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Evaluation of macronutrient status of soil and soil fertility mapping of college of agriculture and research station, Kanpa, Mahasamund, Chhattisgarh

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Abstract

The present investigation was conducted to evaluate the soil fertility status of Research farm of College of Agriculture and Research Station, Kanpa, Mahasamund, Chhattisgarh. Total 77 soil surface samples (0-15cm) were taken from each plot and analyzed soil pH, EC, OC, available macronutrient N, P, K and S. Soil fertility map was prepared by using GPS, Arc GIS 10.3 Software used with kriging technique. The available nutrients were categorized into different fertility class and the fertility status of the research area were reported on basis of nutrient index value. The findings demonstrated that the pH of the soil varied from 5.62 to 7.36, that the soil reaction revealed the soils to be slightly acidic. EC with a range of 0.04 to 0.22 and a mean of 0.09 for soil water suspensions, the study area's soils were found to be acceptable for all types of crops. With a mean value of 0.50 g/kg, the OC ranged from 0.32 to 0.67, indicating that 53 percent of soils have a low to medium category of organic carbon. The available N content of the majority of the soil samples was found to be low; it ranged from 125 to 238, with a mean of 173 kg/ha. The available phosphorus ranged from 4.02 to 11.9 which is found low, the available potassium ranged from 214 to 359, which is in medium category. The available Sulphur varied from 22.2 to 44.78 with mean 31.67 kg/ha which is in medium category. NIV categorized the research area's soils into low fertility classes for nitrogen, phosphorus; medium fertility classes for sulphur, potassium. All soil comes under low category for available Nitrogen (100%), low in available phosphorus (100%) and medium in K (95%). Hence 25% of additional dose of nitrogen and phosphatic fertilizer and RDF for K is recommended along with recommended dose of fertilizer for major crops in that area.

Keywords: Soil fertility, macronutrient, NIV, GPS, ArcGIS, Kriging

Introduction

Soil is one of the most ubiquitous and underappreciated substance on Earth. Yet in several fascinating ways this miraculous substance holds the key to life. Soils perform vital functions to sustain plant and animal life, regulate water flow, filter and buffer pollutants, cycle nutrients and provide physical stability and sort. It is the soil that dictates how survival, nourishment and livelihood of mankind are moving. soil is a natural body comprised of solids, liquids and gases that occurs on the land surfaces, occupies space, and is characterized by one or both of the following: horizons or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. The term "soil fertility" describes the soil's inherent capacity to supply macro and micronutrients needed for crop production. The results of the physical, chemical, and biological studies reveal how well the soil can supply mineral nutrients (Ganorkar and Chinchmalatpure, 2013) [4]. Soil quality plays a critical role, especially considering the ongoing soil degradation caused by various factors. Balanced fertilization involves providing plants with the required nutrients in the correct quantities and proportions, at the appropriate times, and using the most effective methods and timing based on crop and agronomic conditions (Goovaerts, 1998) [5]. Fertility evaluation is a critical tool for effective planning of a specific land-use system (Havlin *et al*., 2019) [7]. Among the various methods, soil testing is the most widely used and universally applicable approach.

It remains the key instrument for planning and managing land use effectively. Laboratory soil analysis is a valuable tool for determining the nutrient levels in the soil. The nutrients that are present in the soil can also be found out through soil testing. This serves as the cornerstone for fertilizing crops with nutrients to increase yield. When applied to the research farm of College of Agriculture and Research Station, Mahasamund, Chhattisgarh soil fertility assessment becomes even more significant because it impacts the farmer's choice to adopt new farming methods and alternative crop varieties.

Methods and Materials

Study area

The study was carried out research farm of CARS, Kanpa, Mahasamund (Fig. 1) which is located in eastern part of Chhattisgarh with 21.1 N latitude and 82.1 E longitude. Soil samples up to a depth of 15 cm were collected using the random sampling method with the help of soil auger and local spade, each sample was properly labeled. The collected samples were air-dried, gently crushed using a wooden rod, passed through a 2 mm sieve and stored in labeled plastic bags for further laboratory analysis following standard procedures. Soil pH was measured using a glass electrode pH meter as per piper (1967) [14] and electrical conductivity was assessed using the Solu-bridge method (black, 1965) [2]. Organic carbon content was estimated by the Walkey and Black method (1934) [20]. Available nitrogen was determined using the alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [19] while available phosphorus was measured using 0.5 M $NaHCO_3$ as descried by Olsen (1954) [13]. Available potassium was analyzed using the neutral ammonium acetate method (Hanway and Heidal, 1952) [6].

