

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

Abstract

Mapping the spatial variability of soil fertility by employing Geographic Information System (GIS) provides an elicited 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 low to high and varied from 0.22-0.82 percent. The soils of farm were low in available nitrogen (112-161 kg ha⁻¹) medium to high in available phosphorus (10-22 kg ha⁻¹) and medium to high in available potassium (170-538 kg ha⁻¹). The DTPA extractable micronutrients (Zinc, Copper and Manganese) status was found sufficient to high except Iron, which was found in low to sufficient 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 therefore, the 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 will help in easy monitoring of precision fertilizer management.

Keywords: Mapping, Spatial variability, Geographic Information System and Micronutrients.

1. INTRODUCTION

In any agricultural operation, soil is the utmost importance as it is the cradle for all crops and plants. This is the resolve of nutrients that play 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 are shrinking and reckless the utilization of these resources with intensification of agriculture resulted in the fast depletion of nutrients. It is therefore 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, compost and mulch in addition to leaching [3]. At present nutrient mining is a great threat 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 and its classification 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. A better understanding of the spatial variability of soil properties would enable for refined agricultural and environmental management practices by identification of proper sites for management.

2. MATERIALS AND METHODS

The farm, which is part of the study area, located in the north-west of CCS Haryana Agricultural University campus on Hisar-Ludhiana 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 and 29°09'08"N latitudes and 75°40'39"E and 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 figure 1. The analytical results of each soil sample was categorized as low, medium and high for organic carbon and macronutrients and as deficient, moderate and sufficient for micronutrient 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].

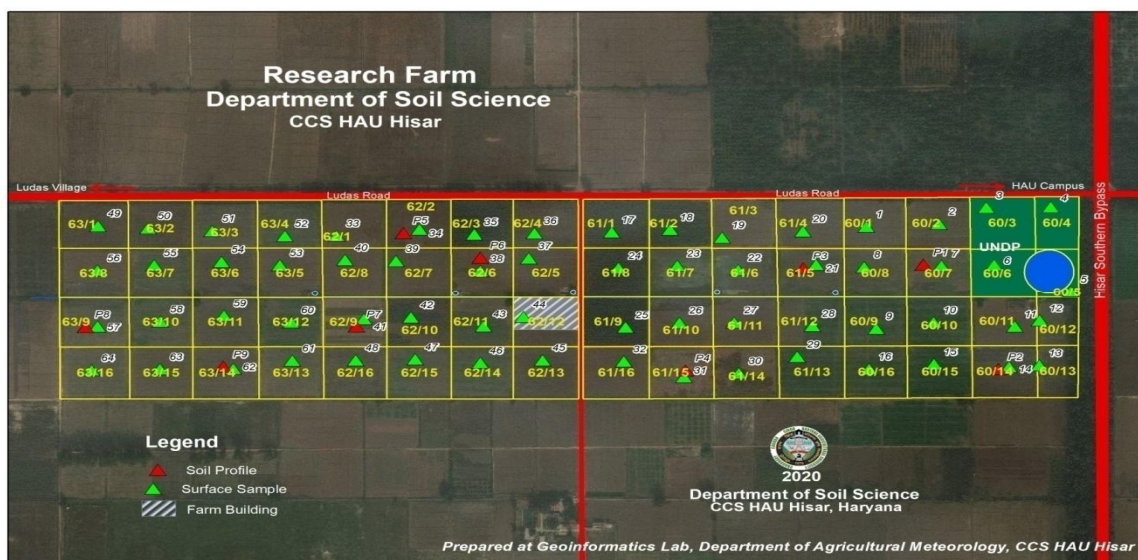


Fig. 1: Location map and sampling sites of the soil research farm

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.

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 a 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 0.86dSm⁻¹ with a mean value of 0.32dSm⁻¹ and showed low variation (0.02) (Table 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 results regarding 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 study area ranged from low to high (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.

