International Journal of Plant & Soil Science

34(22): 1546-1554, 2022; Article no.IJPSS.91648
ISSN: 2320-7035

Spatial Distribution of Nutrients in Research Farm, Department of Soil Science, CCS HAU Hisar, Haryana

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i2231531

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/91648

Original Research Article

Received 27 June 2022
Accepted 06 September 2022
Published 12 September 2022

ABSTRACT

Mapping the spatial variability of soil fertility by employing Geographic Information System (GIS) provides an elicit information for current and future use. To know the fertility status of the research farm, sixty four surface soil samples were collected to evaluate the spatial distribution of nutrients. The soils of the study area were sandy loam to sandy clay loam in texture and slightly alkaline to moderately alkaline (7.40-8.20) in reaction and non-saline (0.19-0.86 dS m^{-1}) in nature. Organic carbon was recorded high to low and varied from 0.22-0.82 percent. The soils of the research farm were low in available nitrogen (112-161 kg ha^{-1}), high to medium in available phosphorus (10-22 kg ha^{-1}) and high to medium in available potassium (170-538 kg ha^{-1}). The diethylenetriaminepentaacetic acid (DTPA) extractable micronutrients (Zinc, Copper and Manganese) status was found moderate to sufficient except Iron, which was found in moderate to deficient category (4.30-12.56 mg kg^{-1}). Available nitrogen, phosphorus and potassium showed high variation as indicated by coefficient of variance values (142.58, 16.63 and 10380.04, respectively). Organic carbon (0.02), zinc (0.07), iron (6.28), copper (0.19) and manganese (2.25) showed small variation as indicated by low variance. Organic carbon was significantly correlated with nitrogen and potassium suggesting synergistic effect. All the soils were low in available nitrogen that's why application of nitrogenous fertilizers is necessary to ameliorate nutrient deficiency and enhance crop production. The spatial variability maps of nutrients provide an insight of fertility status of the area and this will help in easy monitoring of precision fertilizer management.

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Keywords: Mapping; spatial variability; geographic information system; micronutrients.

1. INTRODUCTION

"In any agricultural operation, soil plays a vital role as it is the cradle for all crops and plants. This is the resolve of nutrients that plays an important role in supplying the growth of crops and other vegetative keeping the environment clean" [1]. "In India, the limited soil resources available for agriculture were shrinking and the improper utilization of these resources with intensification of agriculture resulted in the fast depletion of nutrients. Therefore, it is important to regularly monitor the fertility status of soil from time to time with a view to sustain the soil health" [2].

"Soil fertility fluctuates throughout the growing season due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manures, composts and mulch in addition to leaching" [3]. "At present, nutrient mining is a great thread to Indian agriculture as there is a wide gap between nutrient addition and nutrient removal. Indian agriculture is operating on a net negative balance of plant nutrients at the rate of 10 million tonnes (Mt) per annum" [4]. "One of the reasons for lower production is imbalanced use of fertilizers by the farmers without knowing soil fertility status and nutrient requirement of crops leading to adverse effects on soil and crop both in terms of nutrient toxicity and deficiency" [5]. "The deficiencies are so intense and serve that visual symptoms are very often observed in major crops. Hence, evaluation of fertility status of the soil of an area or a region is an important aspect in the context of sustainable agriculture" [6].

"Mapping the spatial variability of soil fertility by applying GIS provides and elicits information for current and future uses. Spatial variability maps of different nutrients clearly show the specific locations of the areas, where attention is required with respect to management of plant nutrients" [7]. The cause of spatial variability of soil physico-chemical properties in agriculture fields is soil forming processes and the internal factors associated with them. This variability is intrinsic in nature, but some of the variability can be generated by external factors such as tillage and crop production practices [8,9].

Keeping above things in view, a systematic study was carried out to explore the spatial variability of important soil parameters viz. texture, pH, organic carbon (OC), available nitrogen (N), available phosphorus (P), available potassium (K), available zinc (Zn) and micronutrients in research farm, Department of Soil Science, CCS HAU Hisar, Haryana. By identifying suitable sites for treatment, a greater understanding of the spatial variability of soil attributes will enable more advanced agricultural and environmental management approaches.

