International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2022; 10(6): 103-110

Received: 13-09-2022
Accepted: 16-10-2022

Soil fertility mapping of instructional farm, college of agriculture and research station, Raipur, Chhattisgarh

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Abstract
A systematic set of geo-referenced samples was collected from Instructional Farm, College of Agriculture, district Raipur, Chhattisgarh covering the entire area using GPS (Global positioning system) and fertility status map was generated by integrating the individual nutrient map in Arc Map 10.3. A random sampling procedure was used to gather surface (0-15 cm) soil samples, yielding a total of 126 samples for analysis of soil chemical characteristics. Soil response (pH), electrical conductivity (EC), organic carbon (OC), available macro-nutrients (e.g. N, P, K, S), & DTPA-extractable micro-nutrients (e.g. Iron, Manganese, Copper, Zinc, and hot water extractable Boron) were all tested in the soil samples. The soil pH of the study region ranged from 6.51 to 7.78. It indicates that the pH of the soil is in the neutral to slightly alkaline range. The electrical conductivity found to be fall under the normal category with average value of 0.25 dS/m. Organic carbon in this soil was found to be around 0.38%. Available Nitrogen content was found between 163 to 278 kg ha^{-1}. The available Phosphorus content varied from 2.6 to 28.9 kg ha^{-1}. Available Potassium content ranged from 201.23 to 443.96 kg ha^{-1}. The available sulphur content ranged from 9.32 to 36.67 kg ha^{-1}. DTPA extractable micronutrient anions content was found that the Iron content varied from 4.1 to 31.4 mg kg^{-1}. The Manganese content ranged between 2.2 to 22 mg kg^{-1}. Copper content varied from 0.4 to 1.7 mg kg^{-1}. Zinc content ranged from 0.4 to 2.3 mg kg^{-1}. Hot- water soluble Boron content found to be between 0.1 to 0.8 mg kg^{-1}.

Keywords: Available nutrients, DTPA-extractable, GIS, soil fertility

Introduction
One of the most important variables influencing crop yields is soil fertility. In the context of sustainable agriculture production, soil characterization is critical for assessing the fertility status of an area's or region's soils. The response (production) efficiency of chemical fertilizer has decreased dramatically in recent years under intensive agriculture due to uneven and inadequate fertilizer application combined with low efficiency of other inputs.

Introduction of high yielding varieties (HYV) in Indian Agriculture in mid- sixties compelled the farmers to use high doses of NPK fertilizers along with micronutrient fertilizers. Present agricultural systems are exploitive of nutrients through intensive tillage, monocropping year after year, use of high yielding varieties, imbalanced use of nutrients coupled with limited use of organic manures, less recycling and burning of crop residues, soil erosion, undulated topography and indiscriminate use of irrigation water. Balanced use of organics, fertilizers and biofertilizers plays an important role to maintain soil fertility in long run. The availability of macro and micronutrients to plants is influenced by several soil characteristics. Land use pattern also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh *et al.* 2003) [4]. Similarly, different cropping systems are suitable for different soil groups as regards to production and productivity.

Materials and Methods
The study area was carried out at Instructional Farm, College of Agriculture and Research Station Raipur, District Raipur, Chhattisgarh is located at latitude 22°33'N and 21°14'N, and the longitudes of 82°6'E and 81°38'E with an altitude is 280 M.A.S.L. The farm has a total area of 71.24 acres, which is mainly Vertisols and Inceptisols soils. Surface soil samples (0-15 cm depth) were obtained from several instructional farm of IGKV, Raipur based on the handheld GPS device.

Total of 126 soil samples were obtained from the farm area for examination of soil chemical characteristics. The collected soil samples were air dried after grinding with wooden pestle and mortar, than sieved through 2 mm sieve, labelled and stored.

Soil pH was determined by glass electrode pH meter, electrical conductivity with Solu-bridge method as described by Black (1965) [15], organic carbon by wet digestion method (Walkley and Black's, 1934) [5]. Available nitrogen was estimated by alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [6], Available phosphorus extracted by 0.5M $NaHCO_3$ solution buffer at pH 8.5 (Olsen *et al*., 1954) [11] was used for neutral alkaline soils. Available potassium was estimated through neutral normal ammonium acetate by flame photometer (Jackson, 1967) [7]. Available sulphur was extracted from the soil using 0.15 per cent $CaCl_2$ extractable method using Spectrophotometer at 420 nm. The micronutrients (Zn, Cu, Fe and Mn) were extracted with 0.005M diethylene triamine penta acetic acid (DTPA), 0.01M calcium chloride dehydrate and 0.1M triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) [8] and concentrations were analyzed by atomic absorption spectrophotometer 4129. Hot water soluble method was used for boron analysis. Azomethane-H and EDTA were utilised as buffering solutions in this approach. The extracted aliquot's B content was evaluated using a spectrophotometer.

The formula of nutrient index (NI) and classification of available nutrients as low (<1.66), medium (1.67-2.33) and high (>2.34) as suggested by Parker *et al.* (1951) [12] was evaluated as follows: Nutrient index = [(1 × samples in low category) + (2 × samples in medium category) + (3 × samples in high category)]/Total no. of samples.

The values (deficient, sufficient or high) were tagged with each geo referenced point. Soil fertility maps were prepared using ARC GIS version 10.3 (Sharma *et al.* 2006; 2008) [1] employing kriging as the interpolation method. The ratings employed for different fertility parameters are presented in table 1.

