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Short Note

Micronutrient cations status in vegetable growing soils of sub-humid and wet-temperate zones of Himachal Pradesh

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Abstract

Composite surface (0 to 0.15 m) soil samples were collected from vegetable growing fields in mid-hills sub-humid and high-hills wet-temperate sub-agroclimatic zones of Himachal Pradesh. The soils in wet temperate zone of Himachal Pradesh were more acidic (pH 5.2 to 6.8) in contrast to soils in mid–hills sub-humid zone (pH 5.8 to 7.5) sandy loam to clay loam in texture, medium to high in organic carbon content. Soils were medium in available-N, low to medium in available-P and medium to high in available-K. In sub-humid zone, the DTPA-extractable micronutrients ranged between 0.64 to 11.0 mg kg^{-1} for Zn, 0.14 to 2.80 mg kg^{-1} for Cu, 10.6 to 70.8 mg kg^{-1} for Fe and 2.1 to 34.9 mg kg^{-1} for Mn, while in wet-temperate zone between 0.44 to 2.06 mg kg^{-1} for Zn, 0.02 to 3.60 mg kg^{-1} for Cu, 22.8 to 96.6 mg kg^{-1} for Fe and 2.5 to 40.0 mg kg^{-1} for Mn. Soils in some parts of wet temperate zone of Himachal Pradesh are inherently low in DTPA-extractable Zn (19%), Cu (13%) and Mn (6%) while parts of sub humid zone are low in DTPA-extractable Cu (16%) and Mn (5%). All the DTPA micronutrients showed positive correlation with organic carbon. DTPA-Fe and Mn showed a negative correlation with soil pH. Among mechanical separates, the availability of DTPA-Cu and Mn was higher with finer soil fractions and decreased with coarser ones and reverse relation was observed with DTPA-Zn.

Key words: Micronutrients, DTPA- extractable Zn, DTPA- extractable Fe, DTPA- extractable Mn, DTPA-extractable Cu.

Micronutrients are essential for plant growth, yield maximization and quality improvement of crop produce (Kumar *et al.* 2004; Wani *et al.* 2003), but have not received the required attention like macronutrients for sustainable crop intensification. Studies have indicated widespread deficiencies of micronutrients along with macronutrients limiting the realization of crop productivity potential (Wani *et.*

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al. 2009, 2013; Sahrawat *et al.* 2007, 2010; Girish Chander *et al.* 2012, 1013). The reasons for occurrence of such deficiencies are nutrient mining under intensive farming and undue focus on high analysis NPK fertilizers while ignoring the micronutrients. Micronutrients are no doubt required in smaller quantities, but any deficiency acts as a weakest link inhibiting realization of productivity potential and sustainability. The inherent capacity of soils to supply micronutrients primarily governs their vulnerability for occurrence of such deficiencies and therefore needs desired attention to assess sensitive regions for resorting to appropriate fertilizer management strategies to apply deficient micronutrients from external sources. However, such information on soils in sub-humid and wet-temperate regions of Himachal Pradesh is very limited. Sub-humid region occupies 32% of the total geographical area (55,67,300 ha) and 37% of the net cultivated area (5,60,154 ha) of the state, while wet-temperate region covers 35% of the geographical area and 21% of the cultivated area of the state (DoAHP, 2011). Vast tracts in these regions have diversified into high input based seasonal and off-season vegetable production and are prone to setbacks in yield and sustainability due to heavy nutrient mining and deterioration in soil fertility. The present study was undertaken to determine the DTPA-extractable micronutrients status of undisturbed soils in sub-humid and wet-temperate regions of Himachal Pradesh.