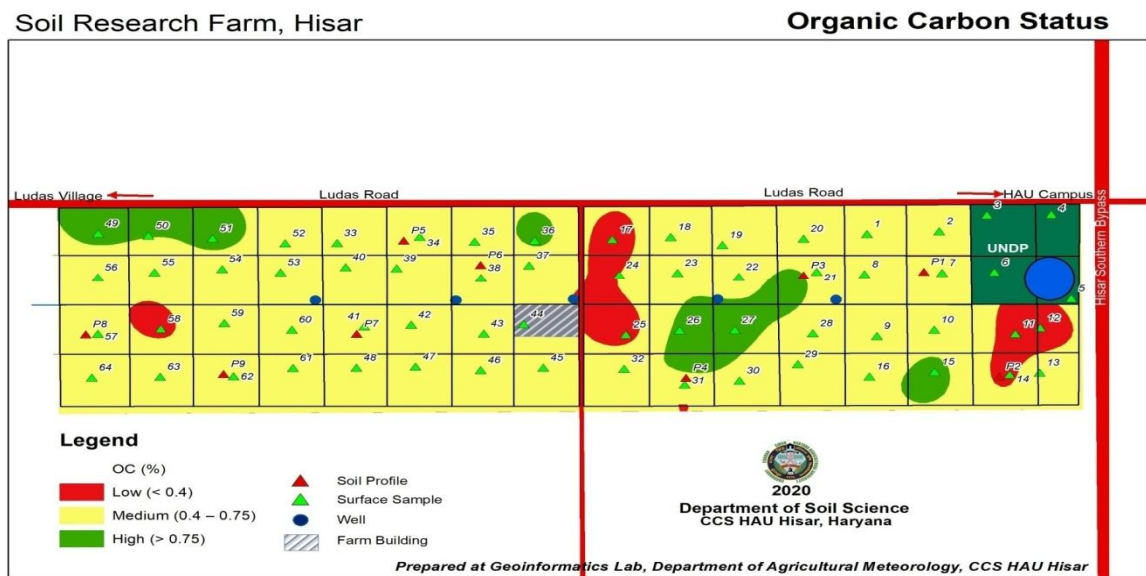


Figure 2 Organic carbon status

3.5 Available Nitrogen (N)

Available N was low and varied from 112 to 161 kg ha⁻¹ with mean value of 139 kg ha⁻¹ (Table 1). The low soil N may be due to mostly low organic carbon content throughout the study area as the N was found to be positive and significant correlated with the organic carbon of the soil ($r = 0.59^{**}$; $p \leq 0.05$) (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 NO₃⁻-N which could have been lost by leaching [18]. The spatial variability map of available N is presented in figure 3 which depicts that entire area was low in nitrogen.