Table 1: Soil Fertility ratings for available nutrients

Classification for soil pH values							
Classes	**Strongly acidic**	**Moderately acidic**	**Slightly acidic**	**Neutral**	**Slightly alkaline**	**Moderately alkaline**	**Strongly alkaline**
Range	< 4.5	4.5 - 5.5	5.5 – 6.5	6.5 – 7.5	7.5 – 8.5	8.5 – 9.5	> 9.5
Classification for total soluble salt content (EC in dS m^{-1})							
Low			**Medium**	**High**		**Very high**	
< 1			1.0 – 2.0	2.0 – 3.0		> 3.0	
Rating of Chemical Soil Parameters							
Soil Parameters			**Low**		**Medium**	**High**	
Organic C (%)			<0.5		0.5-0.75	>0.75	
Available N(kg/ha)			<280		280-560	>560	
Available P(kg/ha)			<12.5		12.5-25	>25	
Available K(kg/ha)			<135		135-335	>335	
Available S(kg/ha)			<22.5		22.5-35	>35	
DTPA extractable Fe (mg/kg)			<4.5		4.5-9.0	>9.0	
DTPA extractable Mn (mg/kg)			<3.5		3.5-7.0	>7.0	
DTPA extractable Cu (mg/kg)			<0.2		0.2-0.4	>0.4	
DTPA extractable Zn (mg/kg)			<0.6		0.6-1.2	>1.2	
Hot water soluble B (mg/kg)			<0.5		0.5-1.0	>1.0	

Results and Discussion

Here, in table: 2 the depicted values are obtained through laboratory analysis of all soil samples collected from instructional farm of IGKV, Raipur for evaluation of fertility status.

Soil reaction

The soil pH of the study region ranged from 6.51 to 7.78, it indicates that the pH of the soil is in the neutral to slightly alkaline range. Majority of soil samples (94.44%) had a neutral soil reaction, while the remaining 5.56% had a slightly alkaline reaction (Table 2). The findings were also represented as a soil fertility map (Fig: 2). It might be due to barren nature of the field with Vertisols dominant soil (Mandal *et al*., 2018) [2].

Electrical conductivity

The electrical conductivity of the soil water suspension ranged from 0.15 to 0.52 dS/m in soil of study area with a mean value of 0.25 dS/m. Most of the 100% collected soil samples fall under normal E.C. (<1.0 dS/m) category (Table 2). It indicated that there is no soil limitation for crop production from soluble salt content in soil. Based on the soil EC test results from the KVK, horticultural, and instructional farms of IGKV, Raipur, a GIS-GPS based soil thematic map was also created (Fig: 3). Similar results were also reported by like Balakrishna *et al*., 2017 [3] in Palari Block soil and Dameswar *et al*., 2017 [9] in Kasdol Block soil in Chhattisgarh.

Organic carbon

Organic Carbon content in study area ranged from 0.15 to 0.63% with a mean value of 0.38%. From all collected soil samples 85.71% of the 126 samples gathered had a poor rating, while the remaining 14.29% had a medium fertility category (Table 3). The findings were also represented in a fertility map (Fig. 4) with standard limitations. It may be ascribed due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature (Sathish *et al*., 2018) [13].

Available nitrogen

Available N content in soil of study area ranged from 163 to 278 kg ha^{-1} with mean value of 202.39 kg ha^{-1}. It has been revealed that 100% of the study area was deficient in available N (Table 3). The available soil N analysis result was also represented in a soil fertility map (Fig:5) with standard limitations. The Nutrient Index (N.I.) value for N fertility was discovered to be 1 and hence falls into the low N.I. range because all of the soil samples had a low rating for available N. It may be ascribed to the nitrogen is lost through various mechanisms like ammonia volatilization, nitrification, chemical and microbial fixation, leaching, runoff and these soils had a very low content of organic carbon. (Vaisnow *et al*., 2010) [14].

