-extractable Zn, Cu, Mn and Fe were examined. The soils were neutral to slightly alkaline, and the EC values of all the soil samples were within normal limits. The general state of the soil organic carbon concentration was medium to high. The DTPA- Mn, Fe, Cu and Zn in soils of the studied area were found to be in medium category. Positive correlations between the DTPA-extractable iron, copper, zinc and manganese with the organic carbon content was observed.

Introduction

Agriculture plays a vital role in Indian economy and over 70 per cent of rural households depend upon it (Arjun, 2013). Soil is an important factor of crop production and the nutrients in a soil determine its fertility and the crop output. The availability of nutrients in soil varies naturally from soil to soil and some nutrients may be sufficient while others may be insufficient (Rajendiran *et al.,* 2020; Ruhela *et al.,* 2022), so the evaluation of a region's nutrient status helps farmers to develop a plan for proper fertiliser applications and soil management measures accordingly that will result in economically better returns. One of the most important factors affecting agricultural productivity is the reduction in soil fertility caused by negligence of micronutrients supply. The importance of micronutrients in well-balanced plant nutrition is widely known. Despite the fact that they are required in much lesser quantities than main nutrients, they have a significant influence in crop development and post green revolution, they have shown a negative impact on human nutrition as well as crop productivity (Das *et al.,* 2020; Bhardwaj *et al.,* 2020).It is difficult to get the most out of NPK fertilisers and cultivate high yielding types without an appropriate supply of micronutrients. Micronutrient availability is determined by their distribution in soil as well as other physicochemical characteristics of the soil (Yadav, 2011). Information on micronutrient status for various soil types, districts, and regions, as well as for the entire country, is critical for determining the nature and degree of deficiencies/toxicities and formulating strategies for correcting them in order to improve crop output. Therefore, an attempt has been made to generate information regarding the DTPA extractable Fe, Cu, Zn and Mn status of soils of Sirmour district of HP.

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Material and Methods

The survey was carried out during the months of February-March 2020 in the tomato growing areas of Sirmour districts(Nahan, Pachhad, Rajgarh, Sangrah and Shillai block)of Himachal Pradesh. District Sirmour is located in outer Himalayas, which is commonly known as Shivalik range. The district lies between 30^0 22' 30" to $31^{.0}$ 01'20" north latitudes and 77^0 01' 12" to 77^0 49' 40" east longitudes. The RiverGiri, a tributary of the river Yamuna, is the biggest river in Sirmour district. The district's climate is sub-tropical to moderate, depending on elevation. The region receives about 1405 mm of yearly rainfall on average (Anonymous, 2013). The monsoon season accounts for 90% of total precipitation. The district's average maximum and lowest temperatures are roughly 35°C and 5°C. The district's soil ranges from thin, barren dirt found high in the mountains to rich, deep alluvial soil found in lowlands. In the months of February and March 2020, one hundred representative surface (0-15 cm) and subsurface (15-30 cm) soil samples were taken from fifty different locations around the Sirmour area. Two soil samples were taken from each site/location, at a depth of 0-15 cm (surface) and 15-30 cm (deep) (sub-surface). The samples were obtained with a stainless steel auger and spade to avoid contamination. The soil samples were dried in the shade and pulverised with a wooden pestle and mortar before passing through a 2 mm sieve. The processed samples were then placed in cloth bags fortesting.

Table 1: Critical limits used for available micronutrients (Lindsay and Norvell, 1978)

Micronutrients (mg/kg)	Availability				
	Very low	Low	Medium	High	Very high
Zn	<0.5	0.5-1.0	1.0-3.0	3.0-5.0	>5.0
Cu	<0.1	0.1-0.3	0.3-0.8	0.8-3.0	>3.0
Fe	<2.0	2.0-4.0	4.0-6.0	6.0-10	>10
Mn	<0.5	0.5-1.2	1.2-3.5	3.5-6.0	>6.0

The pH and electrical conductivity of the soil was measured using a pH metre and an EC meter on a 1:2 soil/water ratio (w/v) solution(Jackson, 1973). The rapid titration method was used to quantify organic carbon in soil(Walkley and Black, 1934). DTPA-extractable micronutrients (Zn, Fe, Cu, and Mn) were estimated using an atomic absorption spectrophotometric technique(Sharma *et al.,* 2017).

