



Background levels of zinc, iron, manganese and copper in soil series of Haryana and their relationship with soil properties

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ABSTRACT

The availability of micronutrients under Aeolian plain, alluvial plain and Aravali hills soils of Haryana may be influenced due to different agro-climatic features and also variation in physico-chemical properties of the soil, which may ultimately affect the optimum crop yield. The soils are neutral to alkaline in reaction, safe in electrical conductivity, low to high in organic carbon content and slightly calcareous in nature. According to the concept of soil nutrient index soils are deficient in DTPA-Zn while sufficient in DTPA-Mn, Fe and Cu content which underlines the need of Zn application in order to enhancing the crop productivity. Thus, it is clear from the investigation that available Zn, Cu, Fe and Mn concentration in soil of different districts in various soil series varied considerably in alluvial zone of Haryana. Organic carbon content in soil was found positively and significantly correlated with DTPA extractable Zn, Cu and Fe. Soil pH did not show any relationship with available Zn, Cu, Fe and Mn in all the soils falls under different series.

Key words: Haryana, Micronutrients, Soil Series, Soil properties

Soil fertility is one of the important factors controlling yields of the crops. With the introduction of high-yielding varieties, use of micronutrient free high analysis fertilizers, less addition of FYM and use of marginal lands for crop production resulted in fast surfacing of micronutrient deficiencies in field crops. Micronutrient content in soils and the capacity of the soils to supply micronutrients in quantities sufficient for crop growth vary widely. Soil micronutrients maps developed, covering large areas to improve our understanding regarding micronutrients problems would be helpful in taking policy decisions regarding distribution of micronutrient carrying fertilizer materials to the location deficient in respective micronutrients. Besides this, the delineation results will be of immense use in developing location specific recommendations to enhance micronutrients content in food crops.

Deficiency of cationic micronutrients like Zn, Fe, Mn and Cu have been reported in different soils worldwide (Alloway 2008) and in Indian soils over the years (Singh and Behera 2011). The availability of these micronutrients to crop plants is affected by many soil factors which varied from

one micronutrient to another as well as their relative degree of effectiveness. However, the geographical distribution of micronutrients in soil is closely related to the composition of the parent materials and soil forming processes.

Information regarding Zn, Fe, Mn and Cu in soil series is helpful to assess the contribution of sub-soil layers to crop nutrition and potential capacity of the soil to supply these nutrients during crop growth. It also helps in understanding the effect of different management practices in a physiographic unity. Soil characterization in relation to evaluation of fertility status of the soils of an area or a region is an important aspect in context of sustainable agriculture production. Such systematic information in soils of Haryana is lacking. In this investigation, soil samples have been collected from different well established soil series in the state, so that the data can be used as a reference by different users and farmers. A systematic and informative data base of Zn, Fe, Mn and Cu sufficiency or deficiency has been generated which is essential to formulate the strategies for amelioration of such deficiencies timely and more preciously. The specific purpose of this study was to delineate the available Zn, Fe, Mn and Cu status in different soil series of Haryana state and to find out their relationship with different soil properties.

MATERIALS AND METHODS

The study area under different soil series of Haryana state is located between 27° 37' to 30° 55' N latitude and 74°

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28° to 77° 36' E longitudes with an altitude ranging between 200 to 300 m amsl and covering an area of 4.42 million ha⁻¹. These soil series were selected based on the physical and chemical properties of the soils. In order to assess the micronutrients status, 172 geo-referenced surface (0-15 cm) soil samples covering some selected soil series of Haryana were collected using GPS. Locations of the soil sample sites (X, Y coordinates) of all the soil samples were recorded. The point location which were recorded while taking soil samples, fed into the geographic information system (GIS) environment to generate the sample site map. The points having same category were grouped into a polygon and the maps for generating micronutrient status map. The samples were dried, grounded and passed through 2mm sieve for analysis of soil properties and relevant micronutrient cations. The soil pH, EC, organic carbon and CaCO₃ were estimated by using the standard procedures as described by Jackson (1973). The micronutrients in these soil series samples were extracted with DTPA solution as per the method outlined by Lindsay and Norvell (1978) and concentration of Zn, Fe, Mn and Cu in the extract was estimated using Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The range and mean value of analyzed relevant soil physico-chemical properties of soil samples of different soil series of Haryana are presented in Table 1 showed that all the soils varied widely in their pH, EC, organic carbon, calcium carbonate and texture. A perusal of the data revealed that the soils in the study area varied between neutral to alkaline in reactions with pH varied from 6.8 to 9.8. The EC mean values ranged from 0.09 to 4.80 dS/m and falls within safe limit of electrical conductivity. All the soils were found low to high in organic carbon varying from 0.08 to 0.93 (%) with an average of 0.58 %. The high content of organic carbon might be due to addition of organic matter either through artificially or naturally and its subsequent decomposition. The free CaCO₃ content varied from nil to medium in calcareous nature.