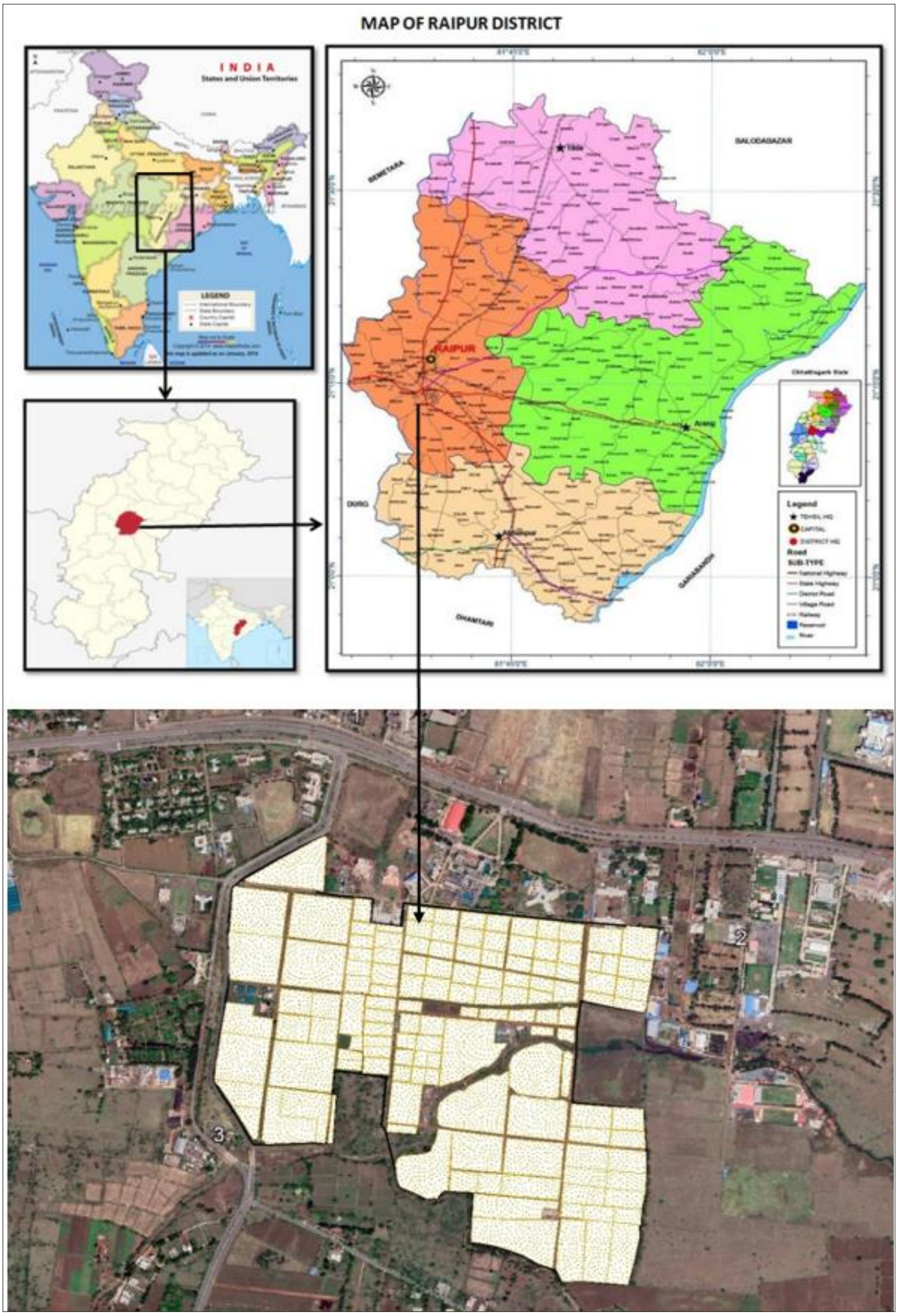

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Fig 1: Location of Instructional farm, IGKV, Raipur (Chhattisgarh)

Available phosphorus

Available P content in the study area found to be varied from 2.60 to 28.9 kg ha^{-1} with average content of 16.21 kg ha^{-1}. It was revealed that 24% samples fall under deficient category, 72% samples in medium range and 4% falls under high range of available P content (Table 3) which can be observed in the fertility map (Fig: 6). The Nutrient Index (N.I.) value for phosphorus fertility was found to be 1.80, putting it in the medium N.I. range. It might be due to the mostly affected by past fertilization, pH, Organic matter content, texture various soil management and agronomic practices (Balakrishna *et al*., 2017) [3].

Table.2 Salient soil properties of study area

Soil Characteristics	Range	Average	Standard Deviation
pH	6.51 - 7.78	7.04	0.280
EC (dS/m)	0.15 - 0.52	0.25	0.067
OC (%)	0.15 - 0.63	0.38	0.107
N (kg/ha)	163 – 278	202.39	22.639
P (kg/ha)	2.6 - 28.9	16.21	5.609
K (kg/ha)	201.23 - 443.96	296.42	54.50
Fe (mg/kg)	4.1 - 31.4	10.66	4.986
Mn (mg/kg)	2.2 – 22	7.09	3.266
Cu (mg/kg)	0.4 - 1.7	0.92	0.290
Zn (mg/kg)	0.4 - 2.3	1.04	0.395
S (kg/ha)	9.32 - 36.67	22.16	7.767
B (mg/kg)	0.1 – 0.8	0.28	0.160

Available potassium

Soil available K status ranged from 201.23 to 443.96 kg ha^{-1} with mean value of 296.42 kg ha^{-1}. As 82% samples falls into the medium category and the remaining 18% samples fall into the high category (Table 3), indicating no K deficient area within the study area. The data was also used to create a soil fertility map (Fig: 7). The nutrient index for K fertility was found to be 2.10, which falls into the medium category. These findings matched those of Balakrishna (2017) [3] in the Palari block.

Available sulphur

Available S status was found to be ranged between 9.32 to 36.67 kg ha^{-1} with a mean content of 22.16 kg ha^{-1}. Also it was found that out of all collected samples 56.34% were classified as low, 39.68% as medium, and the remaining 3.98% as sufficient (Table 3). Sulphur fertility was discovered to have a nutrient index value of 1.47, which is in the low range. For a better understanding of geographical variation in nutrient status, these findings were displayed in a GIS-GPS based soil fertility map (Fig: 8). These findings are also consistent with Goswami *et al*. research (2014).

Available boron

Hot water extractable B content in the study area found to be ranged between 0.10 to 0.80 mg kg^{-1} with a mean value of 0.28 mg kg^{-1}. Out of 100% samples collected 88.88% samples reported in deficient and rest 11.12% samples in sufficient B content category (Table 3). The result was also processed into a soil fertility map (Fig: 9). These findings were consistent with Kumar's (2014) findings.