Results and Discussion

Soil pH

A perusal of data in table 2 revealed that soil pH of the soils of different blocks of Sirmour district. The soil pH value in Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks for surface soils ranged from 6.93 to 7.41, 7.12 to 7.43, 6.62 to 7.44, 6.62 to 7.45 and 6.61 to 7.44 with the mean value of 7.20, 7.37, 7.05, 7.27 and 7.09, respectively. Whereas, the soil pH varied from 6.99 to 7.48, 7.32 to 7.48, 6.66 to 7.48, 6.63 to 7.49 and 6.63 to 7.48 with mean values of 7.27, 7.44, 7.11, 7.33 and 7.15, respectively in sub-surface soils. The highest mean soil pH values were recorded in Pachhad block in both surface (7.37) and sub-surface (7.44) depths. While, lowest mean value was recorded in Rajgarh block in both surface (7.05) and sub-surface (7.11) depths. The soil pH increased with increase in the soil depth which was also reported by Chandel (2020) and Salve and Bhardwaj (2020)which may be due to soil pH was less at upper layer due to the continuous use of farm yard manure in agriculture soil result decrease soil pH value at the surface layer. The reduction in soil pH was mainly due to the release of organic acids in the soil upon decomposition of organics. These results are similar as the findings of Suri (2018) who also observed the identical trends in the soils of the Sirmour district where pH was found to be neutral to alkaline in reaction.

Electrical conductivity

A scrutiny of data presented in table 2 revealed that in different blocks of Sirmour district the electrical conductivity of soils were in normal range. The soil EC value in Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks for surface soils ranged from 0.14 to 0.25, 0.11 to 0.25, 0.13 to 0.27, 0.14 to 0.20 and 0.12 to 0.21 dS/m with the mean value of 0.18, 0.17, 0.18, 0.16 and 0.16dS/m, respectively. While, it ranged from 0.11 to 0.19, 0.10 to 0.20, 0.11 to 0.22, 0.11 to 0.18 and 0.11 to 0.20dS/m with mean values of 0.15, 0.15, 0.15, 0.13 and 0.14dS/m, respectively in sub-surface soils.The data on EC(Table 2) of the studied soils revealed that all the sites do not have any salinity problem and decreased with increase in the

Table 2: Soil reaction, electrical conductivity(dS/m) and organic carbon (g/kg)content of the soils of Sirmour district

Blocks		Soil pH		EC (dS/m)		OC (g/kg)	
		0-15	15-30	0-15	15-30	0-15	15-30
1	Nahan	6.93-7.41 (7.20)	6.99-7.48 (7.27)	0.14-0.25 (0.18)	0.11-0.19 (0.15)	7.35-22.50 (16.68)	7.20-21.00 (14.81)
2	Pachhad	7.12-7.43 (7.37)	7.32-7.48 (7.44)	0.11-0.25 (0.17)	0.10-0.20 (0.15)	5.70-21.80 (13.41)	5.10-19.80 (11.95)
3	Rajgarh	6.62-7.44 (7.05)	6.66-7.48 (7.11)	0.13-0.27 (0.18)	0.11-0.22 (0.15)	6.80-22.10 (13.30)	6.00-19.50 (11.78)
4	Sangrah	6.62-7.45 (7.27)	6.63-7.49 (7.33)	0.14-0.20 (0.16)	0.11-0.18 (0.13)	9.50-15.30 (12.33)	8.60-13.50 (11.30)
5	Shillai	6.61-7.44 (7.09)	6.63-7.48 (7.15)	0.12-0.21 (0.16)	0.11-0.20 (0.14)	6.80-16.40 (10.24)	6.50-14.80 (8.99)

(Values in parenthesis are the mean value)

depth. The main reason of low EC of soil might be due to high leaching of soluble salts takes place from surface to sub surface because of the high permeability. Loria *et al.* (2016) also revealed similar normal range (0.134 to 0.137) of EC in vegetable growing soils of HP.

Organic carbon

The data in the table 2 showed that the organic carbon content of the soils of the study area was medium to high. The data showed that the OC values in the surface layers ranged from 7.35 to 22.50, 5.70 to 21.80, 6.80 to 22.10, 9.50 to 15.30 and 6.80 to 16.40 g/kg with the mean value of 16.68, 13.41, 13.30, 12.33 and 10.24 g/kg in Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks, respectively. Whereas, in sub-surface layer the value varied from 7.20 to 21.00, 5.10 to 19.80, 6.00 to 19.50, 8.60 to 13.50 and 6.50 to 14.80 g/kg with mean values of 14.81, 11.95, 11.78, 11.30 and 8.99 g/kg, respectively. The highest OC mean value was found to be in Nahan block in both surface (16.68) and sub-surface (14.81) depths. While, lowest mean value was recorded in Shillai block in both surface (10.24) and sub-surface (8.99) depths. The OC content was found to be high on the surface layer as compared to lower layers. The higher organic carbon content of surface soils as compared to sub-surface soils may be attributed to accumulation of root, plant biomass and increased microbial activity. The accumulation of organic matter on the surface may have increased the organic carbon content in the upper surface as compared to sub-surface soils. Also, the addition of organic manures is also done on the surface which might have resulted in increased OC content. The findings collaborated with the findings of Chandel (2013).