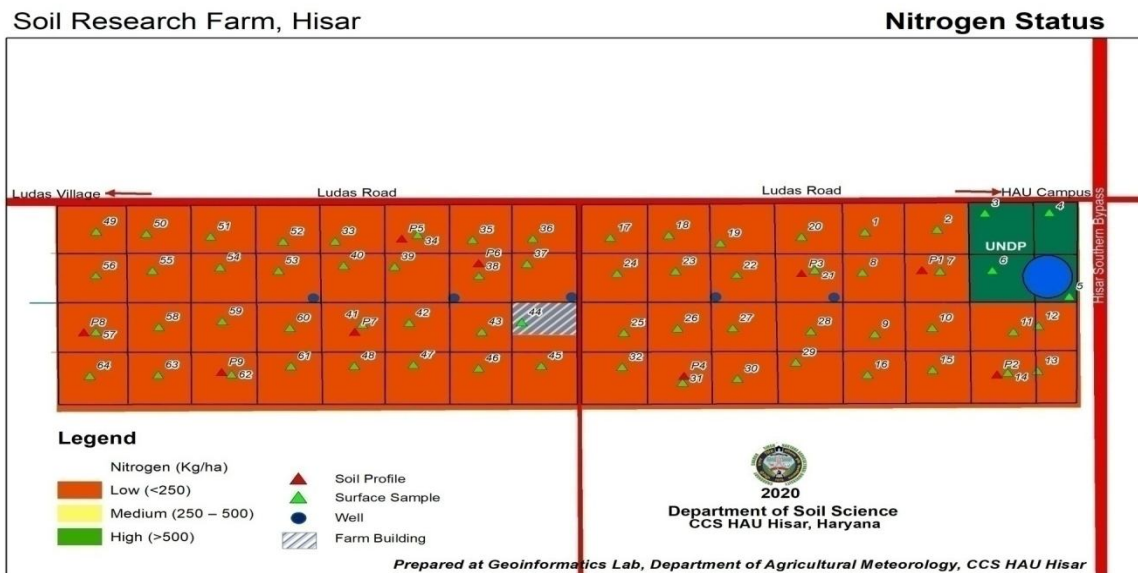


Figure 3 Nitrogen status

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 average content of 16 kg ha⁻¹ (Table 1). Available P content was reported to be higher throughout the farm due to excessive use of P fertilizers during the earlier years which showed spotic deficiency of inherent P status, thereby needs to apply P fertilizers over there for having improved land as well as water productivity. There is a positive correlation between OC and available P (Table 2) indicating that higher available P is associated with higher organic matter.