DTPA extractable micronutrients

Available Fe content in the study area found to be ranging from 4.1 to 31.4 mg kg^{-1} with mean value of 10.66 mg kg^{-1}. The majority of soil samples were determined to be sufficient (61.90%), with the remaining 37.30% in the high range and 0.8% in the poor deficient range (Table 3). The findings were also represented as a soil fertility map (Fig: 10).

Available Mn content found to be within 2.2 to 22 mg kg^{-1} with a mean value of 7.09 mg kg^{-1} of soil in the study area. Out of 126 samples collected, 57.14% fall into the sufficient fertility category, while the remaining 38.09% and 4.77% fall into the high and insufficient Mn fertility categories, respectively (Table 3). Based on the test results for soil available Mn of the farm using standard limits, a GIS-GPS based soil thematic map was also created (Fig: 11). These findings were also supported by previous research by various researchers, such as Balakrishna (2017) [3] and Dameswar (2017) [9].

Available Cu content in study area found to be ranges from 0.4 to 1.7 mg kg^{-1} with a mean value of 0.92 mg kg^{-1}. There were no samples in the low rating category among the 126 samples collected, 1.59% samples were sufficient, and the remaining 98.41% samples were in the high rating category (Table 3). The results were also represented in a fertility map (Fig: 12) with standard limits. These findings matched those of Jatav (2010) [10] in the soil of the Baloda block in Chhattisgarh.

Available Zn content in study area found to be ranges from 0.40 to 2.30 mg kg^{-1} with a mean value of 1.04 mg kg^{-1}. Also it was found that 74.60% samples were in sufficient and 25.40% samples in high fertility category (Table 3). The studied soil Zn result was also shown in a soil fertility map (Fig: 13) with standard limitations.

Table 3: Overall fertility classes based on the NIV of nutrients of the soil

S. No.	Soil Characteristics	Range	Average	% Samples Category			NIV	Fertility Class
				Low	Medium	High		
1	OC (%)	0.15 - 0.63	0.38	85.71	14.29	0	0.90	Low
2	N (kg/ha)	163 - 278	202.39	100	0	0	1.00	Low
3	P (kg/ha)	2.6 - 28.9	16.21	23.80	72.22	3.98	1.80	Medium
4	K (kg/ha)	201.23 - 443.96	296.42	0	81.75	18.25	2.10	Medium
5	S (kg/ha)	9.32 - 36.67	22.16	56.34	39.68	3.98	1.47	Low
6	Fe (mg/kg)	4.1 - 31.4	10.66	0.80	61.90	37.30	2.36	High
7	Mn(mg/kg)	2.2 – 22	7.09	4.77	57.14	38.09	2.33	Medium
8	Cu (mg/kg)	0.4 - 1.7	0.92	0	1.59	98.41	2.98	High
9	Zn (mg/kg)	0.4 - 2.3	1.04	0	74.60	25.40	2.25	Medium
10	B (mg/kg)	0.1 – 0.8	0.28	88.88	11.12	0	1.11	Low