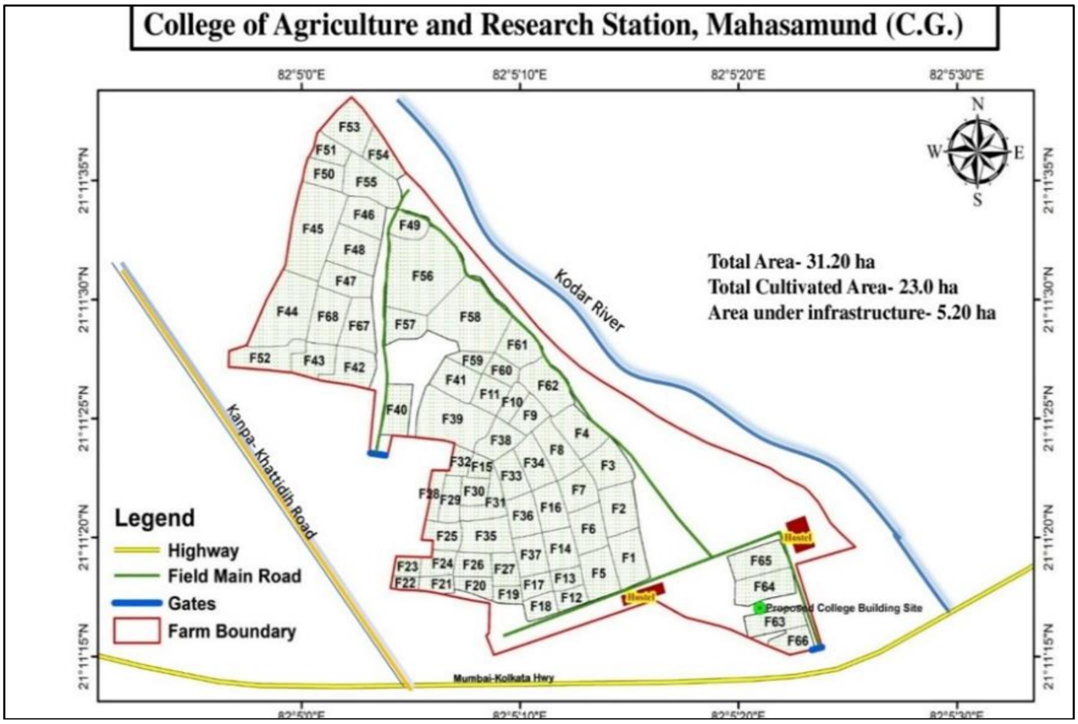

Fig 1: Study area: CARS, Kanpa, Mahasamund (C.G)

Table 1: Soil parameters and methods adopted for laboratory analysis.

S. No.	Parameters	Methods
1.	Soil pH	Glass electrode method (1:2.5) by Piper 1967 [14]
2.	Electrical conductivity	Conductivity bridge method by Black (1965) [2]
3.	Organic Carbon	Rapid titration method by Walkley and Black (1934) [20]
4.	Available Nitrogen	An alkaline potassium permanganate ($KMnO_4$) by Subbiah and Asija (1959) [19]
5.	Available Phosphorus	Olsen modified method by Olsen (1954) [13]
6.	Available Potassium	Ammonium acetate method by Hanway and Heidal (1952) [6]
7.	Available Sulphur	Turbidimetric method by Williams and Steinberg (1969)

Soil rating of chart

Table 2: The Rating of Available Macronutrient Status

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	22.5-45	>45

The Nutrient Index values and fertility classes

According to Parker, the Nutrient Index Value (NIV) for various soil characteristics is calculated based on the proportion of soil samples falling into low, medium or high nutrient availability categories. These categories help in classifying the soil into different fertility levels. The formula used for calculating NIV is

$$NIV = \frac{1 \times PL + 2 \times PM + 3 \times PH}{100}$$

Where,
NIV = nutrient index value
PL =% samples fall under low category
PM =% samples fall under medium category
PH =% samples fall under high category

Table 3: Nutrient index values for nutrients

NIV for the Nutrient	Fertility class (based on NIV)		
	Low	Medium	High
Macronutrients (N, P, K and S)	<1.67	1.67-2.33	>2.33

Results and Discussion

Soil reaction

Soil reaction determines for the physical state, microbial activity, salinity, alkalinity, nutrient availability and intrinsic interactions of the soil with other elements. Soil reaction (pH) of the collected soil samples, with a mean value of 6.23, ranging from 5.36-7.36 (as in Table 4). Results shows that 70.5% of the total soil samples fell into the slightly acidic category (<6.5), 29.5% in the neutral category (6.5-7.5) (Fig 2). This led to the conclusion that almost all of the study area's soils react between being slightly acidic to neutral. This indicate that soil reaction is greatly affected by landforms due to washing out of base cations from upper land situation and its accumulation at low-lying areas. The results are in close agreements with the findings of Iyer *et al*. (2019) [8].