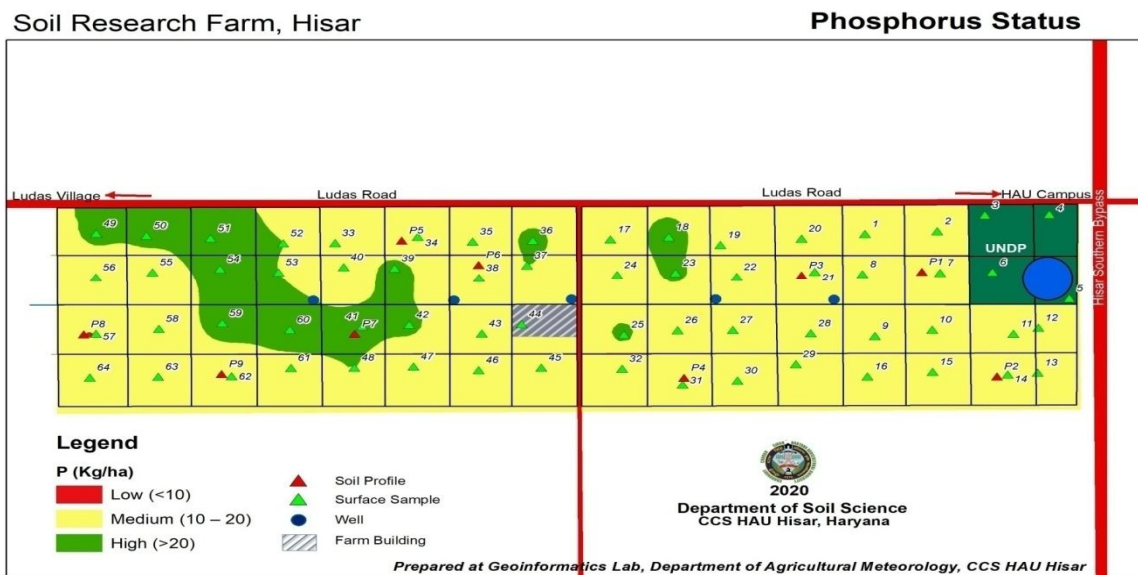


Figure 4 Phosphorus status

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**

3.7 Available Potassium (K)

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

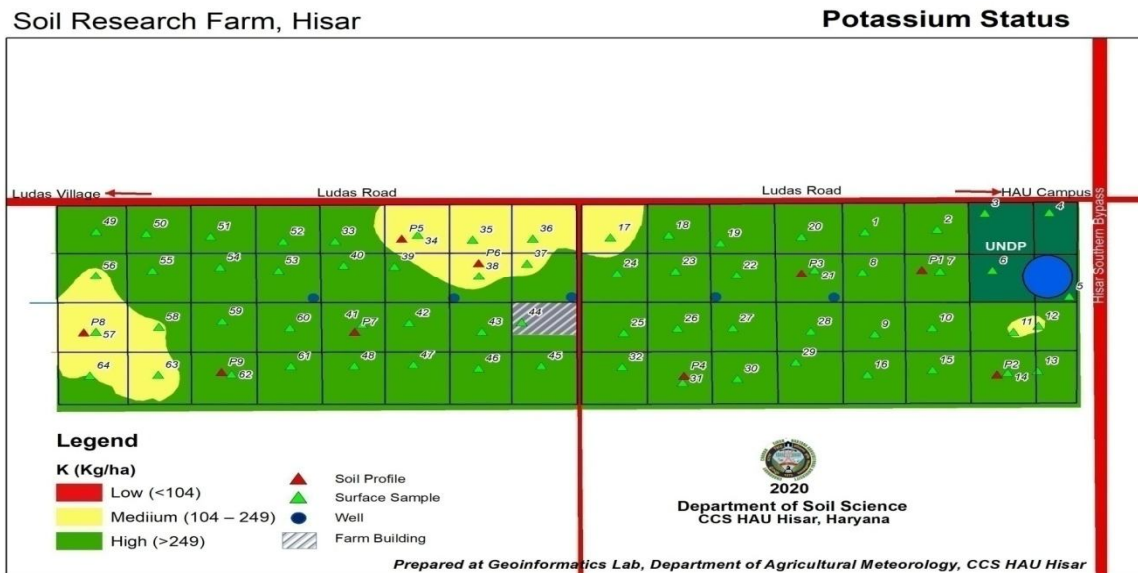


Figure 5 Potassium status

3.8 DTPA Extractable Micronutrients

Available Zn content in 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 sufficient to high category due to continuous application of zinc fertilizers in the farm. Available Fe content in the study area found to be ranging from 4.30 to 12.56 mg kg⁻¹ with mean value of 6.81 mg kg⁻¹(Table 1). Almost all the soil samples fall in sufficient category except a few which were found in low category. Available Mn content in all soil samples were in sufficient to high category with its content varying from 10.27 to 15.75 mg kg⁻¹ with a mean value of 12.85 mg kg⁻¹ of soil (Table 1) in the study area. Available Cu content in 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 sufficient to high category. All micronutrients showed low variation and a positive and significant correlation were also observed among all micronutrients suggesting that these elements are 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.

