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Mapping of available nutrients in soils of Ambala district (Haryana)– A GIS approach

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Summary

The current study was carried out to assess the GIS map-based soil fertility evaluation with regard to traditional soil testing in the Ambala. This study presents the soil spatial variability maps for soil pH, electrical conductivity, organic carbon, available N, P, K, S, Zn, B, Fe, Mn and Cu. Soil samples were collected during *Rabi* season of year 2015. Nearly 70 per cent samples had pH between 6.8 and 8.2. The electrical conductivity (EC) varied from 0.10 to 0.98 dS m^{-1} with an average value of 0.39 dS m^{-1}. The organic carbon (OC) in these soils ranged between 0.2 and 0.59 per cent with an average value of 0.37 per cent, the distribution of OC was 58, 42 and 0 per cent, respectively as low, medium and high rating. All the soil samples tested were found to be deficient in N. Only 18 per cent soil samples were deficient in available P, while 62 and 20 per cent samples had medium to high P status. Eighteen (18) per cent samples were found to be low, whereas 74 per cent samples were medium and remaining 10 per cent samples tested high in available K status. 28 per cent samples fell under low status and 40 per cent samples were medium and 32 per cent samples were in high S status. Majority of the soil (96%) samples were having low status of B. 14.00 per cent samples fell under medium status, 6.00 per cent samples were normal and 80.00 per cent samples were high in Zn status. All the soils had sufficient amount of Fe and Cu.

Key words : Soil testing, Macro, Micro-nutrients, GIS maps

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Introduction

Haryana is a principal state where 95 per cent of total cultivable area is under rice wheat cropping system. The share of rice and wheat in total foodgrains production of Haryana has increased sharply from 50 per cent in 1966-67 to more than 90 per cent in the recent past (Swaminathan, 2002). Rice-wheat crop rotation has been followed for several decades and the contrasting edaphic needs of these two crops have resulted in increased pest pressure, nutrient mining, inappropriate use and management of chemical fertilizers, input use efficiency is low and soil organic matter content has reduced (Abrol *et al.*, 2011). During 1960 to 1990, genetic improvements leading to development of highly fertilizer responsive varieties coupled with improved management strategies resulted in a dramatic rise in productivity and production from RWCS (Singh *et al*., 2003). Now this system is showing the sign of fatigue and there is question mark on its ecological and economical sustainability (Garg *et al.*, 2006). Intensive cultivation, growing of exhaustive crops, imbalanced and inadequate crop nutrition largely through chemical fertilizers has made the soils not only deficit in the nutrients but also deteriorated the soil health resulting in diminishing crop response to the recommended dose of nitrogenous fertilizer in the region. Non-judicious enhancement and its bias in favour of the N fertilization further worsen the situation (Singh *et al*., 2008).

Antil *et al*. (2001) had reported that 92.0, 70.6 and 7.8 per cent of soil samples were having low level of organic carbon, available P and available K, respectively in Haryana. While Gupta and Dahiya (2003) reported 54.0, 4.4, 21.0 and 26 per cent of soil samples were deficient in Zn, Mn, Fe and Cu micronutrients in Haryana.In Haryana, with the intensive cropping of high yielding varieties of rice and wheat in the state, deficiency of zinc (Zn) initially and subsequently deficiencies of iron (Fe) in rice and manganese (Mn) in wheat emerged as threats to sustaining high levels of foodgrain production (Singh, 2009). But due to widespread and regular application of Zn fertilizers, the occurrence of Zn deficiency has declined in recent years, but multiple-micronutrient deficiencies may become a problem in future, if not addressed properly (Gupta, 2005; Narwal *et al.*, 2010 and Shukla *et al*., 2014).

Soil related limitations affecting the crop productivity including nutritional disorders can be determined by evaluating the fertility status of the soils. Therefore, it is necessary to evaluate the fertility status of the soil and promote the recommendations of soil test for balanced nutrition to maintain soil health. Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is made. Out of 16 plant nutrients, C, H and O being contributed by air and water, rest 13 are taken up from soil. Presently, farmers are applying nitrogen, phosphorus, potash and zinc only and for other 10 nutrients we are ruthless on soil bank. Generally, NPK consumption ratio of 4:2:1 is considered as desirable based on recommendation of 120:60:30 NPK kg/ha dose (4:2:1) for wheat/rice. While it was (14:5:1) in Ambala (Haryana) during 2010-11. High cropping intensity, burning of crop residues, imbalance fertilizer application and high yielding varieties of these two crops has resulted in to depletion in fertility of soil, which necessitates testing of soil.

Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. Under this context, GIS-based soil fertility mapping has appeared as a promising alternative (Burgess and Webster, 1980; Chevallier, 2000; Zhang and Srinivasan, 2009 and Mali and Singh, 2015). The approaches like integrated nutrient management, balance fertilization, site specific nutrient management will be possible if these kinds of fertility maps are available for a village (Chandravanshi *et al.*, 2014). The current study was carried out to assess the GIS map-based soil fertility evaluation with regard to traditional soil testing in the Ambala. This study presents the soil spatial variability maps for soil pH, electrical conductivity, organic carbon, available –N, P, K, S, Zn, B, Fe, Mn and Cu. The information generated will be useful for managing soil resources and for the fertilizer recommendations for maximizing crop yields and further to maintain the optimum fertility in soil year after year.

Resource and Research Methods

The present investigation was carried out to assess macro and micro-nutrient status of the soils of Ambala district. The Ambala lies on the North-Eastern edge of Haryana between 27°39’45" North latitude and 74°33’53" to 76°36’52" East longitude. Ambala is an intensively rice-wheat growing district in Haryana. The climate of the area is semiarid, with an average annual rainfall of 1100 mm (75–80% of which is received during July to September), minimum temperature of 0 to 4ºC in January, maximum temperature of 38-42ºC in June and relative humidity of 67 to 83 per cent throughout the year. Soil samples were collected during *Rabi* season of year 2015.

This district consists of six blocks *viz.*, Ambala-I, Ambala-II, Saha, Barara, Shahjadpur and Naraingarh. Soil samples consisting of seven samples (locations) from Ambala-I, six from Ambala-II, eighteen from Saha, three from Naraingarh, nine from Shahjadpur and seven from Barara blocks were collected. Total two hundred and fifty representative soil samples (0 to 15cm) were collected at random from fifty villages of Ambala district. The samples were collected by making grid of 2.5 ha and five samples from each grid (location) were taken with the help of soil auger. The exact sample location was recorded using a GPS. All the five samples from each location were mixed together and one composite or representative sample was made. The composite soil samples were air-dried, ground and passed through 2 mm sieve for chemical analysis. All the samples were stored in the polythene bags for further analysis. Six parameter of soil samples *i.e.* pH, electrical conductivity, organic carbon, available N, P and K were analysed with Mridaparikshak, A mini lab developed by ICAR, Indian Institute of Soil Science, Bhopal. Rest of six parameters *i.e.* secondary and micronutrients (S, Zn, B, Fe, Mn and Cu) were analysed at CSSRI, Karnal. For analysis of Cu, Fe, Zn and Mn processing were carried out according to the procedure given by Lindsay and Norvell (1978). Available sulphur (S) was determined by the method given by Chesnin and Yien, 1950, while the hot water soluble B was estimated by UV-VIS Spectrophotometer (Wear, 1965).

The point data (sample points) were recorded with their location (DMS) with the help of hand held GPS device. To interpret the soil properties on spatial domain, all information was transferred in GIS environment (shape file) after converting the DMS values in Degree Decimals. Geospatial tools of interpolation were used for spatial analysis of these point based information and ArcGIS 10.3 software used for this purpose. Among different kind of techniques available in GIS, interpolation was done with inverse distance weighted function which gives better results for unsurveyed area on the basis of surveyed sample points and also deemed better when surveyed points are not homogeneously distributed. Things that are close to one another are more alike than those that are farther away and, as the locations get farther away, the measured values will have little relationship to the value of the prediction location (*http://arcgis.com**). In this way, surface/layers were generated for all soil parameters and overlaid with block boundary of Ambala district.

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physico-chemical properties :

Soil reaction (*pH*):

The pH of investigated soils varied from 6.70 to 8.95. Nearly 70 per cent samples had pH between 6.8 and 8.2 and remaining 2 per cent and 14 per cent were having pH below 6.8 and higher than 8.2, respectively. Most of the soils are neutral to alkaline in reaction. The neutral to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the retention of basic cations on the exchangeable complex of the soil (Table 1).