Soil electrical conductivity (dS/m)

The electrical conductivity of the soil water suspension ranged from 0.04 to 0.22 d S/m with a mean value of 0.09 d S/m (as in Table 4). All the soil samples fall under the normal range (<1.0 d S/m) (fig.3). Results indicated that the soils of study area safe for growing of all types of crops. The very less EC value of area may be ascribed to extensive leaching of all soluble salt to deeper layer and runoff losses from surface soil layer. The results were supported by the research work done previously by Meher *et al*. (2020) [12], in the soils of Pahanda, Durg district in Chhattisgarh state.

Soil organic carbon (%)

The variations in the soil organic carbon content were 0.32 to 0.67% with an average of 0.50% (as in Table 4). Out of all the soil samples, majority of the soil samples i.e. 54% were found to be in medium in OC, 46% samples in low organic carbon status and no samples fall in high OC category (fig. 4). The soil carbon content was found to be medium to low in the study area which may be due to high temperature that enhanced oxidation of native organic matter and carbon and also low rates of organic matter additions in soils. Similar results were also supported by Singh *et al*., (2018) [16], Kumar *et al*., (2017) [11] and Dadsena *et al*. (2021) [3].

Table 4: Salient Findings of the Soil Properties Analysis

Sl. No	Parameter	Range	Mean	Standard deviation
1	pH	5.36-7.36	6.23	0.49
2	EC (dS/m)	0.04-0.22	0.09	0.034
3	Organic Carbon (%)	0.32-0.67	0.50	0.092
4	Available nitrogen(kg/ha)	125-238	173.6	37.91
5	Available phosphorus(kg/ha)	4.02-11.9	7.06	2.11
6	Available potassium(kg/ha)	214-359	276.6	30.14
7	Available sulphur(kg/ha)	22.2-44.78	31.67	5.22

Available nitrogen (N) Status in Soil

The available Nitrogen content in the soil samples ranged from 125-238 kg/ha with a mean value of 173.6 kg/ha (as in Table 4). Most of the soil samples were found in low nitrogen status (fig.5). It can be noted that the whole area seems N deficient which might be due to the fact that these soils were poor organic C content which is biggest source of N. It can also be due to the extensive leaching and runoff losses of various form of N, a tropical environment is its high temperature which leads to rapid loss of soil organic matter due to volatilization. The similar results were supported by Singh *et al*. (2019) [17].

Available phosphorus (P) status in soil

According to the Olsen's method, the available phosphorus status in 77 samples ranged from 4.02 to 11.9kg/ha, with an average value of 7.06 kg/ha (as in Table 4). All the soil samples are found in the low range (fig. 6) Because continuous cropping without sufficient P fertilization, low organic matter content, cold or wet soil conditions, high concentrations of iron, soil compaction, and poor soil moisture or aeration. This means that in order to meet the nutritional needs of normal crops, the soil solution must be refilled numerous times during the growing season. This result is also supported by M.J. Alam *et al*. (2024) [1]

Available potassium (K) status in soil

The available potassium of study area ranged from 214 to 359 kg/ha, with a mean value of 276.6 kg/ha (as in Table 4). Results showed that samples fell into the medium and high categories as 94% and 6%, respectively (fig. 7). As 73 samples fall in medium category and rest 4 samples are in high category. It tends to adsorb onto negative surface sites and trap K within the clay lattice. However, it releases these potassium as the external potassium reserve is exhausted, preserving a healthy potassium pool that meets with plant requirements. Other factors like fertilization and reserves from parent material could also be at contribute. Similar results indicated that the soils had high K levels. The results were similarly consistent with research conducted in the high fertility range soils of Raipur district, Chhattisgarh, by Shrivastava *et al*. (2016). These findings also supported by Shukla (2011) [15] and Jatav (2010) [10].