It is well known that the area under soil series in Haryana is characterized by light in texture, moderate to high in pH and low to medium in organic content. These soils were also studied in the field in detailed description and classified using soil taxonomical classification procedure. Majority of the soils of eighteen soil series falls under alluvial plain followed by Aeolian plain and only one type of soil series falls under Aravali hills soil. The details of the samples collected from all the eighteen soil series along with their name, crop/cropping history, location and areas falls under different series has been given in Table 2.

Geo-referenced micronutrients deficiency in Haryana soils

Zinc: The deficiency of DTPA-micronutrients varied among soil types, agro climatic conditions, types of crops grown and other agronomic practices. As evident from Table 3 deficiency of Zn in soil series of Aeolian plain varied with a minimum of 16.6% in Isarwal series to as high as

Table 1 Physico-chemical properties of soils series in Haryana

Soil properties	Range	Mean
pH (1:2)	6.8- 9.8	
EC (dS/m)	0.09- 4.80	0.87
Organic carbon (%)	0.08- 0.93	0.58
CaCO ₃ (%)	0- 1.80	0.88
Texture	Loam to sandy loam	Sandy loam

25% in Rawalwas soil series. Whereas in soils of alluvial plain, it varied from <1.0 or no deficiency in Kaul series to 20 % Nai soil series. In Aravali hills soil series none of the sample was found deficient in available Zn. In all the soil series 6.71% of the soils under study had available Zn content below the critical level of 0.6 mg/kg (Lindsay and Norvell 1978) and in rest of the soil series, available Zn content was above the critical level. The low amount of available Zn may be attributed to light textured soils having parent materials deficient in Zn minerals. Among the 18 soil series, 9 series had the highest and 9 soil series had the lowest available Zn. Owing to the variations in soil texture, pH and organic matter content of the soils, wide variations in the proportion of Zn-deficient soils have been observed in different districts within states.

Iron: The Fe is another cationic micronutrient, which limits the growth and development of crops when not available in sufficient quantity. The status of DTPA extractable-Fe was found to vary from 2.6 to 20.4 mg/kg with a mean of 8.88 mg/kg in soil series of Aeolian plain, from 2.8 to 20.7 mg/kg in series of alluvial plain and 1.3 to 20.4 mg/kg in soils of Aravali hills series (Table 3). Among all the soil series under study about 10.63% of the soil were found available Fe below the critical limit of 4.5 mg/kg (Lindsay and Norvell 1978). Out of 18 soil series, 10 soil series namely Khoh, Lukhi, Nai, Uchani, Kaul, Ujina, Narnaund, Bejpura, Zarifa Viran and Shadzadpur have no samples below critical level. The low content of available Fe in these soil series may be due to their alkaline in nature, poor in organic content and light in their textural class.

Manganese: Due to its increasing deficiency in north Indian states like Haryana and Punjab Mn nutrition has drew attention of stakeholders in recent years. There was large variation in distribution of available Mn concentration in various soil series and distribution pattern did not follow any specific trend in different series. The mean DTPA- Mn concentration in the soil samples of Aeolian Plain series ranged from 2.1 to 26.3 mg/kg and in soils of alluvial plain, it varies from 2.8 to 26.7 mg/kg (Table 3). However in soil series of Aravali Hills, the Mn content ranges from 1.8 to 16.2 mg/kg. Its overall deficiency in the country has been analysed to be 4.4% but its deficiency is alarming in soil series of Aeolian plain as per the proposed critical limit by Lindsay and Norvell (1978). The variation may be attributed to the nature of parent material, climatic conditions and susceptibility of Mn to change from oxidized to reduced states and vice-versa. This is further corroborated by findings recorded by Randhawa and Singh (1997) and Behera and Singh (2010).