2. MATERIALS AND METHODS

The research farm, which is the part of study area, located in the north-west of CCS Haryana Agricultural University campus on Hisar-Ludas road, 243 kilometres from the state capital Chandigarh and 180 kilometres from the national capital Delhi. The experimental area of department of Soil Science lies between 29°08'58"N to 29°09'08"N latitudes and 75°40'39"E to 75°42'24"E longitudes and comprises of 34.1 hectares. The altitude of the study area is 215 meters above mean sea level.

Detailed soil survey of Soil Research Farm, CCS HAU, Hisar was carried out using the standard procedures. The base maps of the area were prepared and auger samples were collected using grid and GPS system during 2021-2022 for their analysis in the laboratories. Based on morphological and physico-chemical characteristics, 64 surface soil samples from Soil Research Farm, CCS HAU, Hisar were collected and the location of the samples were recorded by the handheld GPS and the location map is presented in Fig. 1. The analytical results of each soil sample was categorized as low, medium and high for organic carbon and macronutrients and deficient, moderate and sufficient for micronutrients based on standard rating values. "The correlation analysis was done to determine the relationship among various parameters. The descriptive statistics and correlation analysis of the data were done using SPSS software" [10].

The maps were composed in Ark Map 9.2 software to display the different layers of the extracted information in an effective manner for this purpose, the different layers of extracted information in *.shp* format were loaded in Ark Map and the maps were composed having legend to represent the categories of different classes.

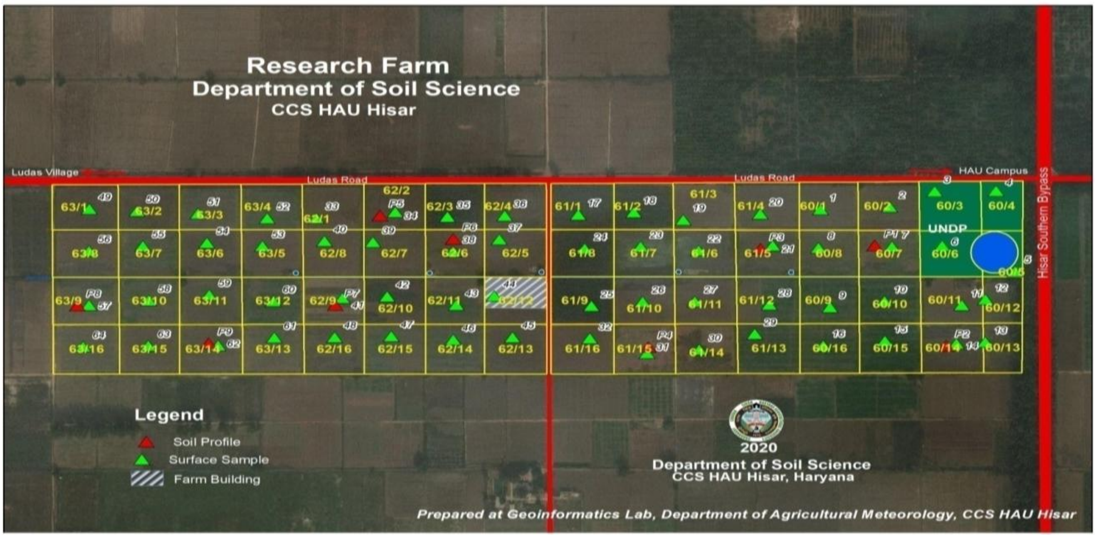

Fig. 1. Location map and sampling sites of the soil research farm

3. RESULTS AND DISCUSSION

3.1 Soil Texture

The soils of the study area were sandy loam to sandy clay loam in texture. Skewness values of -0.42 to 2.11 for different soil properties revealed that some soil properties were not normally distributed (Table 1). “This variation and non-normal distribution of the properties in the studied area may be attributed to adoption of different soil management practices including variation in fertilizer application and other crop management practices” [11,12].