Soil Research Farm, Hisar

Zinc Status

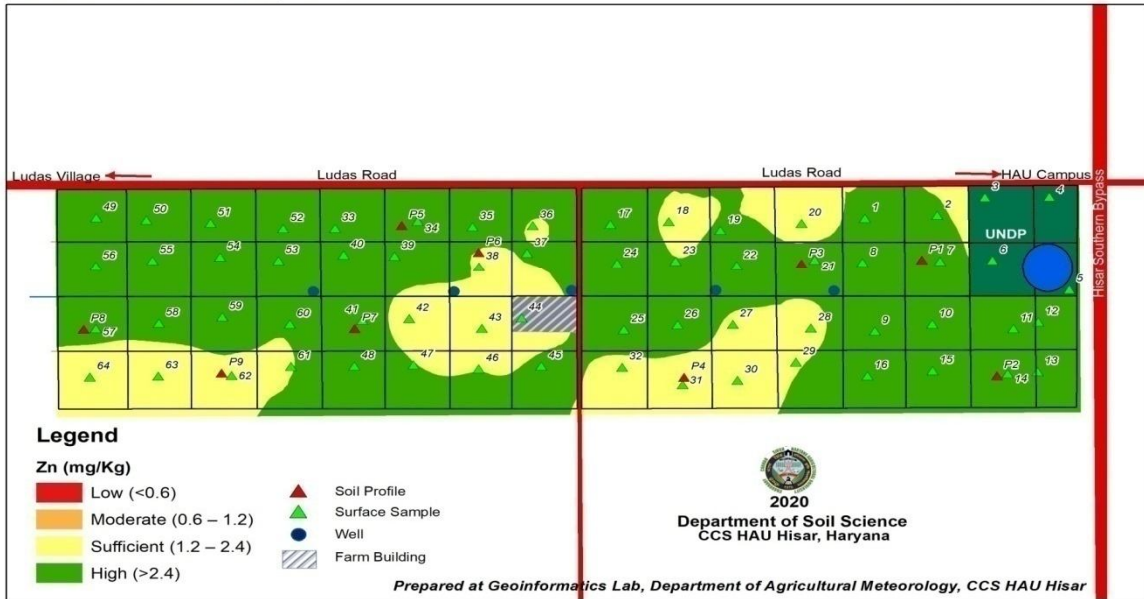


Figure 6 Zinc status

Soil Research Farm, Hisar

Iron Status

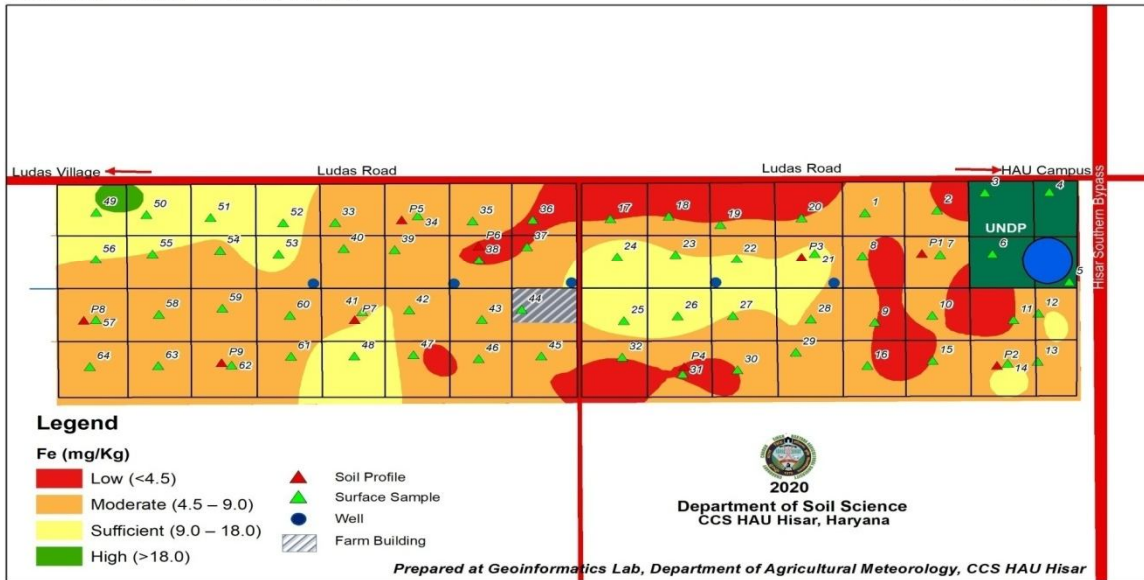


Figure 7 Iron status

Soil Research Farm, Hisar

Manganese Status

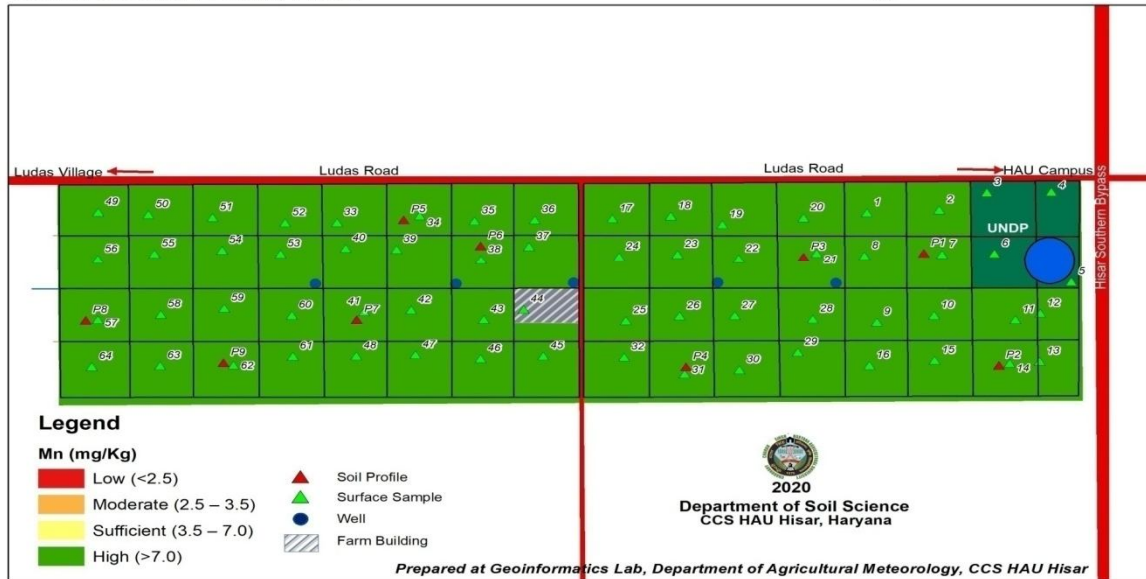


Figure 8 Manganese status

Soil Research Farm, Hisar

Copper Status



Figure 9 Copper status

4. CONCLUSIONS

From the above intensive study of the Research farm, Department of Soil Science, CCS HAU, Hisar, it can be concluded that the soils were low in available nitrogen, low to high in organic carbon and medium to high in phosphorus and potassium. Organic carbon was significantly correlated with N, P and K suggesting that higher available N, P and K are associated with higher organic matter. The soils were categorized as sufficient to high in Zinc, Copper & Manganese except Iron which was found in low to sufficient category. Positive and significant correlation was observed among micronutrients suggesting that these elements are functions of the same pedological factors. The spatial variability maps of nutrients provide an insight of fertility status of the area and will help in easy monitoring of precision fertilizer management.

REFERENCES

1. Kumar SD, Samadhiya VK, Chandrakar T, Sharvan N, Mahendra S, Homeshvari. Macro and Micronutrient Status of Research farm, College of Agriculture and Research Station, Kurud, district Dhamtari, Chhattisgarh. *The Pharma Innovation International Journal*. 2021;8(10):32-35.