Salt concentration :

The electrical conductivity (EC) gives an indication

Table 1 : Criteria for assessment and percentage content of macro and micro nutrients in soils

Sr. No.	Soil property	Saline	Normal		Alkaline
1.	pH	<6.8	6.8 to 8.2		>8.2
	Soil property		Normal	Alkaline	
2.	EC (dS/m)		<1.0	>1.0	
	Nutrient	Low	Normal		High
3.	OC (%)	<0.4	0.4-0.75		>0.75
4.	N (kg/ha)	<250	250-500		>500
5.	P (kg/ha)	<10	10-20		>20
6.	K (kg/ha)	<110	110-250		>250
7.	S (ppm)	<10	10-20		>20
	Nutrient	Low	Medium	Normal	High
8.	Zn (ppm)	<0.6	0.6-1.2	1.2-1.4	>1.4
9.	B (ppm)	<0.5	0.5-1.5	1.5-3.0	>3.0
10.	Fe (ppm)	<4.5	4.5-9.0	9.0-18.0	>18.0
11.	Mn (ppm)	<2.5	2.5-3.5	3.5-7.0	>7.0
12.	Cu (ppm)	<0.2	0.2-0.4	0.4-0.8	>0.8

about salt concentration of soil. In Ambala it varied from 0.10 to 0.98 dS m^{-1} with an average value of 0.39 dS m^{-1}. All the soil samples were in normal EC range (<1.0 dS m^{-1}). The normal EC of samples of Ambala may be ascribed to leaching of salts to lower horizons. At the same time, it gives an idea that large salinity is not a problem in the Ambala district, which indicating good quality of soil and considered suitable for agricultural purposes.

Organic carbon :

The organic carbon (OC) in these soils ranged between 0.2 and 0.59 per cent with an average value of 0.37 per cent. Considering the soils having <0.4 per cent OC as low, 0.4-0.75 per cent as medium and >0.75 per cent as high in OC status, the distribution of soil samples under these categories was 58, 42 and 0 per cent, respectively. Thus, the majority of the soils of Ambala district are low to medium in their organic carbon status. Due to continuous, rice-wheat cropping system since long and burning of residues after harvest might have resulted in low organic carbon in the soil over a period of time.

Macronutrient status of soils :

Available nitrogen :

The available N of the soils in the district ranged between 66.90 to 174.05 kg ha^{-1} with a mean value of 134.00 kg ha^{-1}. All the soil samples tested were found to be deficient in N. It is quite obvious that efficiency of applied N is very low due to the fact that N can lost through various mechanisms like NH_3 volatilization, nitrification succeeding denitrification, chemical and microbial fixation, leaching and runoff (De Datta and Buresh, 1989), Which has been resulted in low amount of available N in the soil.

Available phosphorus :

The available P content of soils varied from 7.45 to 30.10 kg ha^{-1} averaging to 14.60 kg ha^{-1} for all the soil samples tested. Only 18 per cent soil samples were deficient in available P, while 62 and 20 per cent samples had medium to high P status in Ambala district. Adequate amount of P in the tested area may be attributed to continuous application of phosphatic fertilizers to crops and resulted in build up of phosphorus. As efficiency of applied P is very low and it comes in available form very slowly and plants take up only 10-40 per cent of applied P during the growing season (Aulakh and Pasricha, 1999) and the rest resides in the soils as less soluble products. It is also recommended that in case of paddy, the application of DAP could be omitted, if recommended dose of it is applied to previous crop wheat.

Available potassium :

The available K content ranged from 77.72 to 311.82 kg ha^{-1} with a mean value of 166.75 kg ha^{-1}. Eighteen (18) per cent samples were found to be low, whereas 74 per cent samples were medium and remaining 10 per cent samples tested high in available K status. Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium rich minerals like illite and feldspars. Due to the continuous drain of K from soil reserve over the years without its replenishment, the deficiency of K has started appearing in certain pockets of the district, which

Table 2 : Nutrient status of soils of Ambala district

Nutrients	Min.	Max.	Mean	S.D.	C.V.
pH (dS/m)	6.70	8.95	7.89	0.495	6.272
$EC_{(1:2)}$	0.10	0.98	0.39	0.213	55.261
OC (%)	0.20	0.59	0.37	0.100	27.027
N (kg/ha)	66.90	174.05	113.99	27.569	24.186
P (kg/ha)	7.45	30.10	14.61	5.468	37.431
K (kg/ha)	77.72	311.82	166.75	54.978	32.971
S (ppm)	0.00	64.72	18.13	13.777	76.000
Zn (ppm)	0.743	4.374	1.937	0.793	40.922
B (ppm)	0.010	0.600	0.202	0.141	69.740
Fe (ppm)	8.210	211.200	35.029	34.784	99.299
Mn (ppm)	2.814	27.360	8.697	4.231	48.644
Cu (ppm)	1.085	2.830	1.749	0.434	24.795

is a serious matter of concern.

