Assessment of soil properties using geospatial techniques at DDUCE-OF Farm

ABSTRACT

The purpose of this study was to identify the geographic variability and mapping of different soil properties using geospatial techniques at DDUCE-OF Farm. For this purpose, surface soil samples (0-15 cm depth) were collected with the help of GPS at definite locations of research farm area at DDUCE-OF, CCSHAU, Hisar during rabi, 2021. These samples were analyzed in the laboratory for various physico-chemical and biological properties. Soil properties of DDUCE-OF farm revealed that soils are sandy loam to loam in texture having pH ranged from 7.15 to 8.65 and electrical conductivity (EC) ranged from 0.30 to 2.75 dS/m. The soil organic carbon (SOC) content was observed medium to high (0.41 to 0.94%).The available N was low (126 to 196 kg/ha), P ranged from 8.50 to 23.5 kg/ha (from low to high in content) and available K was found medium to high and ranged from 128.5 to 554.0 kg/ha. The available S ranged between 60 to 725 mg/kg and was observed sufficient. The soil microbiological bacterial count status ranged between 4.6×10^3-9.8×10^9 CFU count per g of soil in various blocks of organic farm. The DTPA-extractable micronutrients Zn (1.00-4.47 mg/kg), Fe (7.26-19.92 mg/kg), Mn (3.88-17.77 mg/kg) and Cu (0.93-4.64 mg/kg) were sufficient in amount and heavy metal contents (Ni, Pb, Cd, Cr, As) were found below their permissible limit. The study concluded that the soil mapping and survey is significant because it aids in the evaluation of soil qualities and their application in organic farming.

Keywords: Organic farming, Soil properties, Geospatial, Micronutrients, Heavy metals

INTRODUCTION

The agriculture plays a key role in ensuring the food security and sustaining the livelihood of human beings. Different agricultural crops i.e. cereals, pulses, oilseeds, vegetables, fruits and plantation crops are good components of food commodity as far as health aspects are concerned. In addition, there are so many benefits of inclusion of food commodities in human diet. Modern agriculture requires sustainable use of soil resources because soil quality can easily be deteriorated within a short period of time. For sustainable agricultural productivity, it is utmost important to improve and maintain soil physical, chemical and biological health. The characterization of physical, chemical and microbiological properties of soil in relation to organic cultivation is important for recommending the nutrient and water input for optimum plant growth. The organic manures like FYM, vermicompost, poultry manure, biofertilizers etc.

Comment [A1]: kg.ha^{-1}

Comment [A2]: mg.kg^{-1}

Comment [A3]: The sentence structure in the abstract needs to be rearranged: Aims, study design, place and duration of study, methodology, results, and conclusion

Comment [A4]: the number of citations is very small, it is necessary to add citations from the latest recent research in this field are the source of energy to the soil, microflora and organic carbon content is considered to be an index of the soil health (Chand *et al.,* 2006). The micro biodiversity plays a crucial role in ensuring the availability of inherent and applied nutrients in the soil to the crop plants.

A better understanding of the impact of continuous cropping systems on physical, chemical and microbiological properties of soil is essential for the quantification of soil quality impacts and thereby enhancing the cropping system sustainability (Aparicio and Costa, 2007). Thus, there is an urgent need to not only improve the soil quality but also to sustain soil health for crop productivity which not only useful to the farming communities in providing reliable income but also protects the soil from degradation. This requires an urgent shift from sole chemical to organic agriculture. Soil properties plays an important role in selection and successful implementation of any organic/natural farming strategy and practicing organic/natural farming supposed to have positive impact on soil properties. So assessing soil properties, initially and repeatedly, is very important to study the impact of organic/natural farming under different cropping systems. Geospatial techniques are quiet useful to maintain any spatial and temporal database like soil properties. The purpose of this study was to identify the geographic variability and mapping of different soil properties using geospatial techniques at DDUCE-OF Farm. Keeping in view the importance, the present investigation was taken up to assess the soil physico-chemical and microbiological properties of different cropping systems under organic cultivation.