DTPA-extractable micronutrients

DTPA-extractable Fe, Cu, ZnandMnwere analyzed and found to be in medium category in all the soils of the study area. The DTPA-extractable Fe content in the different blocks of the studied area, *i.e.* Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks for surface soils ranged from 4.54 to 7.76, 4.24 to 6.72, 4.59 to 7.81, 5.23 to 5.88 and 4.45 to 5.82mg/kgwith the mean value of 5.53, 5.22, 5.64, 5.49 and 5.49mg/kg, respectively. While, it ranged from 4.15 to 6.51, 4.02 to 6.36, 4.32 to 6.65, 4.65 to 5.52 and 4.19 to 5.01mg/kg with mean values of 4.95, 4.79, 5.11, 4.99 and 4.90mg/kg, respectively in sub-surface soils (Table 3).The highest mean value for DTPA-extractable Fe was recorded in Rajgarh block in both surface (5.64) and sub-surface (5.11) depths. While, lowest mean value was recorded in Pachhad block in both surface (5.22) and sub-surface (4.79) depths. The results of the study were also collaborated with the results of Chauhan (2018). The decrease in DTPA-extractable iron with the increase in the depth of soil might be due to reduction of OC in the sub-surface layers. Similarly, surface horizons had higher concentration of DTPA-extractable Fe due to higher organic carbon content in surface horizons. Also, solubility of Fe decreases by approximately 1000-fold for each unit increase of soil p, which may be also the reason. This trend was also reported by Arshad (2020). Among various sites selected for the study, the DTPA-extractable copper in the surface layer (0-15 cm) varied from0.38 to 1.93, 0.39 to 1.65, 0.36 to 2.32, 0.52 to 1.27 and 0.42 to 0.74mg/kgwith the mean value of 0.73, 0.78, 0.97, 0.75 and 0.61mg/kgin Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks, respectively. Whereas, in sub-surface layer (15-30 cm) the value varied from 0.32 to 1.82, 0.35 to 1.52, 0.31 to 2.18, 0.45 to 1.17 and 0.37 to 0.69 mg/kgwith mean values of 0.63, 0.68, 0.87, 0.67 and 0.54mg/kg, respectively. The results get strength from the findings of Mahajan*et al.* (2007) and Fayed and Rateb (2013). Further, analysis of the result revealed that the trend of decrease in copper content with increase in depth may be due to the fact of their positive and significant correlation with organic carbon as the OC content decreased with increase in the soil depth in these soils.Also, Also, solubility of Cu decreases by approximately 100-fold for each unit increase of soil pH.

Table 3: Status of DTPA-extractable Iron (mg/kg) and Copper (mg/kg) of the soil of Sirmour district

Blocks		DTPA-extractable Iron (mg/kg)		DTPA-extractable Copper (mg/kg)	
		0-15	15-30	0-15	15-30
1	Nahan	4.54-7.76 (5.53)	4.15-6.51 (4.95)	0.38-1.93 (0.73)	0.32-1.82 (0.63)
2	Pachhad	4.24-6.72 (5.22)	4.02-6.36 (4.79)	0.39-1.65 (0.78)	0.35-1.52 (0.68)
3	Rajgarh	4.59-7.81 (5.64)	4.32-6.65 (5.11)	0.36-2.32 (0.97)	0.31-2.18 (0.87)
4	Sangrah	5.23-5.88 (5.49)	4.65-5.52 (4.99)	0.52-1.27 (0.75)	0.45-1.17 (0.67)
5	Shillai	4.45-5.82 (5.49)	4.19-5.01 (4.90)	0.42-0.74 (0.61)	0.37-0.69 (0.54)

(Values in parenthesis are the mean value)