3.2 Soil Reaction (pH)

The pH of the soil is an important chemical property as it impacts the capacity for plant growth, nutrient availability, soil physical condition and microbial activity. The pH of soil samples in the study area ranged from 7.40 to 8.20 indicating slightly alkaline to moderately alkaline in reaction according to pH classifications defined by Soil Survey Staff [13] (Table 1). The results may be attributed to the reaction of fertilizers with the soil colloids, which resulted in the reaction of basic cation on the exchangeable complex of the soil [14].

3.3 Electrical Conductivity (EC)

The EC of saturation extract revealed that soils were non-saline in nature and varied from 0.19 to 0.86 dSm^{-1} with a mean value of 0.32 dSm^{-1} and showed low variation (0.02) (Tables 1, 2). “The low EC may be due to free drainage which favoured the removal of released bases by percolating and drainage water” [15]. Similar non-saline nature of soils in various arid and semi-arid regions of India were also reported by Sehgal [16].

3.4 Organic Carbon (OC)

Organic carbon content in the study area ranged from high to low (0.22 to 0.82 percent) with a mean value of 0.52 percent and showed low variation (0.02) (Table 1, 2). It may be ascribed due to the fact that soils have very low carbon pool and high carbon decomposition due to warm climate [17]. It can be increased by applying organic matter in the form of FYM which may ultimately help in improving soil fertility.

3.5 Available Nitrogen (N)

Available N was found low and varied from 112 to 161 kg ha^{-1} with a mean value of 139 kg ha^{-1} (Table 1). It might be due to mostly low organic carbon content throughout the study area. The available N was found to be positive and significant correlated with the organic carbon of the soil (r = 0.59**; p≤0.05) (Table 2). “The low available N in such soils may be due to semi-arid condition of the area that have favoured rapid oxidation and less accumulation of organic matter, releasing more NO_3^--N which could have been lost by leaching” [18]. The spatial variability map of available N is presented in Fig. 3 which depicts that entire area was low in nitrogen.