Available sulphur :

The available S content (Table 2) of the soils of Ambala ranged from 0.00 to 64.72 ppm with an average value of 18.13 ppm. Considering the soil test rating for available S (< 10 ppm as low, 10-20 ppm as medium and >20 ppm as high in the status of S), 28 per cent samples fell under low status and 40 per cent samples were medium and 32 per cent samples were in high S status. The general statistics calculated from 50 soil samples revealed that the available-S content ranged from 0.00 to 64.72 ppm with a mean value of 18.13 ppm, standard deviation 13.77 ppm and co-efficient of variation (CV%) 76.00 per cent. Sulphur deficiency is wide spread across the world soils (Scherer, 2009). Intensification of agriculture with high yielding varieties and multiple cropping coupled with use of high analysis sulphur free fertilizers along with restricted or no use of organic manures have accrued in depletion of soil sulphur reserve.

Micronutrient status of soils :

Available zinc :

The available Zn content of the soils of Ambala district ranged from 0.743 ppm to 4.374 ppm with an average value of 1.937 ppm. Considering the soil test rating for available Zn (< 0.6 ppm as low, 0.6-1.2 ppm as medium and 1.2-1.4 normal and >1.4 ppm as high in the status of Zn) the tested soils fell under medium, normal and high status in available Zn content. In general out of 50 samples, 14.00 per cent samples fell under medium status, 6.00 per cent samples were normal and 80.00 per cent samples were high in Zn status. The general statistics revealed that the available-Zn content ranged from 0.743 ppm to 4.374 ppm with an average value of 1.937 ppm, standard deviation 0.793 ppm and co-efficient of variation (CV%) 40.92 per cent.

Boron :

Hot water soluble B content in soils ranged from 0.010 to 0.600 ppm with a mean value of 0.202 ppm. Majority of the soil (96%) samples were having low status and remaining 4 per cent tested samples were having medium status of B in Ambala. The general statistics revealed that the available-B content had standard deviation 0.141 ppm and co-efficient of variation (CV %) 69.74 per cent. Boron is involved in the production of nucleic acid and plant hormones, the movement of plant sugars and in carbohydrate metabolism and translocation. Due to the lack of boron, there is hypertrophy, degeneration and disintegration of cambium cells in the meristematic tissues. Its deficiency may cause sterility, small fruit size and poor yield of tomato (Davis *et al.*, 2003). Its application in root and leafy vegetable crop growing areas could not overlooked.

Iron :

Available Fe contents in the soils ranged from 8.21

Table 3 : Tested samples falling in different ranges of available nutrients

Soil property	Saline	Normal		Alkaline
pH	2	70		28
Soil property	Normal		Alkaline	
EC (dS/m)	100		-	
Nutrient	Low	Normal		High
OC	58	42		-
N (kg/ha)	100	-		-
P (kg/ha)	18	62		20
K (kg/ha)	16	74		10
S (ppm)	28	40		32
Nutrient	Low	Medium	Normal	High
Zn (ppm)	-	14	6	80
B (ppm)	96	4	-	-
Fe (ppm)	-	2	30	68
Mn (ppm)	-	4	32	64
Cu (ppm)	-	-	-	100