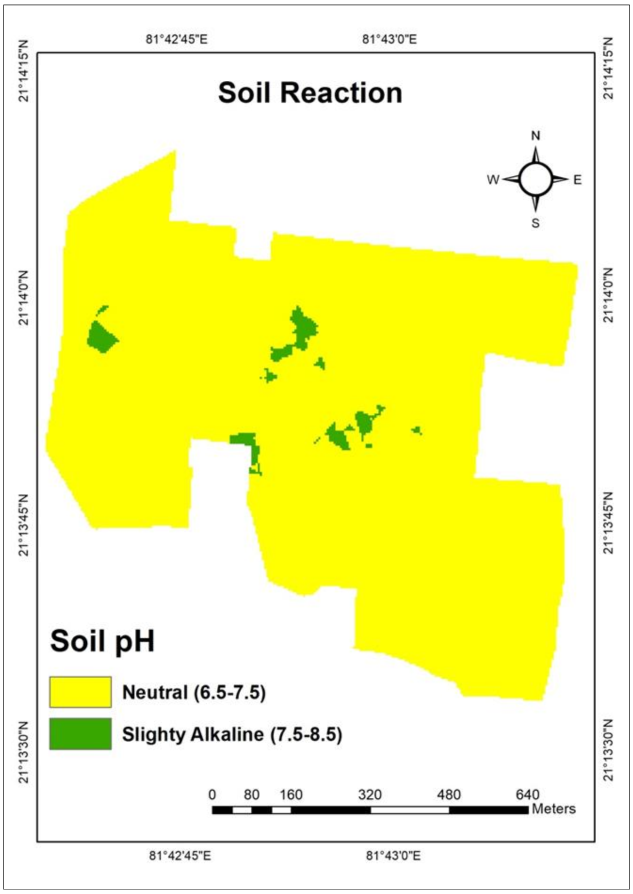


Fig 2: Status of Soil pH in Instructional Farm

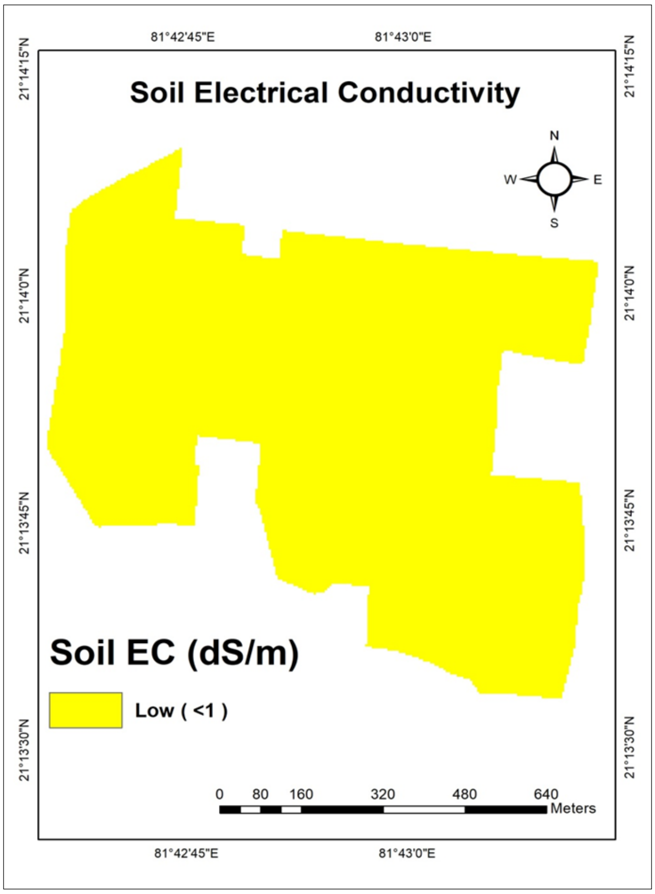


Fig 3: Status of Soil Electrical Conductivity in Instructional Farm

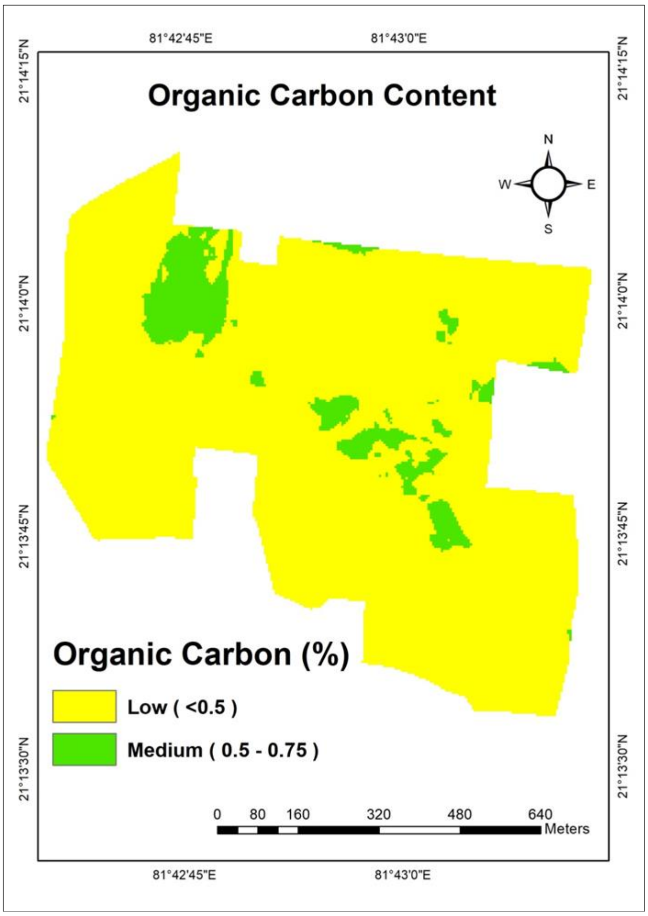