Critical analysis of the data in table 4 revealed that the DTPA-extractable zinc in the surface layer (0-15 cm) ranged from 1.17 to 3.51, 1.59 to 3.29, 1.29 to 3.52, 1.54 to 2.94 and 1.27 to 3.12mg/kgwith the mean value of 2.49, 2.18, 2.14, 2.17 and 1.69mg/kgin Nahan, Pachhad, Rajgarh, Sangrah and Shillai blocks, respectively. Whereas, in sub-surface layer (15-30 cm) the value varied from 1.04 to 3.23, 1.13 to 3.01, 1.15 to 3.41, 1.29 to 2.48 and 1.15 to 2.93 mg/kg with mean values of 2.20, 1.86, 1.90, 1.77 and 1.51mg/kg, respectively.Therefore, the analysis revealed that all samples were in medium category and the decreased zinc content with increase in the soil depth was may be due to the positive relation of Zn with the OC content. Also, the solubility of Zn in the soil decreases 100-fold for each unit increase in soil pH, which may be also the reason for the decrease content in lower depths. Similar trend has been reported by Meena *et al.* (2006).The DTPA-extractable manganese in the surface layer of the study area soils varied from 1.39 to 3.84, 1.75 to 3.96, 1.62 to 3.48, 1.77 to 3.73 and 1.84 to 2.52 mg/kg with the mean value of 2.92, 2.68, 2.56, 2.64 and 2.20 mg/kg in Nahan, Pachhad,Rajgarh, Sangrah and Shillai blocks, respectively. While, in sub-surface layer the manganese content varied from 1.21 to 3.52, 1.28 to 3.59, 1.25 to 2.95, 1.42 to 3.52 and 1.29 to 2.12mg/kgwith mean values of 2.36, 2.10, 1.90, 2.18 and 1.65 mg/kg, respectively (Table 4). The lowest mean value for DTPA-extractable Mn was found to be in Shillai block in both surface (2.20) and sub-surface depths (1.65). While, highest mean values were recorded in Nahan block in surface (2.92) and sub-surface (2.36) depths.The trend is in line with the findings of Sharma *et al.* (2003)who showed the higher content of Mn on surface soils which might be due to the chelating of organic compounds released during the decomposition of organic matter left after the harvest of the crop. Correlation relationships of different properties were determined in which (**) and (*) was attributed to significant at the 0.01 level and significant at the 0.05 level, respectively.

Table 4: Status of DTPA-extractable Zinc (mg/kg) and Manganese (mg/kg) of Sirmour district

Blocks		DTPA-extractable Zinc (mg/kg)		DTPA-extractable Manganese (mg/kg)	
		0-15	15-30	0-15	15-30
1	Nahan	1.17-3.51 (2.49)	1.04-3.23 (2.20)	1.39-3.84 (2.92)	1.21-3.52 (2.36)
2	Pachhad	1.59-3.29 (2.18)	1.13-3.01 (1.86)	1.75-3.96 (2.68)	1.28-3.59 (2.10)
3	Rajgarh	1.29-3.52 (2.14)	1.15-3.41 (1.90)	1.62-3.48 (2.56)	1.25-2.95 (1.90)
4	Sangrah	1.54-2.94 (2.17)	1.29-2.48 (1.77)	1.77-3.73 (2.64)	1.42-3.52 (2.18)
5	Shillai	1.27-3.12 (1.69)	1.15-2.93 (1.51)	1.84-2.52 (2.20)	1.29-2.12 (1.65)

(Values in parenthesis are the mean value)

Table 5: Correlation coefficient (r) values of important soil parameters

Dependent variable		Soil pH		EC(dS/m)		OC(g/kg)	
		0-15	15-30	0-15	15-30	0-15	15-30
1	Fe	0.014	-0.028	0.077	0.088	0.665**	0.651**
2	Cu	-0.320*	-0.322*	-0.044	-0.057	0.364**	0.367**
3	Zn	-0.091	-0.112	-0.018	-0.034	0.405**	0.452**
4	Mn	0.083	-0.008	-0.360**	-0.270	0.288*	0.309*

****. Significant at the 0.01 level**
***. Significant at the 0.05 level**

These values correspond to the probability of observing such an extreme value by chance. Correlation studies showed that iron and manganese showed a negative relationship with soil pH at 15-30 cm depth, however, positive relationship at 0-15 cm depth, but it did not achieve statistical significance. But, DTPA-extractable copper showed a negative and significant correlation with soil pH for both surface (-0.320*) and sub-surface depth (-0.322*). In case of EC, DTPA-extractable Mn showed a significant and negative relationship (-0.360**). Positive correlations between the DTPA-extractable iron, copper, zincand manganese with the organic carbon content was observed. Increased organic matter content improved micronutrient availability because (i) organic matter improves soil structure and aeration, (ii) organic matter protects micronutrients from oxidation and precipitation into unavailable forms, and (iii) organic matter supplies soluble chelating agents that increase the solubility of micronutrient contents. Mahajan *et al.* (2007) also showed a positive relationship between the DTPA-extractable copper, zinc and manganese with the OC content which shows that DTPA-extractable micronutrients have significant and positive effect of OC content in the soil and OC readily affects the availability of the micronutrients in the soil.

Conclusion

The assessment of available nutrients is crucial for the proper use of fertilizers and the assurance of higher crop yields which helps in maximizing the profits. The study area was found to be neutral to slightly alkaline in reaction and the electrical conductivity values of all the soil samples were under normal range. The organic carbon content was under medium to high range. The soils of the study area fall in the medium category with respect to the DTPA-extractable micronutrients viz., iron, copper, zinc and manganese contents. Correlation studies showed that increase in the organic matter content improved the micronutrient availability.

Conflict of interest

The authors declare that they have no conflict of interest.

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