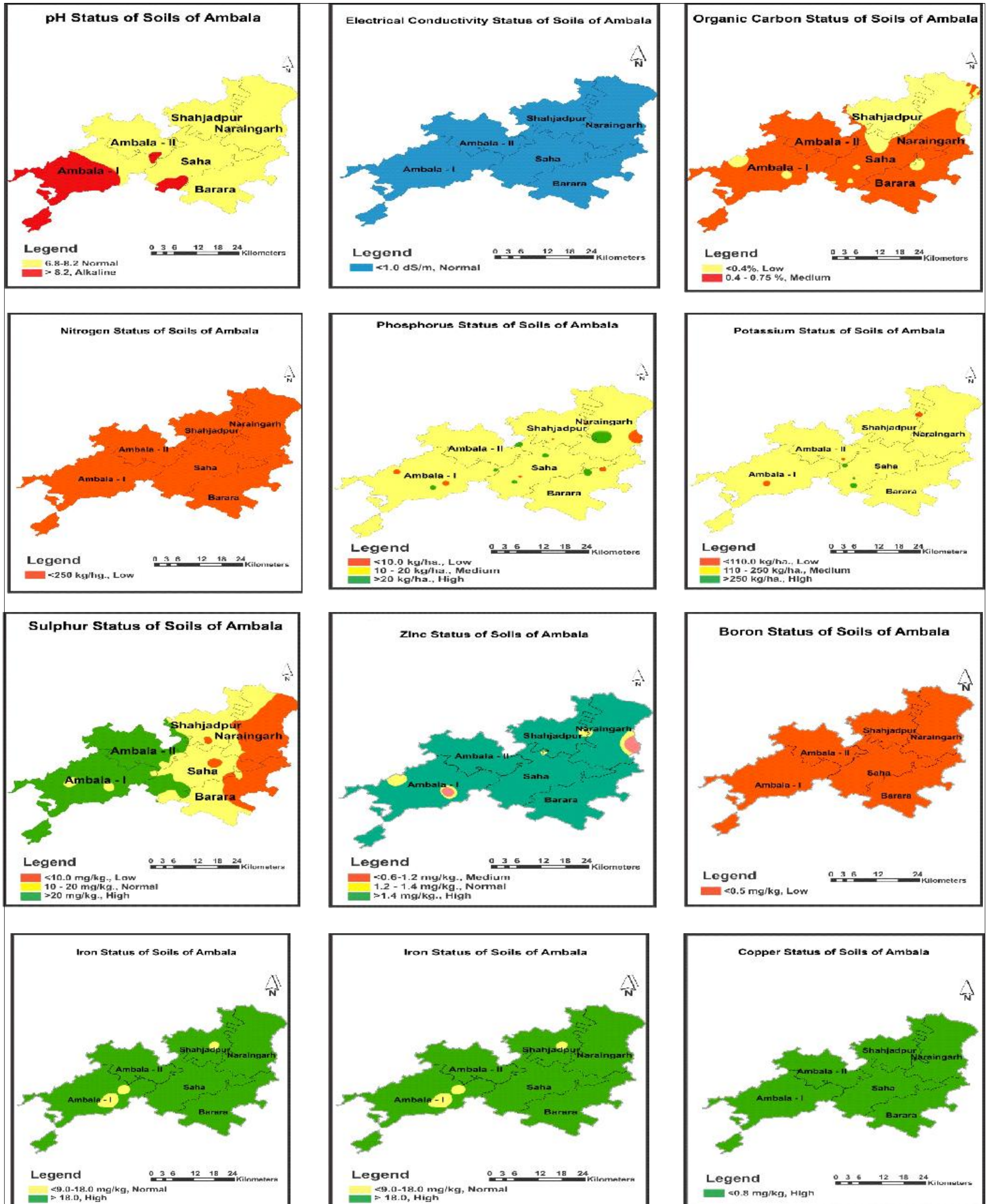

Fig. 1 : Spatial distribution of macro and micro nutrient in soils of Ambala

to 211.20 ppm with a mean value of 35.02 ppm. All the soils had sufficient amount of Fe considering 4.5 ppm as critical limit.

Manganese :

Available Mn in the soils varied from 2.814 to 27.360 ppm with a mean value of 8.697 ppm. Considering 2.5 ppm as critical limit, 2.5 to 3.5 as medium, 3.5 to 7.0 as normal and greater than 7.0 ppm as high level, 4 per cent, 32 per cent and 64 per cent samples were have medium, normal and high Mn content in their soils, respectively.

Copper :

Available copper content in the surface soils ranged from 1.085 to 2.830 ppm with a mean value of 1.749 ppm. Considering 0.2 ppm as critical limit for Cu deficiency, all the soils were found to be in adequate range.

Conclusion:

Organic carbon status of the soils of the Ambala district has deteriorated because of crop residues burning and continuous rice wheat cropping system. The available N status at the alarming level of its availability in all the test sites. The continuous application of phosphatic fertilizers resulted in the build up of phosphorus in certain pockets of the district. In such soils, the farmers can omit P applications for one or more cropping seasons and emphasize on the application of other nutrients, which are at critical level. The potassium deficiencies in certain pockets have started appearing as most of the farmers in the district are not applying K fertilizers. In both the cases of either low or medium level of available K, we need to apply recommended doses of fertilizers to improve the crop yields. The oilseed producer farmers need to emphasize sulphur application as it is master nutrient for yield improvement of oilseed crops. Vegetable cultivating farmers do not forget to apply boron as it highly deficient in soils of Ambala.

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