MATERIALS AND METHODS

Comment [A5]: Material and Methods with subtitle : area study, experimental design, data collection methods/measurement of research results, data analysis

Eighty six soil samples were collected from a depth of 0-15 cm at definite location of DDUCE-OF farm with the help of GPS under different cropping system during 2020-21 (Table 1 and Figure 1). Soil samples were air-dried and ground to pass through a 2-mm sieve in the laboratory. Thereafter, these soil samples were analyzed for various physical, chemical and biological parameters using standard procedure. The pH and Electrical Conductivity (EC) were determined in (1:2) soil:water suspension with the help of glass electrode pH meter and conductivity meter bridge, respectively using an Eutech pH meter (Jackson, 1967). Organic Carbon (OC) was estimated by wet digestion method (Walkley and Black, 1934). Soil texture was determined using qualitative methods by feel method given by Soil Science Division Staff. 2017. Available nitrogen was determined using steam distillation method (Subbiah and Asija, 1956) and estimated on Gerhardt's Fully automatic N analyzer (VAPODEST 500 C). Available P was determined by the method of Olsen *et al.* (1954) and estimated on double beam UV spectrophotometer. Available potassium was determined using neutral normal ammonium acetate method (Hanway and Heidal, 1952) and estimated on flame photometer. Available Sulphur was determined by using turbidity method (Chesnin and Yien, 1950) and measured at 420 nm by double beam UV spectrophotometer. The count of bacteria was carried out by using serial dilution pour plate method (Wollum, 1982). DTPA-extractable micronutrients in soil samples were determined by Lindsay and Norvell (1978) using Atomic Zeenit 700 P Atomic absorption spectrophotometer (Analytik Jena). Spatial variability maps of the farm were also prepared on ArcGIS 10.5 software.

Table 1. GPS based location of DDUCE-Organic Farming, CCS HAU, Hisar

Sr. No.	Identification (Muraba no./Kila no.)	LAT (N)	LONG (E)
1	1787/1-15	29°8'26.61865"	75°42'03.95412"
2	1787/17-18 & 1788/19-20	29°8'22.099192"	75°42'03.84657"
3	1787/17-18 & 1788/19-20	29°8'20.52923"	75°42'03.63334"
4	1787/17-18 & 1788/19-20	29°8'19.24023"	75°42'03.89050"
5	1798/4-5 & 1797/1-2	29°8'18.90584"	75°42'04.05551"
6	1798/4-5 & 1797/1-2	29°8'17.92993"	75°42'04.59689"
7	1798/6-7 & 1797/9-10	29°8'17.05974"	75°42'03.40659"
8	1798/6-7 & 1797/9-10	29°8'16.28365"	75°42'03.90425"
9	1798/14-15 & 1797/11-12	29°8'15.66052"	75°42'03.74837"
10	1798/14-15 & 1797/11-12	29°8'14.51231"	75°42'03.40365"
11	1798/16-17 & 1797/19-20	29°8'13.63752"	75°42'03.72070"
12	1798/16-17 & 1797/19-20	29°8'12.97929"	75°42'05.41718"
13	1798/24-25 & 1797/21-22	29°8'11.94397"	75°42'05.04910"
14	1798/24-25 & 1797/21-22	29°8'11.50980"	75°42'05.12921"
15	1798/24-25 & 1797/21-22	29°8'10.56584"	75°42'04.75088"
16	1798/24-25 & 1797/21-22	29°8'10.32646"	75°42'02.56423"
17	1798/24-25 & 1797/21-22	29°8'11.66244"	75°42'02.31566"
18	1798/24-25 & 1797/21-22	29°8'12.04059"	75°42'02.73003"
19	1798/16-17 & 1797/19-20	29°8'12.53377"	75°42'02.63344"
20	1798/24-25	29°8'10.91040"	75°41'58.50811"
21	1798/24-25	29°8'11.42910"	75°41'58.25951"