Fig 4: Status of Soil Organic Carbon in Instructional Farm

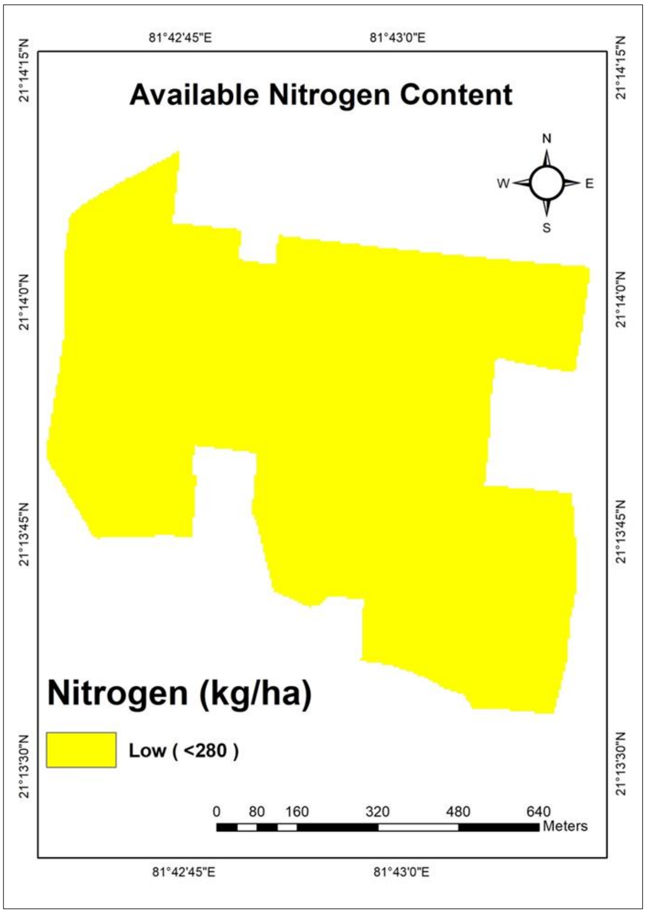
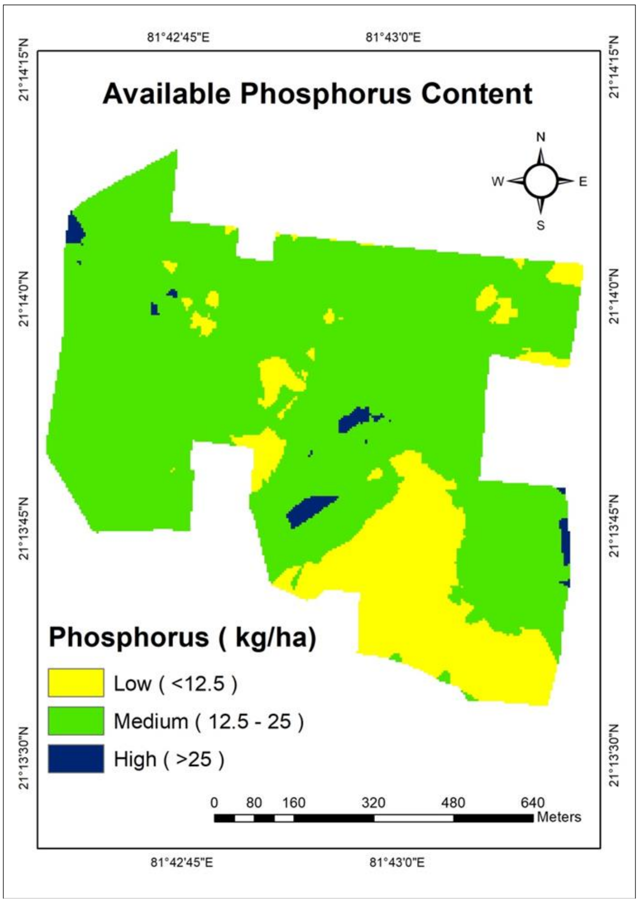


Fig 5: Status of Soil Available Nitrogen in Instructional Farm



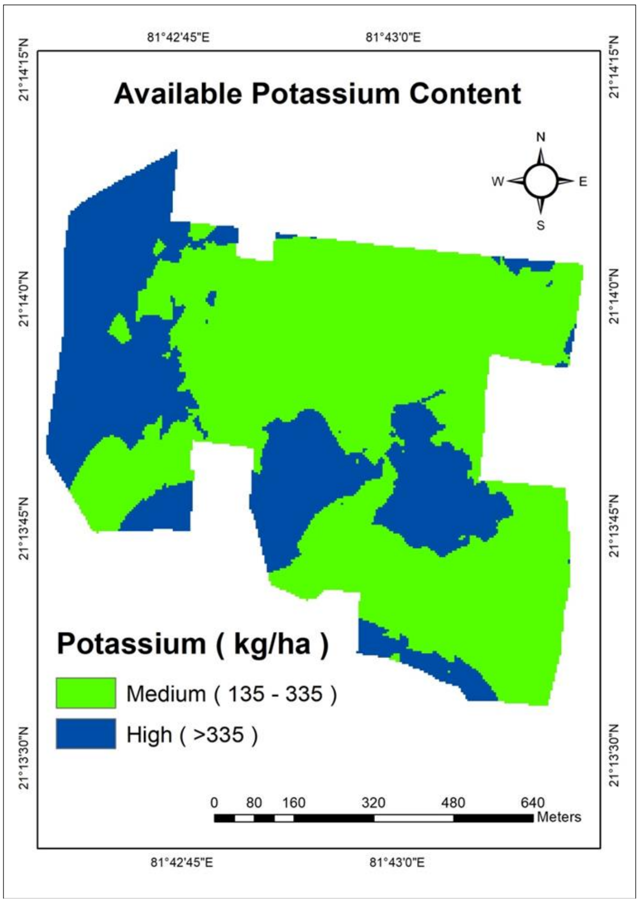
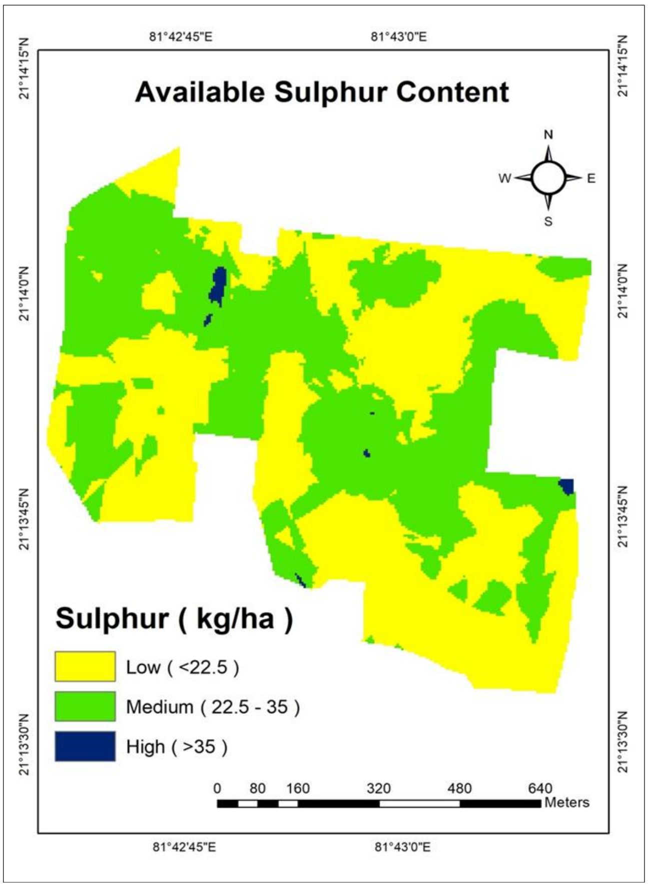