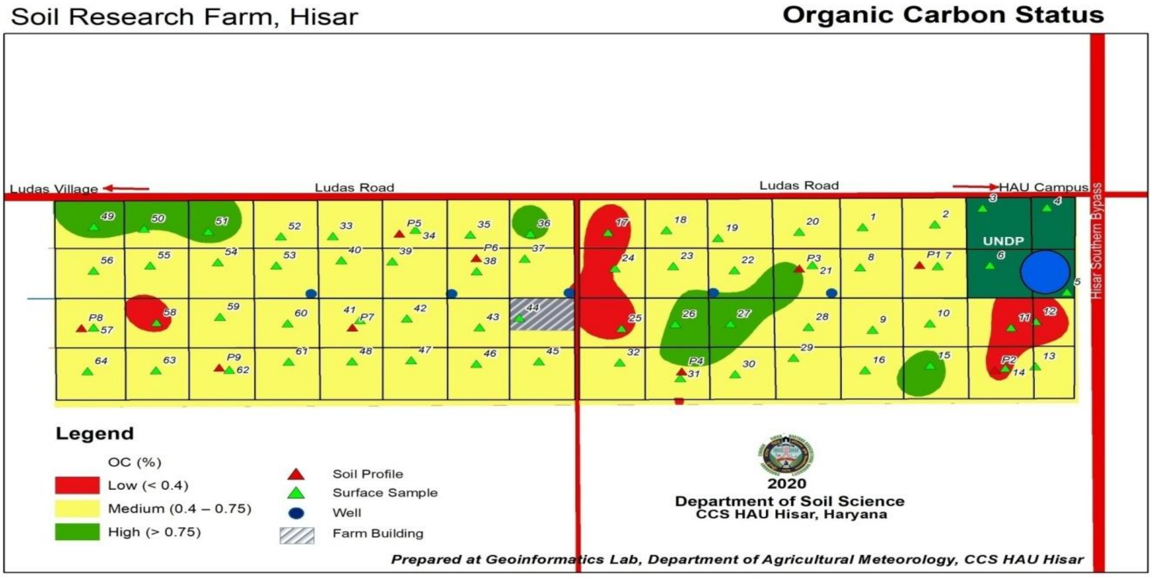

Fig. 2. Organic carbon status

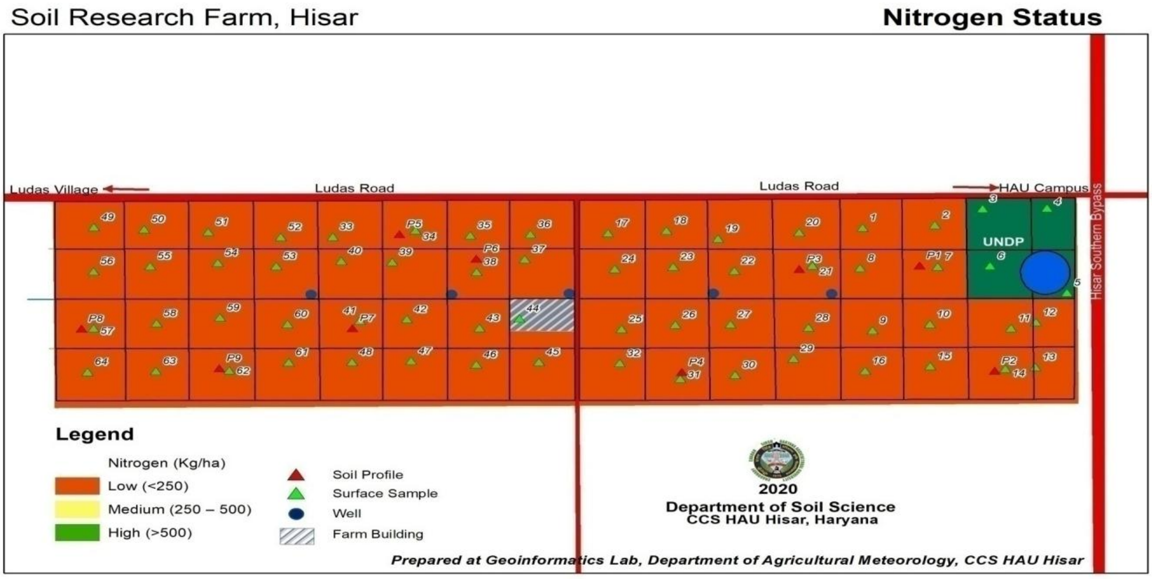

Fig. 3. Nitrogen status

Table 1. Descriptive statistics of soil parameters

Parameter	Range	Mean	Std. Deviation	Variance	Skewness	Kurtosis
pH	7.40-8.20	-	0.23	0.05	-0.39	-0.88
EC	0.19-0.86	0.32	0.14	0.02	2.11	5.62
OC	0.22-0.82	0.52	0.13	0.02	0.20	0.13
N	112.00-161.00	139.36	11.94	142.58	-0.42	-0.58
P	10.00-22.00	15.69	4.08	16.63	0.37	-1.26
K	170.00-538.00	323.89	101.88	10380.04	0.57	-0.59
Zn	2.06-3.30	2.52	0.26	0.07	0.76	0.96
Fe	4.30-12.56	6.81	2.51	6.28	0.81	-0.59
Cu	0.88-2.30	1.36	0.43	0.19	0.49	-1.13
Mn	10.27-15.75	12.85	1.50	2.25	0.07	-1.02

3.6 Available Phosphorus (P)

“Phosphorus is the second most essential plant nutrient, and its availability in soils depends on several factors” [19]. Available P in the study area varied from 10 to 22 kg ha^{-1} with an average content of 16 kg ha^{-1}(Table 1). Due to past years' excessive use of P fertilizers, which revealed spotty deficit in inherent P status, it was stated that the available P content was higher throughout the farm. This meant that P fertilizers needed to be applied there in order to boost land and water productivity. There was a positive correlation between OC and available P (Table 2) indicating that higher available P is associated with higher organic matter.