22	1798/24-25	29°8'12.88910"	75°41'58.79381"
23	1798/16-17	29°8'13.30775"	75°41'58.30262"
24	1798/16-17	29°8'14.24275"	75°41'58.48813"
25	1798/14-15	29°8'15.01111"	75°41'58.00801"
26	1798/14-15	29°8'16.37710"	75°41'59.07681"
27	1798/06-07	29°8'17.69484"	75°41'58.40632"
28	1798/06-07	29°8'19.90599"	75°41'58.69464"
29	1798/06-07	29°8'21.49439"	75°41'58.42678"
30	1798/04-05	29°8'22.59261"	75°41'59.14922"
31	1798/08-09	29°8'16.28579"	75°41'54.59676"
32	1798/12-13	29°8'14.39551"	75°41'54.09198"
33	1798/18-19	29°8'12.02528"	75°41'54.39781"
34	1798/22-23	29°8'11.45270"	75°41'54.00614"
35	1798/22-23	29°8'11.20376"	75°41'51.18324"
36	1798/19-20	29°8'12.95334"	75°41'50.98454"
37	1798/12-11	29°8'14.89808"	75°41'51.40607"
38	1798/9-10	29°8'16.36633"	75°41'50.88751"
39	1799/6-7	29°8'16.64844"	75°41'46.43849"
40	1799/15-14	29°8'15.01770"	75°41'46.35051"
41	1799/16-17	29°8'12.74179"	75°41'46.33198"
42	1799/25-24	29°8'11.51907"	75°41'45.92780"
43	1799/24-23	29°8'11.72029"	75°41'42.38070"
44	1799/17-18	29°8'13.15864"	75°41'42.69071"
45	1799/14-13	29°8'14.87429"	75°41'42.75702"
46	1799/7-8	29°8'16.09149"	75°41'42.29602"
47	1799/9-10	29°8'16.64768"	75°41'40.72729"
48	1799/12-11	29°8'15.02620"	75°41'39.68354"
49	1799/10 & 1800/6	29°8'14.76409"	75°41'34.82623"
50	1799/11 & 1800/15	29°8'16.57925"	75°41'34.53757"
51	1800/6-7	29°8'16.47391"	75°41'30.04166"
52	1800/15-14	29°8'15.16431"	75°41'29.48642"

53	1800/7-8	29°8'15.26009"	75°41'26.26669"
54	1800/14-13 1800/12	29°8'16.89074"	75°41'26.13181"
55	1800/22	29°8'11.92422"	75°41'26.62646"
56	1800/19	29°8'12.82674"	75°41'26.88186"
57	1800/18-19	29°8'12.83938"	75°41'29.76962"
58	1800/23-24	29°8'11.95780"	75°41'30.24551"
59	1800/25 & 1799/21	29°8'11.50077"	75°41'34.56004"
60	1800/16 & 1799/20	29°8'13.06103"	75°41'34.77963"
61	1799/19-20	29°8'12.46627"	75°41'38.67720"
62	1799/21-22	29°8'11.28535"	75°41'38.30404"
63	1817/2-3	29°8'09.33766"	75°41'43.18645"
64	1817/3-4	29°8'09.13794"	75°41'46.77910"
65	1817/4-5	29°8'09.94245"	75°41'51.81903"
66	1818/1 & 1818/10	29°8'08.86084"	75°41'54.67087"
67	1818/2 & 1818/9	29°8'08.01904"	75°41'56.58435"
68	1818/3 & 1818/8	29°8'07.57518"	75°42'00.17704"
69	1818/4 & 1818/7	29°8'09.36177"	75°42'04.63763"
70	1818/5 & 1818/6	29°8'06.25841"	75°41'05.37459"
71	1797/17 & 1797/24	29°8'13.80181"	75°42'09.83881"
72	1797/16 & 1797/25	29°8'13.52018"	75°42'15.90653"
73	1819/5-6	29°8'10.99739"	75°42'14.42457"
74	1819/15-16	29°8'09.10316"	75°42'15.45891"
75	1820/20 & 1820/11	29°8'07.73363"	75°42'16.85941"
76	1820/10 & 1820/1-2	29°8'09.32067"	75°42'17.84694"
77	1796/21-22	29°8'10.91280"	75°42'18.93278"
78	1796/19-20	29°8'13.17447"	75°42'17.46757"
79	1796/18	29°8'11.43171"	75°42'20.22162"
80	1796/23	29°8'11.81330"	75°42'20.77093"
81	1796/12	29°8'14.81076"	75°42'18.29098"
82	1796/9 & 1796/12	29°8'15.52488"	75°42'18.23763"
83	1796/9-10 & 1796/1-2	29°8'18.17017"	75°42'17.71617"