Fig 6: Status of Soil Available Phosphorus in Instructional Farm

Fig 7: Status of Soil Available Potassium in Instructional Farm



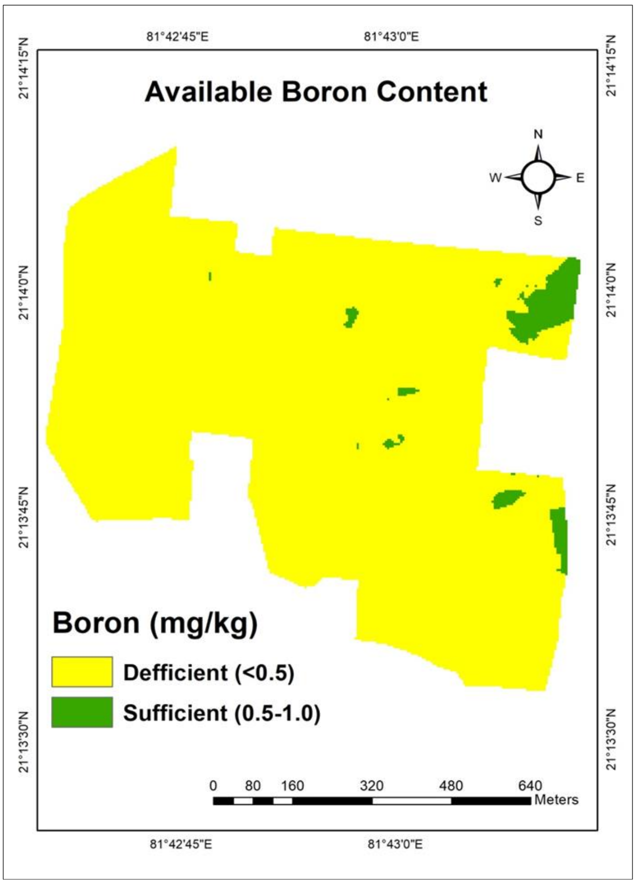
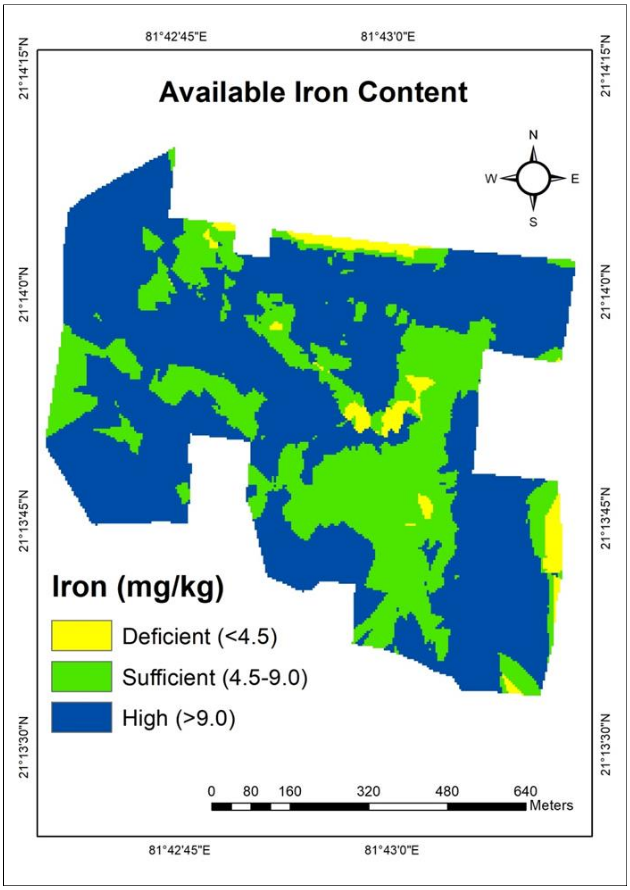