3.7 Available Potassium (K)

Soil available K status varied from 170 to 538 kg ha^{-1} with an average value of 324 kg ha^{-1} (Table 1). Available K showed higher variation (10380) which may be ascribed to heterogeneity of fertilizers application in the study area. The high soil available K might be due to the presence of potassium bearing minerals like feldspars, illite, mica and the correlation analysis showed that available K has a positive and significant correlation with organic carbon ($r = 0.42^{**}$; $p \leq 0.05$) (Table 2) [20,21].

3.8 DTPA Extractable Micronutrients

Available Zn content in the study area was found 2.06 to 3.30 mg kg^{-1} with a mean value of 2.52 mg kg^{-1} (Table 1). All the collected soil samples fall under moderate to sufficient category due to continuous application of zinc fertilizers in the farm. Available Fe content in the study area found to be ranged from 4.30 to 12.56 mg kg^{-1} with a mean value of 6.81 mg kg^{-1} (Table 1). Almost all the soil samples fall under moderate category except a few which were found in deficient category. Available Mn content in all the soil samples were in moderate to sufficient category varied from 10.27 to 15.75 mg kg^{-1} with a mean value of 12.85 mg kg^{-1} (Table 1) in the study area. Available Cu content in the study area was found 0.88 to 2.30 mg kg^{-1} with a mean value of 1.36 mg kg^{-1}(Table 1) and hence all the collected soil samples fall under moderate to sufficient category. All micronutrients showed low variation and a positive and significant correlation among all micronutrients suggesting that these elements are the functions of the same pedological factors (Table 2). Dinesh [22] also observed similar correlation among micronutrients while ascertaining the fertility status of the soils of geomorphic units of north-eastern Haryana.