Composite surface (0 to 0.15 m) soil samples were collected from vegetable growing fields in mid-hills sub-humid and high-hills wet-temperate sub-agroclimatic zones of Himachal Pradesh. The undisturbed soils were used for this purpose with a view to avoid the effects of different cultivation and fertilization practices. The soil samples so collected were air dried, ground with the help of wooden pestle and mortar, sieved through 2 mm sieve and analyzed for pH (Glass Electrode Method, Jackson, 1967), organic carbon (Walkley and Black rapid titration method, Walkley and Black, 1934), texture (International Pipette Method, Black, 1965), Exchangeable calcium (Black, 1965), available nitrogen (Alkaline Permanganate Method, Subbiah and Asija, 1956), available phosphorus (Olsen et al. 1954) and available potassium (AOAC, 1970). The available Zn, Cu, Fe and Mn were estimated by the DTPA method (Lindsay and Norvell, 1978) on atomic absorption spectrophotometer. Simple correlation of DTPA-extractable micronutrients with these soil properties were worked out as per detailed procedure prescribed by Snedecor and Cochran (1994). The findings are discussed below:

Physico-chemical properties of soil

The soils in wet temperate zone of Himachal Pradesh were more acidic (pH 5.2 to 6.8) in comparison to soils in mid–hills sub-humid zone (pH 5.8 to 7.5) which might be due to more leaching of bases because of high precipitation. Soil texture was sandy loam to clay loam in both the zones; however sandy loam and loam were the dominated textured in majority of soils (Table 1). Soils were medium to high in organic carbon content due to luxurious plant growth and slow rate of organic matter decomposition due to low temperature. Majority of soils were medium in available-N, low to medium in available-P and medium to high in available-K. The soils of high-hills wet-temperate zone contained more available-N and lesser contents of available-P and K in comparison to soils in sub humid zone. However, the contents of exchangeable-Ca were also lower in high-hills wet-temperate zone soils in contrast to mid-hills sub-humid zone soils.

Micronutrient cations status in soil

In sub-humid zone, the DTPA-extractable micronutrients ranged between 0.64 to 11.0 mg kg^{-1} for Zn, 0.14 to 2.80 mg kg^{-1} for Cu, 10.6 to 70.8 mg kg^{-1} for Fe and 2.1 to 34.9 mg kg^{-1} for Mn, while in wet-temperate zone between 0.44 to 2.06 mg kg^{-1} for Zn, 0.02 to 3.60 mg kg^{-1} for Cu, 22.8 to 96.6 mg kg^{-1} for Fe and 2.5 to 40.0 mg kg^{-1} for Mn (Table 2). The results showed in general higher contents of DTPA-Fe and Mn in wet-temperate region soils as comparison to

Table 1. **Soils physico-chemical properties in mid-hills sub-humid and high-hills wet-temperate zones of Himachal Pradesh**

Property	Mid hills sub-humid zone	High-hills wet-temperate zone
pH	5.8-7.5	5.2-6.8
Oxid. Org. C (g kg^{-1})	9.3-27.5	9.5-22.7
Exch. Ca (meq/kg)	276-2195	761-1611
Clay (%)	8.9-38.6	10.0-34.8
Silt (%)	12.3-46.5	10.7-41.6
Sand (%)	22.4-78.8	12.1-77.0
Textural Class	Sandy loam – clay loam	Sandy loam – clay loam
Available nitrogen (kg ha^{-1})	282-439	282-502
Available phosphorus (kg ha^{-1})	2.3-37.0	2.3-37.0
Available potassium (kg ha^{-1})	39-560	67-504

Table 2. **DTPA-extractable micronutrient status (mg kg^{-1}) of soils in mid-hills sub-humid and high-hills wet-temperate zones of Himachal Pradesh**

	Mid-hills sub-humid zone				High-hills wet-temperate zone			
	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn
Range	0.64 - 11.0	0.14 - 2.80	10.6 – 70.8	2.1 – 34.9	0.44 – 2.06	0.02 – 3.60	22.8 – 96.6	2.5 – 40.0
Mean	3.36	1.07	35.3	17.5	0.94	1.01	47.5	21.1
% deficiency	0	16	0	5	19	13	0	6