2. Sashikala G, Naidu MVS, Ramana KV, Nagamadhuri KV, Reddy A, Kumar P, Sudhakar P, Krishna T, Giridhara. Mapping of Nutrients status in Tatrakallu village of Anantapuramu district of Andhra Pradesh using Geographic Information System. *Journal of the Indian Society of Soil Science*. 2021;69(2):133-141.
3. Ravikumar P, Somashekar RK. Evaluation of nutrient index using organic carbon, available P and available K concentrations as a measure of soil fertility in Varahi river basin, India. (in) *Proceedings of the International Academy of Ecology and Environmental Sciences*. 2013;3(4):330-343.
4. Ramakrishna PVR, Munawery A. Sustainable soils nutrient management. *Journal of the Indian Institute of Science*. 2012;92:1-8.
5. Ray PK, Jana AK, Maitra DN, Saha MN, Chaudhury J, Sriparna S, Ranjan SA. Fertilizer prescriptions on soil test basis for jute, rice and wheat in Typic Ustochrept. *Journal of the Indian Society of Soil Science*. 2000;48:79-84.
6. Singh RP, Mishra SK. Available macro nutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (U.P.) in relation to soil characteristics. *Indian Journal Science Research*. 2012;3(1):97-100.
7. Jatav MK, Dua VK, Manoj K, Trehan SP, Sushil K. Spatial distribution of soil available Nutrients in the potato growing pockets of Hoshiarpur district of Punjab. *Potato Journal*. 2013;40(2):128-134.