Table 2 Detailed field description of soil series in Haryana

Name of Series	Crops/cropping system	Location	Area
<i>Soil of Aeolian Plain</i>			
Balsamand	Pearl millet and gram	1.5 km south of Balsamand	Western and south-western parts of Haryana Bhiwani, Hisar, Sirsa and part of Rohtak districts
Isarwal	Pearl millet, gram, wheat and mustard	1/2 km from Balsamand on Balsamand	Western part of Haryana Hisar, Bhiwani and Sirsa districts
Rawalwas	Pearl millet, gram and mustard	1.5 km west of village Rawalwas kalan Balsamand - Hisar Road	Western parts of Haryana parts of Hisar, Bhiwani and Sirsa districts
Nimriwali	Pearl millet, gram, wheat and mustard	Near Tosham on Hisar- Tosham road	Western parts of Haryana Hisar, Bhiwani and Sirsa districts
Atela	Pearl millet, gram, wheat and mustard	16 km from Charkhi Dadri on Dadri-Loharu road	South- western parts of Haryana Bhiwani and Mahendergarh districts
Khoh	Wheat, mustard and pearl millet	0.5 km Northwest of village manesar in field No. 10/10 tehsil and district Gurgaon	Gurgaon district
<i>Soil of alluvial plain</i>			
Barwala	Pearl millet, gram, mustard and wheat	3.0 km from Barwala towards south on Barwala- Hansi road	South western parts of Haryana in Hisar, Bhiwani, Sirsa districts
Ladwa	Wheat, gram, mustard and pearl millet	Field No. 64, HAU farm, Hisar	Hisar, Bhiwani and Sirsa districts
Lukhi	Wheat, mustard and pearl millet	Field No. 23/29, east of road to Pataudi, village Uncha Majra, tehsil and district Gurgaon, Haryana	Gurgaon and Mahendergarh districts
Nai	Wheat, gram, mustard, pearl millet and cotton	Nai loamy sand-cultivated	Gurgaon, Rohtak, Rewari, Mahendergarh and Bhiwani districts
Uchani	Wheat, rice and mustard	Field No. 67, HAU farm, Uchani, Karnal District	Karnal, Kurukshetra, Jind, Faridabad, Ambala, Kaithal, Panipat and Sonapat districts
Kaul	Rice, wheat and mustard	Field No 3 block B, CCSHAU farm Kaul and Kaithal	Kaithal, Kurukshetra, Karnal and Jind districts
Ujina	Wheat, cotton and mustard	1.0 km from village ujina on the left side of ujina –sanghel road	Basinal areas of Gurgaon, Rohtak and Kurukshetra districts
Narnaund	Mostly barren Salt tolerant grasses	5.0 km west of Narnaund on Narnaund-Hansi road	Alluvial plains of Hisar, Sonapat and Rohtak districts
Berpura	Gram and mustard	Village Berpura block Naraingarh district Ambala	Northern parts of Haryana
Zarifa Viran	Mostly barren with Salt – loving grasses	200 m southwest of tubewell No.1 CSSRI farm village Gudha, tehsil and district Karnal	Extensive in alluvial in Karnal and adjoining districts of Haryana and parts of Uttar Pradesh
Shahzadpur	Groundnut, millets, pigeonpea, cluster bean and maize in kharif and gram and lentil in rabi Under rainfed agriculture and wheat and barley under irrigation	Left side of the road from Naraingarh to Taka Grundwara villge Kularpur tehsil Naraingarh district Ambala	Extensive in northern parts of Haryana
<i>Soil of Aravali Hills</i>			
Sohna	Mostly used for grazing. Patchy afforestation with shallow rooted	1.5 km west of village Sohna on Sohna- Rewari road	Extensive in southern and south-eastern part of Haryana, i.e. Gurgaon, Faridabad, Rewari and Mahendergarh districts

Copper: Available copper concentration in different soil series in Haryana is given in Table 3. While, overall Cu deficiency is less than 3% (2.3% to be precise) however, it is a cause of concern in the state. Available Cu concentration

in Aeolian plain series soils ranged from 0.2 to 2.5 mg/kg with a mean value of 0.85 mg/kg. In alluvial soil series, the available copper concentration ranges from 0.2 to 5.7 mg/kg with a mean of 1.83 mg/kg and in Sohna series of

Table 3 Distribution of DTPA- extractable Zn, Cu, Fe and Mn in surface soils of different series