84	1797/3-5	29°8'18.22465"	75°42'14.86698"
85	1797/6-8	29°8'16.46698"	75°42'15.46025"
86	1797/13-15	29°8'15.34571"	75°42'15.25052'

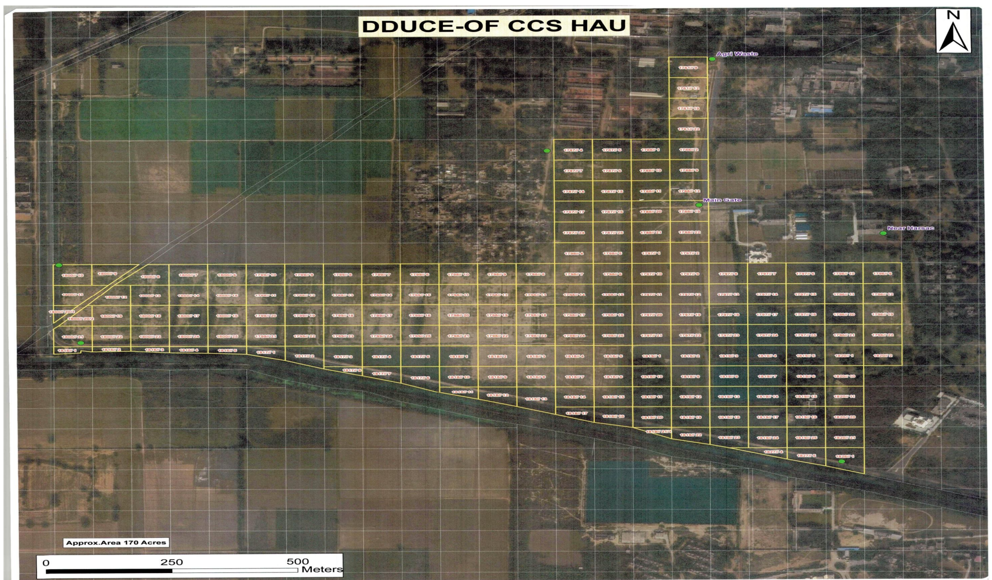


Figure 1: Base Map of DDUCE-OF, CCSHAU, Hisar (Haryana)

RESULTS AND DISCUSSION

Soil pH, Electrical Conductivity (EC) and Organic Carbon (OC)

The soil analysis data at 0-15 cm depth of DDUCE-OF revealed that the soil was sandy loam to loam in texture having pH of the farm ranged from 7.15 to 8.65 (1:2 Soil :Water) with average value of 7.97 in different samples (Table 2). The soil pH of four samples i.e. S.No. 39-42 were found alkaline in nature (>8.50). The soil pH of rest of the farm was neutral to slightly alkaline (<8.50). The electrical conductivity (EC, 1:2 Soil: Water) ranged from 0.30 to 2.75 dS/m. The EC <0.8 dS/m in twenty-six samples i.e. 5-9, 18, 19, 27-30, 72-86 of the farm was suitable for all the crops. In thirty-three samples i.e. 1-4, 10-17, 20-26, 31-40, & 68-71, it varied from 0.8 to 1.6 dS/m which is suitable for all the crops except pulses. The EC of the farm in seventeen samples i.e. S. No. 41-54 & S. No. 65-67 ranged from 1.6 to 2.5 dS/m which may be suitable for salt tolerant crops like barley only. In ten samples i.e. S. No. 55-64 of the farm, EC was higher than critical limit of >2.5 dS/m which may adversely affect the crop growth and corrected measures should be adopted. The soil organic carbon (SOC) was observed medium to high and ranged from 0.41 to 0.94% with average value of 0.60% in various samples of the farm (Table 1, Table 2 and Figure 2). Similar finding was reported by Sharma *et al.* (2014) and they reported that soil pH and EC were reduced and soil organic carbon increased in organic manured plots as compared to non-manured plots.