8. Rao PSC, Wagenet RJ. Spatial variability of pesticides in field soils: Methods for data analysis and consequences. *Weed Science*. 1985;33(2):18-24.
9. Sharma P, Shukla MK, Mexal JG. Spatial variability of soil properties in agricultural fields of southern new Mexico. *Soil Science*. 2011;176:288-302.
10. Levesque R. *SPSS Programming and Data Management: A guide for SPSS and SAS Users*. 4thEdn., SPSS Inc. Chicago. 2007;1:21-27.
11. Tesfahunegn GB, Tamene L, Vlek PLG. Catchmentscale spatial variability of soil properties and implications on site-specific soil management in northern Euthopia. *Soil and Tillage Research*. 2011;117:124-139.
12. Behera SK, Suresh K, Rao BN, Mthur RK, Shukla AK, Manoram K, Ramachandrudu K, Harinarayana P, Prakash CC. Spatial variability of some soil properties varies in oil palm (*Elaeisguineensis* Jacq.) plantation of west coastal area of India. *Solid Earth*. 2016;7:979-993.
13. Soil Survey Staff. *Soil Taxonomy: A Basic system of Soil Classification for Making and Interpreting Soil Surveys*, Second Edition. United States Department of Agriculture- National Resources Conservation Service, Agriculture Handbook. US government Printing Office, Washington, DC, USA. 2006;436:23-31.
14. Chetan G, Mohammad AM, Daljit D, Rishi B. Spatial distribution of physico-chemical properties and macronutrients in rice growing soils of Haryana. *The Ecoscan*. 2016;10:365-370.
15. Gill A, Sharma VK, Dinesh, Thakur P. Evaluation of Soil Physico-Chemical and Biological Properties under different Tea (*Camellia sinensis*) gardens of Himachal Pradesh, India. *Journal of Agriculture Research and Technology*. 2022;1:87-94.
16. Sehgal J L, Dhir RP, Murthy RS. Some taxonomic problems in major soils of the arid and semi-arid regions of India. *Journal of the Indian Society of Soil Science*. 1986;34(1):111-124.
17. Jatav GK, Mishra VN. Evaluation of soil fertility status of available N, P and K in inceptisol of Baloda block in Janjgir district of Chhattisgarh. *J Prog Agric*. 2012;3(1):28-32.
18. Leelavathi GP, Naidu MVS, Ramavatharam N, Sagar KG. Studies on genesis, classification and evaluation of soils for sustainable land use planning in Yervedumandal of Chittoor district, Andhra Pradesh. *Journal of the Indian Society of Soil Science*. 2009;57:109-120.
19. Singh P, Bhatt R, Kaur G. Phosphorus availability in soils and use efficiency for food and environmental sustainability. In: Bhatt R, Meena RS, Hossain A (eds.) *Input Use Efficiency for Food and Environmental Security*. Springer, Singapore. 2021.
20. Deka B, Sawhney JS, Mukhopadhyay SS. Clay mineralogy as influenced by landforms in Siwalik Himalayas. *Clay Research*. 1995;14:16-21.

21.Reza SK, Baruah U, Dutta D, Sarkar D,Dutta DP. Distribution of forms of potassium in Lesser Himalayas of Sikkim, India. Agropedology.2014;24(01):106-110.

22. Dinesh, Bhat MA, Grewal KS. Fertility status of major geomorphic units of northeast Haryana, India. Communicated. 2018;1:41-49.

UNDER PEER REVIEW