Fig 8: Status of Soil Available Sulphur in Instructional Farm

Fig 9: Status of Hot water soluble Boron in Instructional Farm



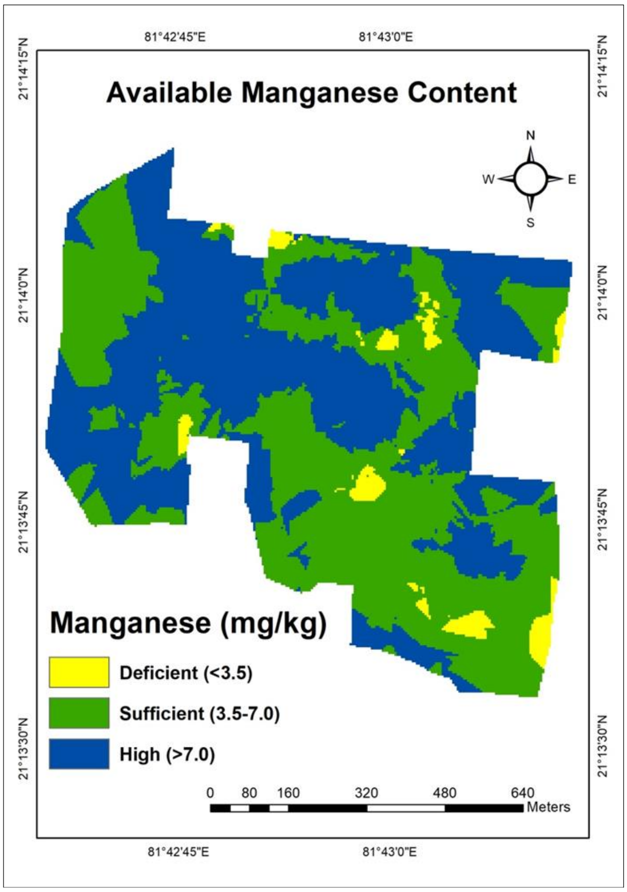
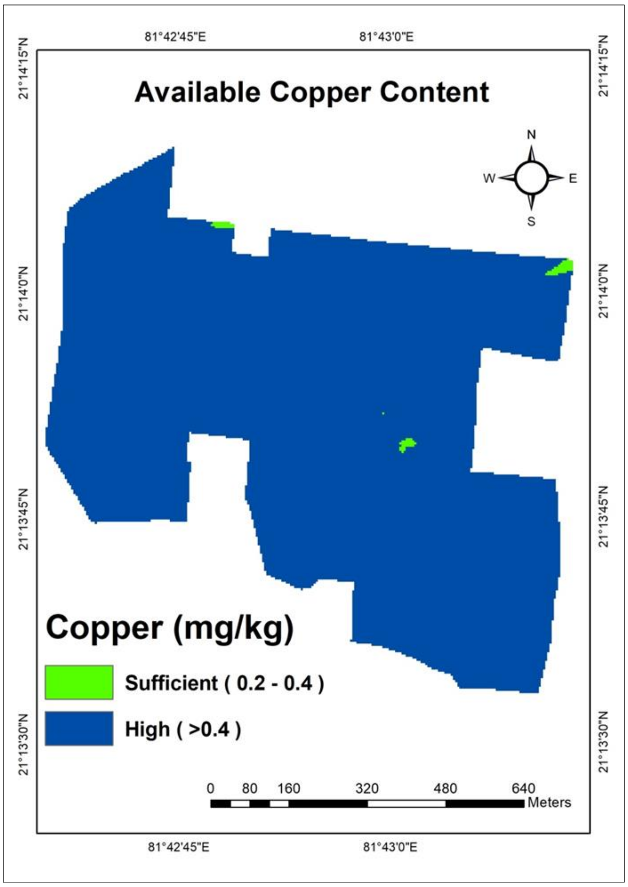


Fig 10: Status of DTPA extractable Iron in Instructional Farm **Fig 11:** Status of DTPA extractable Manganese in Instructional Farm



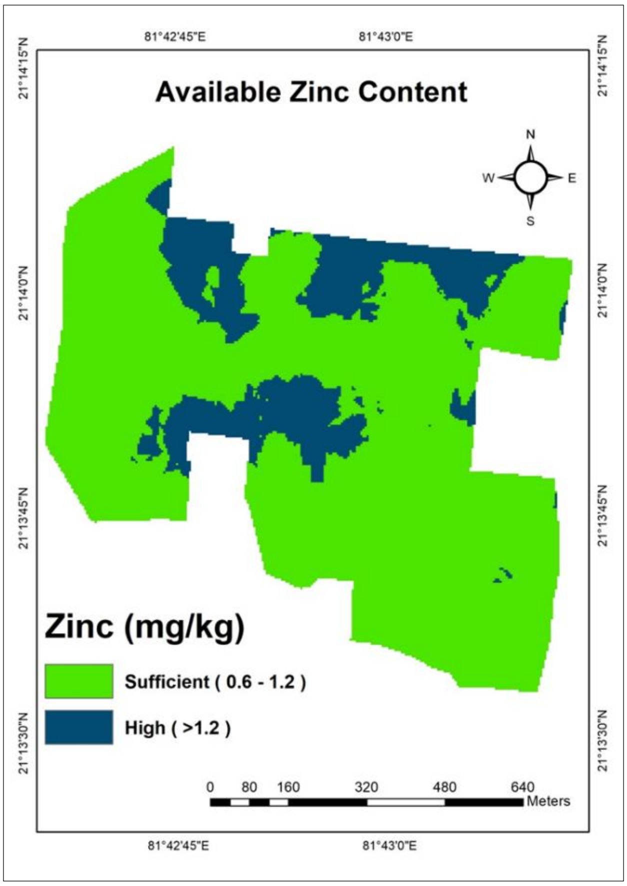


Fig 12: Status of DTPA extractable Copper in Instructional Farm **Fig 13:** Status of DTPA extractable Zinc in Instructional Farm

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