Comment [A6]: Discussion needs to be added by comparing with the latest studies in this field. not just the same or has been confirmed by previous research

Available Nitrogen (N), Phosphorous (P), Potassium (K) and Sulphur (S)

The initial nutrient status (Table 1, Table 2 and Figure 2) revealed that the available N ranged between 126 to 196 kg/ha in various blocks of organic farm. The status of available N was low (<250 kg/ha) in the all the tested samples of organic farm. The available P content ranged from 8.50 to 23.5 kg/ha. Thirty Nine (39) blocks of the farm i.e. S. No. 31-69 had low available P (<10 kg/ha), thirty seven (37) samples from S.No. 1-12, 21-30 and 70-85 were in medium range (10-20 kg/ha) whereas, it was high (>20 kg/ha) in nine (09) samples with the highest value of 23.5 kg/ha. The available K status was found medium to high and ranges from 128.5 to 554.0 kg/ha. The lowest and highest available K content of the farm was observed in the sample 50 and sample 81, respectively. The available S ranged between 60 to 725 mg/kg with average value of 265 mg/kg in various blocks of organic farm. The status of available S was observed sufficient in the all the tested samples of organic farm and the results are in conformity with Manjunatha *et al.* (2013) reported that available N, P and K of soil were found to be increased 143.31, 9.07 and 53.44 kg/ha from fifth to fifteenth year of organic farming practice.

Comment [A7]: Discussion needs to be added by comparing with the latest studies in this field. not just the same or has been confirmed by previous research

DTPA-extractable Micronutrients and Heavy Metals

The DTPA-extractable micronutrients Zn, Fe, Mn and Cu were sufficient in amount and heavy metal contents (Ni, Pb, Cd, Cr, As) were found below their permissible limit (Table 2, Figure 2). Similar results were observed by Dhaliwal *et al.* (2013) and Głodowska *et al.* (2017). They reported that DTPA extractable Zn and Fe content increased with the application of manures and heavy metals were lower in organic farming as compared to conventional farming.

Total Bacterial Count

The soil microbiological status of DDUCE-OF (Table 1 and Table 2) revealed that the bacterial count ranged between 4.6×10^{3} - 9.8×10^{9} CFU/g soil in various blocks of organic farm. The lowest and highest bacterial count of the organic farm was observed in the sample 48 and sample 71, respectively. Similarly, finding was reported by Maharjan *et al.* (2017) and they found that microbial biomass carbon and bacterial count were higher in the organic farming topsoil.

Comment [A8]: Discussion needs to be added by comparing with the latest studies in this field. not just the same or has been confirmed by previous research

Table 2. Range and mean value of initial soil properties of DDUCE-OF, CCS HAU, Hisar

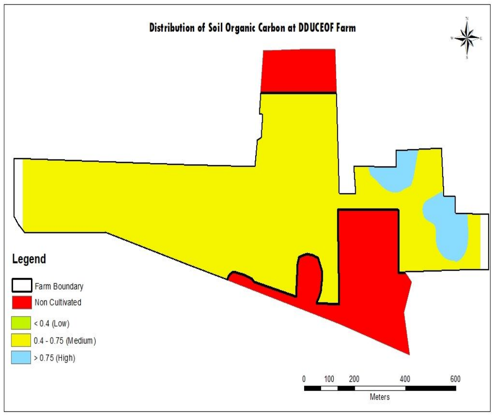
Properties	**Range**	**Mean**	**Critical limit/Permissible limit***
pH (1:2)	7.15-8.65	7.97	<6.5 (acidic), 6.5-7.5 (neutral), 7.5-8.5 (slightly alkaline), >8.5 (Alkali or Sodic soil)
EC (dS/m)	0.30-2.75	1.30	<0.8 (Suitable of all crops), 0.8-1.6 (Suitable of all crops except pulses), 1.6-2.5 (suitable for salt tolerant crops) >2.5 (Harmful to crops)
Organic Carbon (%)	0.41-0.94	0.60	<0.40 (low), 0.40-0.75 (medium), >0.75 (high)
Available N (kg/ha)	126-196	150	<250 (low), 250-500 (medium), >500 (high)
Available P (kg/ha)	8.50-23.5	12.8	<10 (low), 10-20 (medium), >20 (high)
Available K (kg/ha)	152.5-554.0	276	<104 (low), 104-249 (medium), >249 (high)
Available S (mg/kg)	60-725	265	<10 (deficient), >10 (sufficient)
Texture	40.00-44.70 Loam-Sandy loam	42.70	-
Total Bacterial Count (CFU Count per g of soil)	4.6x10^{3} - 9.8x10^{9}	-	-
DTPA-extractable Zn (mg/kg)	1.00-4.47	1.90	<0.6 (deficient), >0.6 (sufficient)
DTPA-extractable Fe	7.26-19.92	13.59	<4.5 (deficient), >4.5 (sufficient)