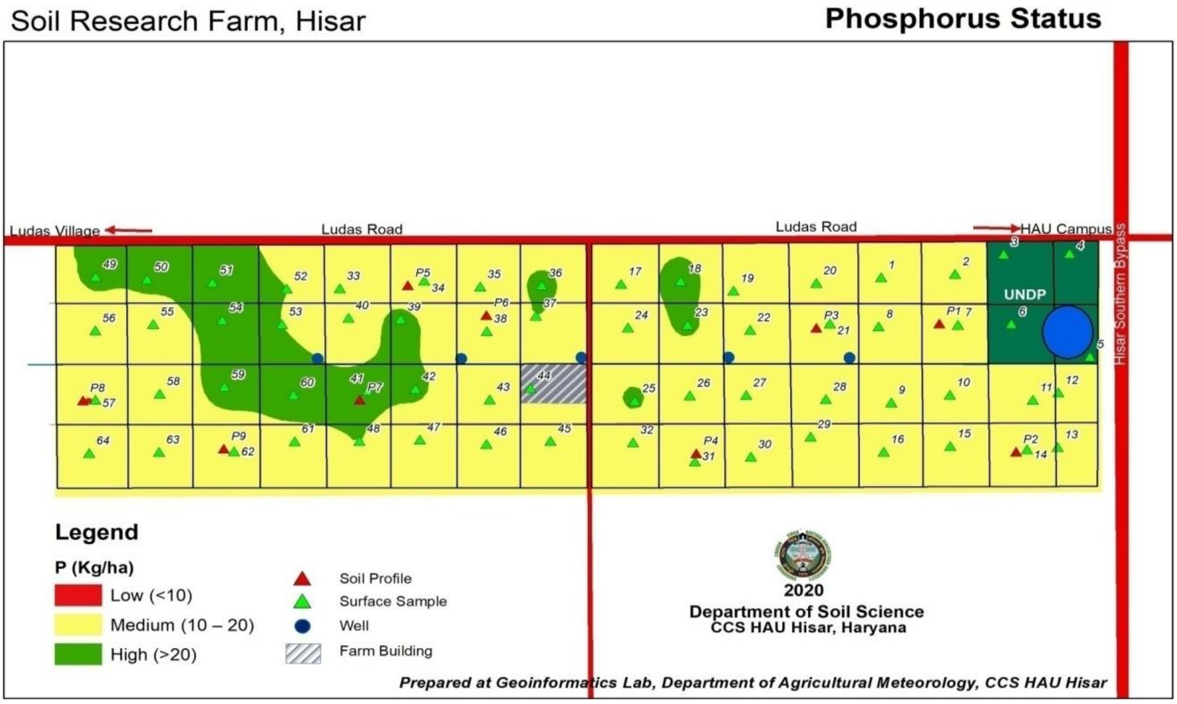

Fig. 4. Phosphorus status

Table 2. Correlation among different soil parameters

Parameter	pH	EC	OC	N	P	K	Zn	Fe	Cu	Mn
pH	1									
EC	0.45**	1								
OC	-0.09	-0.242	1							
N	0.02	-0.022	0.59**	1						
P	-0.32**	-0.023	0.11	0.09	1					
K	-0.09	-0.047	0.42**	0.27*	0.27*	1				
Zn	-0.01	0.065	-0.17	-0.02	0.14	-0.1	1			
Fe	-0.10	0.077	0.14	0.22	0.34**	0.40**	0.32*	1		
Cu	-0.26*	-0.112	0.06	0.18	0.38**	0.21	0.11	0.44**	1	
Mn	-0.27*	0.134	-0.04	0.19	0.30*	0.13	0.29*	0.33**	0.40**	1