Soil series	Zinc		Copper		Iron		Manganese	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
<i>Soil of Aeolian Plain</i>								
Balsamand	0.4-4.5	2.5	0.2-1.7	1.0	2.6-18.8	10.0	2.1-26.3	14.4
Isarwal	0.4-2.5	1.6	0.2-2.5	0.7	2.6-14.0	8.4	2.1-12.6	6.5
Rawalwas	0.4-4.5	2.0	0.2-1.1	0.5	2.6-14.4	7.9	2.1-12.2	5.6
Nimriwali	0.4-2.5	1.6	0.2-2.5	0.7	2.6-14.0	8.4	2.1-12.6	6.5
Atela	0.9-2.3	1.6	0.5-1.4	1.0	3.3-6.6	5.0	11.3-12.8	12.1
Khoh	1.1-2.8	2.1	0.4-1.7	1.2	6.1-20.4	13.6	8.7-16.2	11.4
Overall	0.4- 4.5	1.9	0.2- 2.5	0.85	2.6- 20.4	8.88	2.1- 26.3	9.42
<i>Soils of alluvial plain</i>								
Barwala	1.5-2.6	2.1	0.2-1.6	0.9	3.3-17.4	9.2	4.9-12.8	10.2
Ladwa	0.5-3.5	1.9	0.2-2.5	1.1	2.8-16.3	9.2	2.8-12.7	9.4
Lukhi	0.7-2.6	1.5	0.2-1.9	1.0	4.8-20.4	9.3	5.6-16.2	11.5
Nai	0.4-3.6	2.0	0.4-3.1	1.8	6.1-20.4	13.1	8.7-26.7	19.1
Uchani	0.2-4.7	2.4	0.5-4.9	2.1	5.3-20.3	13.9	3.9-26.5	13.2
Kaul	0.8-4.7	2.4	0.5-3.4	2.3	5.3-17.4	13.3	3.8-16.8	10.0
Ujina	0.4-3.6	2.0	0.4-3.2	1.8	6.1-20.4	13.9	8.7-26.7	18.5
Narnaund	0.1-4.5	2.2	0.5-3.2	2.0	5.9-20.2	14.0	3.9-26.7	15.1
Berpura	0.8-7.7	2.4	0.4-5.7	2.3	5.3-20.6	14.4	3.8-26.5	12.5
Zarifa Viran	1.4-3.6	2.1	1.1-3.4	2.5	9.8-16.9	13.6	6.3-16.8	10.7
Shahzadpur	0.8-4.7	2.4	0.4-5.7	2.3	5.3-20.7	14.4	3.9-26.5	11.9
Overall	0.1- 7.7	2.13	0.2- 5.7	1.83	2.8- 20.7	12.57	2.8- 26.7	12.92
<i>Soil of Aravali Hills</i>								
Sohna	0.7-2.9	1.6	0.2-1.9	1.03	1.3-20.4	9.5	1.8-16.2	9.2

aravali hill soils, it ranges from 0.2 to 1.9 mg/kg with an average content of 1.03 mg/kg. All the soil samples were found adequate considering 0.2 mg/kg as critical limit (Lindsay and Norvell 1978). However, data on available status of Cu did not follow any trend in different soil series of the state (Table 3).

Relationship of available Zn, Cu, Fe and Mn with soil properties

Correlation studies as presented in Table 4 revealed that Fe and Cu availability were found significant positively correlated with organic carbon ($r = 0.298^{**}$ and $r = 0.337^{**}$). This might be due to the formation of soluble Cu-organic complexes on the clay surface. But Cu was negatively

Table 4 Correlation matrix between soil properties and available micronutrients

Nutrient	Physico-chemical properties			
	pH	EC	OC	CaCO ₃
Zn	-0.108	0.143	0.298**	0.013
Fe	-0.022	0.047	0.208	0.105
Mn	0.048	0.113	0.027	-0.066
Cu	-0.113	0.132	0.337**	0.115

** Significant at 1%

correlated with pH indicating increased availability of Cu at lower pH range. Similar results were also reported by Venkatesh *et al.* (2003). The availability of Mn did not show any significant relationship with organic carbon content in different soil series. The results were in close agreement with findings of Ray and Banik (2016). A significant relationship of organic carbon and DTPA extractable Zn, Cu and Fe in surface soils of different series support the findings of Talukdar *et al.* (2009) which explains that complexing agents generated by organic matter promote the availability of these nutrients in soil. DTPA-extractable Zn, Cu, Fe and Mn did not reveal any significant relationship with soil pH and electrical conductivity. Pati and Mukhopadhyaya (2011) also recorded no relationship of soil pH with DTPA- extractable Zn, Cu, Fe and Mn. This indicates that distributions of available cationic micronutrients in these soil series are not influenced by above soil properties. A positive correlation of CaCO₃ with available Zn, Fe and Cu and negative with Mn indicated that there is precipitation of available iron into insoluble products, which supports the classical phenomenon of lime induced iron deficiency. The negative correlation of DTPA Zn, Fe, Mn and Cu with pH may be attributed to their precipitation as hydroxides and carbonates consequently making them immobile and unavailable to the plants. Similar results were obtained by Shinde (2007). This could be attributed to the presence of

organic matter that releases Zn, Fe, Mn and Cu from the parent material and increased their solubility. The similar results were also reported by Sharma *et al.* (2003).

Thus, it is clear from the investigation that available Zn, Cu, Fe and Mn concentration in soil of different districts in various soil series varied considerably in alluvial zone of the state. The soils are neutral to alkaline in reaction, safe in electrical conductivity, low to high in organic carbon content and non-calcareous to calcareous in nature. According to the concept of soil nutrient index soils are deficient in DTPA- Zn while sufficient in DTPA-Mn, Fe and Cu content which underlines the need of Zn application in order to enhancing the crop productivity. Organic carbon content in soil was positively and significantly correlated with DTPA extractable Zn, Cu and Fe. Soil pH did not show any relationship with available Zn, Cu, Fe and Mn in all the soils falls under different series.

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