(mg/kg)			
DTPA-extractable Mn (mg/kg)	3.88-17.77	9.97	<2.5 (deficient), >2.5 (sufficient)
DTPA-extractable Cu (mg/kg)	0.93-4.64	1.92	<0.2 (deficient), >0.2 (sufficient)
DTPA-extractable Ni (mg/kg)	0.00-0.28	0.03	75 (low), 75-150 (medium), >150 (high)
DTPA-extractable Pb (mg/kg)	0.00-0.87	0.08	<250 (low), 250-500 (medium), >500 (high)
DTPA-extractable Cd (mg/kg)	0.10-0.29	0.21	3.0 (low), 3.0-6.0 (medium), >6.0 (high)
DTPA-extractable Cr (mg/kg)	Nil	Nil	50 (low), 50-100 (medium), >100 (high)
DTPA-extractable As (mg/kg)	Nil	Nil	-

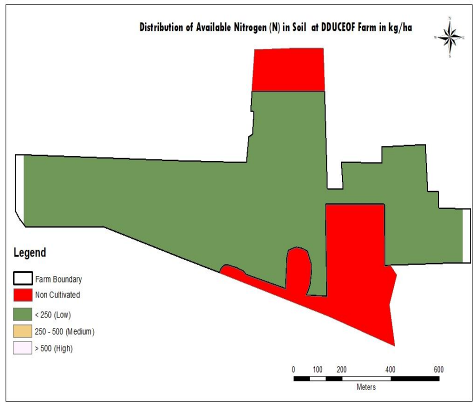
***Source: Indian Standards (1983) and Awashthi (2000), Awashthi (2000) and World Health Organization (1992) and European Union Limit (2002)**

CONCLUSIONS AND PERSPECTIVES:

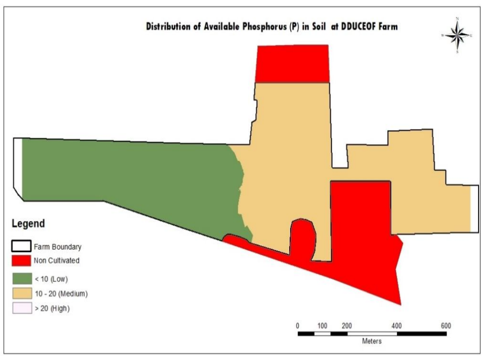
From the present findings, it can be concluded that the The GIS-based mapping provides an opportunity to assess variability in the distribution of nutrients and other yield limiting soil parameters across a large area. The spatial distribution and fertility mapping of the study area will aid farmers in making efficient management decisions based on their proper understanding of the conditions of existing soils under different land use. The study concluded that the soil mapping and survey is significant because it aids in the evaluation of soil qualities and their application in organic/natural farming.



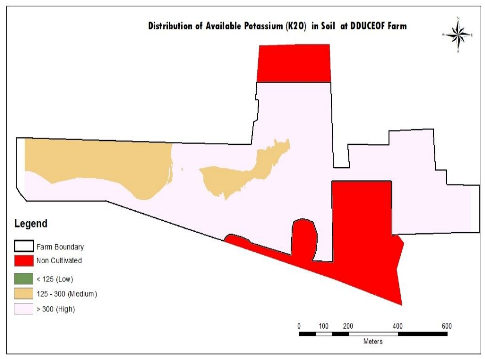
Distribution of Soil Organic Carbon at DDUCEOF Farm
Legend
Farm Boundary
Non Cultivated
< 0.4 (Low)
0.4 - 0.75 (Medium)
> 0.75 (High)
0 100 200 400 600
Meters