***Significant at 0.05 probability level; *Significant at 0.01 probability level*

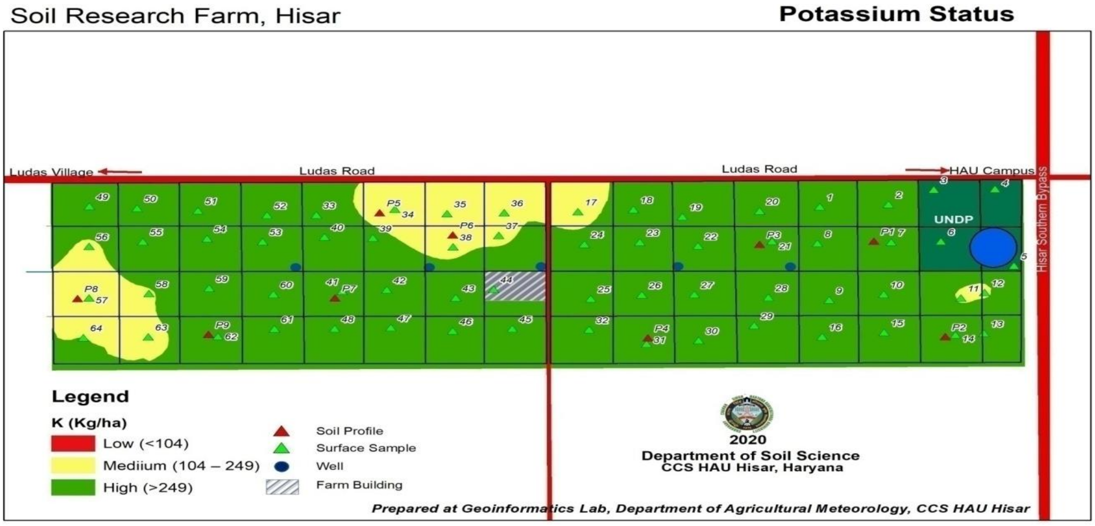

Fig. 5. Potassium status

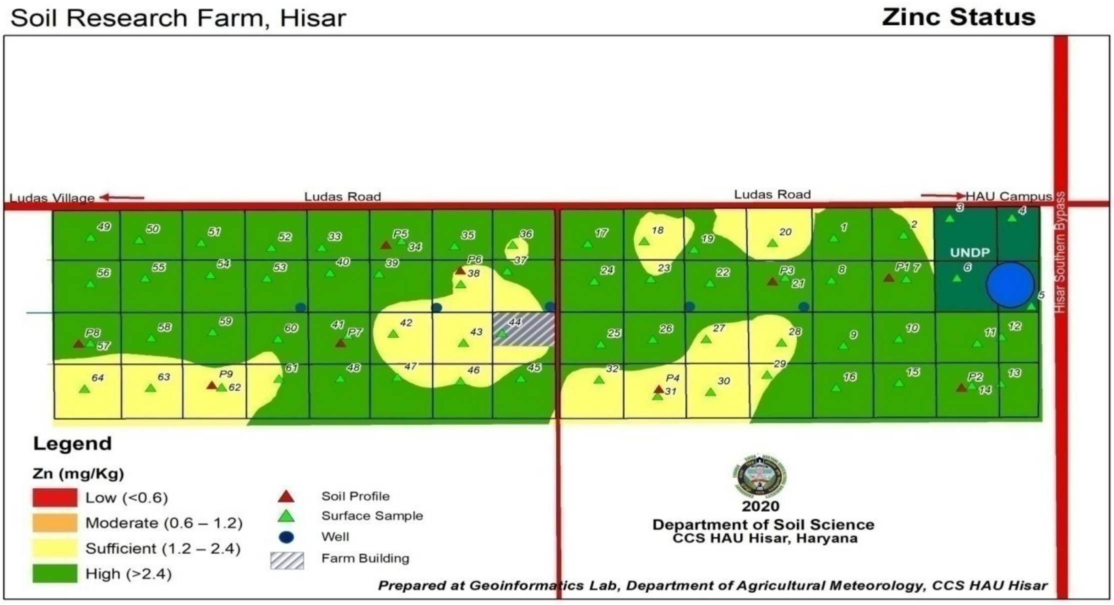

Fig. 6. Zinc status

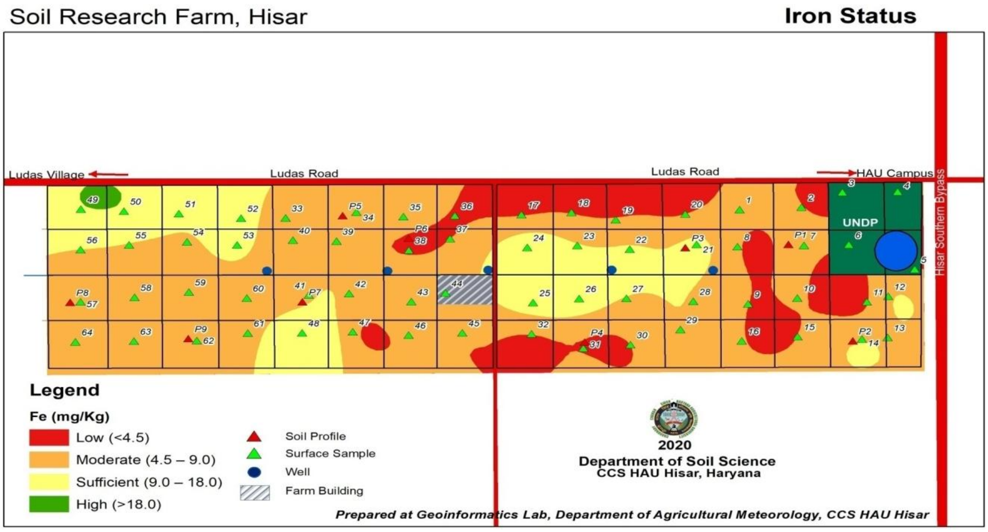

Fig. 7. Iron status

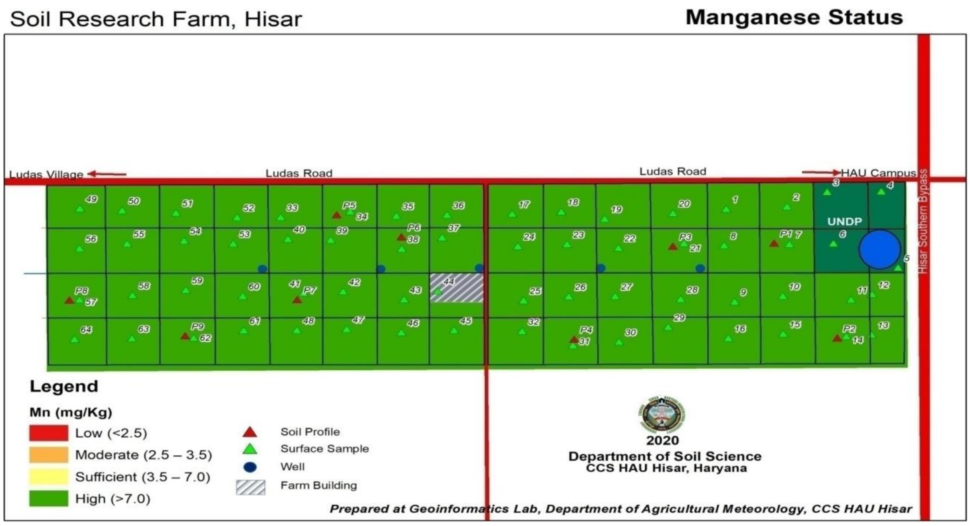

Fig. 8. Manganese status

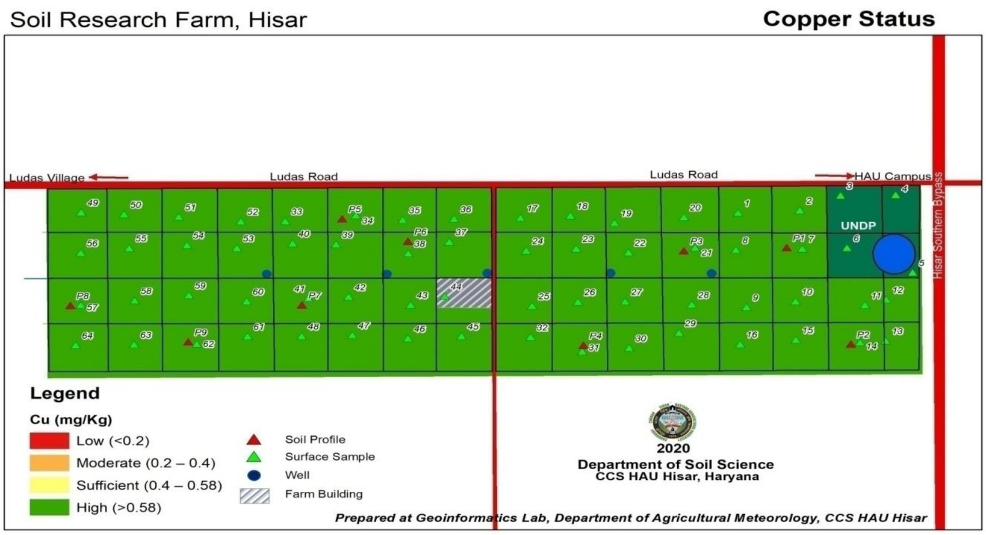

Fig. 9. Copper status

4. CONCLUSIONS

From the above study of the Research farm, Department of Soil Science, CCS HAU, Hisar, it can be concluded that the soils were low in available nitrogen, high to low in organic carbon and high to medium in phosphorus and potassium. Organic carbon was significantly correlated with N, P and K suggesting that the higher available N, P and K were associated with higher organic matter. The soils were categorized as moderate to sufficient in Zinc, Copper & Manganese except Iron, which was found in moderate to deficient category. Micronutrients showed a positive and significant association, indicating that the same pedological causes are responsible for these components' functions. The geographic variability maps of nutrients give an understanding of the region's fertility state, which will make it simple to monitor precise fertilizer management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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