Table 3. **Relationship between soil properties and DTPA- extractable micronutrients**

Soil property	Correlation coefficient (r)			
	Zn	Cu	Fe	Mn
Clay	-0.14	0.14	-0.01	0.18
Silt	-0.28	-0.10	0.08	0.33
Sand	0.27	-0.01	-0.03	-0.29
Organic-C	0.04	0.12	0.13	0.01
pH	0.18	0.16	-0.66**	-0.22

that in sub-humid zone which might be because of more acidic nature of the wet-temperate soils (Average soil pH was 6.1 in wet-temperate zone and 6.5 in sub-humid zone) as they have developed under the influence of high rainfall and coniferous type of vegetation. Considering the critical limits of 0.5 mg kg^{-1} for DTPA-Zn, 0.2 mg kg^{-1} for DTPA-Cu, 4.5 mg kg^{-1} for DTPA-Fe (Follet and Lindsay, 1970) and 3.5 mg kg^{-1} for DTPA-Mn, the soils were sufficient in DTPA-Zn and Fe under sub-humid zone and in DTPA-Fe under wet-temperate zone. In sub-humid zone, about 16 per cent soils had low level of DTPA-Cu and 5 per cent had low DTPA-Mn levels confined in Kangra and Solan districts. The Solan district was critical for both DTPA-Cu and Mn, while Kangra for DTPA-Cu only. Similarly, in wet-temperate zone the low levels of DTPA micronutrients were recorded for Zn (19 per cent), Cu (13 per cent) and Mn (6 per cent) in the districts of Shimla and Kullu. The Shimla district witnessed low levels of DTPA-Zn and Cu, while Kullu district that of DTPA-Zn and Mn. In the regions with detected low levels of micronutrients,

intensive vegetable cultivation is being done which is apparently leading to heavy nutrient mining and raises questions over the sustainability and profitability.

Relationship of soil micronutrient cations with soil properties

In an endeavor to understand the relationship with soil properties, an attempt was made to correlate DTPA-extractable micronutrients in sub-humid and wet-temperate zones with soil mechanical separates, organic-C and pH (Table 3). All the DTPA micronutrients showed positive correlation with organic C suggesting that their availability is high and is controlled by this soil component. DTPA-Fe and Mn showed a negative correlation with soil pH indicating that their availability is largely influenced by acidic nature of the soil. But a significant relationship was observed between DTPA-Fe and pH ($r = -0.66$) only. A similar relationship between DTPA-Fe and pH has also been reported by Kanwar *et al.* (1986) and Sharma *et al.* (2003). Reduction in availability of Fe with an increase in pH may be attributed to precipitation as insoluble $Fe(OH)_2$. As regards the relationship with mechanical separates (sand, silt & clay), the availability of DTPA-Mn was higher with finer soil fractions and decreased with coarser ones. Finer soil fractions provide sites on which plant nutrients are adsorbed and thus have more nutrient holding capacity as compared to coarse textured fractions. As regards the relationship between mechanical separates and DTPA-Zn, a reverse relation was observed where the availability was less with finer soil fraction. This may be due to the oxides of Mn and Fe which have a significant effect on micronutrients particularly Zn reactions in soil resulting in irreversible retention of Zn (Das, 2000). However, relationships between soil properties and micronutrients except that for pH and DTPA-Fe were not statistically significant (Table 3). Soils in some parts of wet temperate zone of Himachal Pradesh are inherently low in DTPA-extractable Zn (19 per cent), Cu (13 per cent) and Mn (6 per cent) while parts of sub humid zone are low in DTPA-extractable Cu (16 per cent) and Mn (5 per cent). These areas are hub of intensive vegetable cultivation and therefore need extensive delineation of on-farm deficiencies and designing fertilizer management strategies that take into account emerging deficiencies to get higher productivity and quality on sustainable basis without degrading natural resources.

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