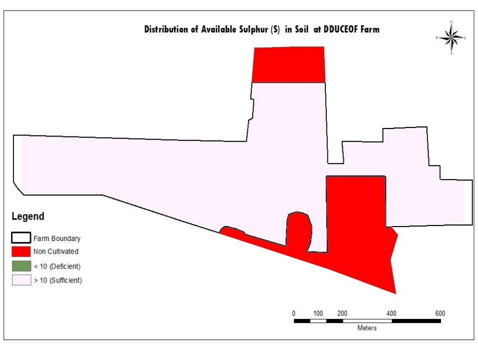
Distribution of Available Nitrogen (N) in Soil at DDUCEOF Farm in kg/ha
Legend
Farm Boundary
Non Cultivated
< 250 (Low)
250 - 500 (Medium)
> 500 (High)
0 100 200 400 600
Meters



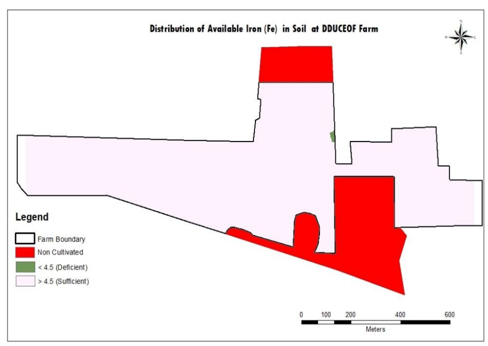
Distribution of Available Phosphorus (P) in Soil at DDUCEOF Farm
Legend
Farm Boundary
Non Cultivated
< 10 (Low)
10 - 20 (Medium)
> 20 (High)
0 100 200 400 600
Meters



Distribution of Available Potassium (K2O) in Soil at DDUCEOF Farm
Legend
Farm Boundary
Non Cultivated
< 125 (Low)
125 - 300 (Medium)
> 300 (High)
0 100 200 400 600
Meters



Distribution of Available Sulphur (S) in Soil at DDUCEOF Farm
Legend
Farm Boundary
Non Cultivated
< 10 (Deficient)
> 10 (Sufficient)
0 100 200 400 600
Meters



Distribution of Available Iron (Fe) in Soil at DDUCEOF Farm
Legend
Farm Boundary
Non Cultivated
< 4.5 (Deficient)
> 4.5 (Sufficient)
0 100 200 400 600
Meters

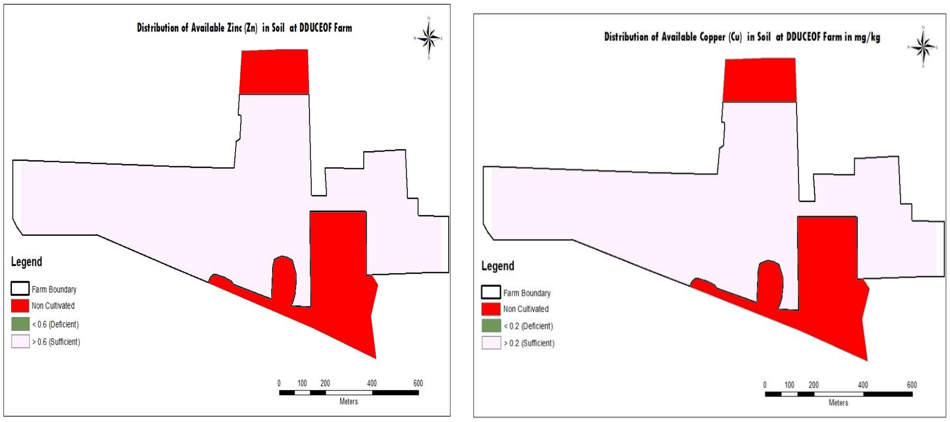


Figure 2. Spatial variability map of Soil Organic Carbon (SOC), Available NPKS and DTPA-extracable Iron (Fe), Zinc (Zn) and Copper (Cu) by DDUCE-OF

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Comment [A9]: very old

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