Available sulphur (S) status in soil

The mean value of the sulphur status was 31.67 kg/ha, ranging from 22.2 to 44.78 kg/ha (as in Table 4). It was seen that 99% of the samples had comes under medium sulphur rating and rest under low rating (fig. 8). The study found that the region's low and medium levels of accessible sulphur might be the result of continuous usage of sulphur-free fertilizers, which are brought on by crop removal of sulphur and the lack of additional sulphur. But even in black soils with medium to high organic content, the breakdown of organic matter and the mineralization process frequently happen too slowly to meet the crop's sulphur requirements. Iyer *et al*. (2020) found that the accessible sulphur content in the soils of the Dharmaur watershed in the Jagdalpur block of the Bastar district of Chhattisgarh state was generally low to medium.

Table 5: Overall fertility classes based on the NIV of nutrient in soils of study area

S. No.	Soil character ristics	Range	Mean	% samples Category			NIV	Fertility class
				Low	Medium	High		
1.	N (kg/ha)	125-238	173.6	100%	0%	0%	1	LOW
2.	P(kg/ha)	4.02-11.9	7.06	100%	0%	0%	1	LOW
3.	K(kg/ha)	214-359	276.6	0%	94%	6%	2.06	MEDIUM
4.	S(kg/ha)	22.2-44.78	31.67	1%	99%	0%	1.99	MEDIUM

Soil fertility maps for pH, EC, OC and Macronutrients

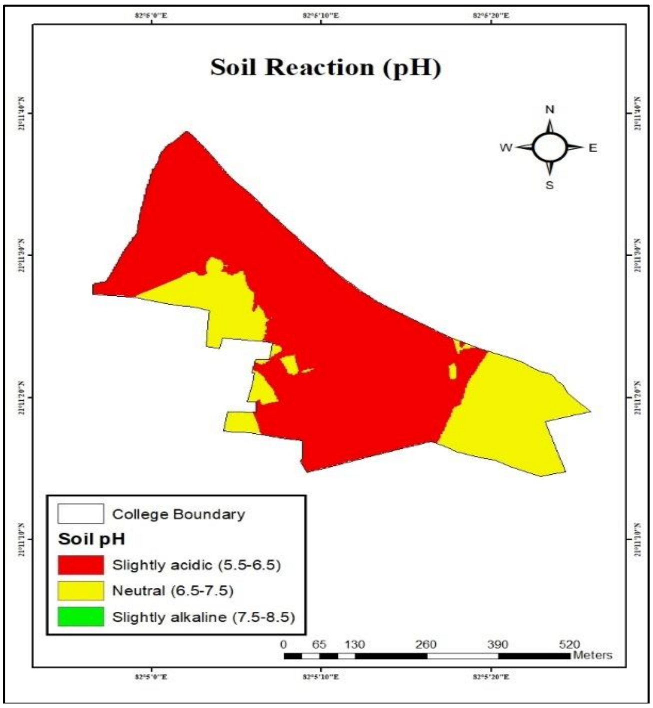

Fig 2: Spatial distribution of soil reaction (pH)

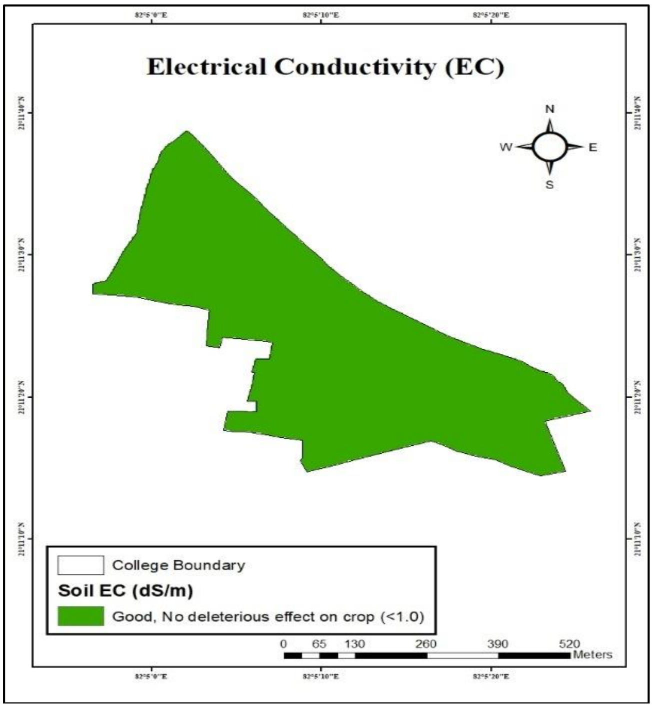

Fig 3: Spatial distribution of electrical conductivity (EC)

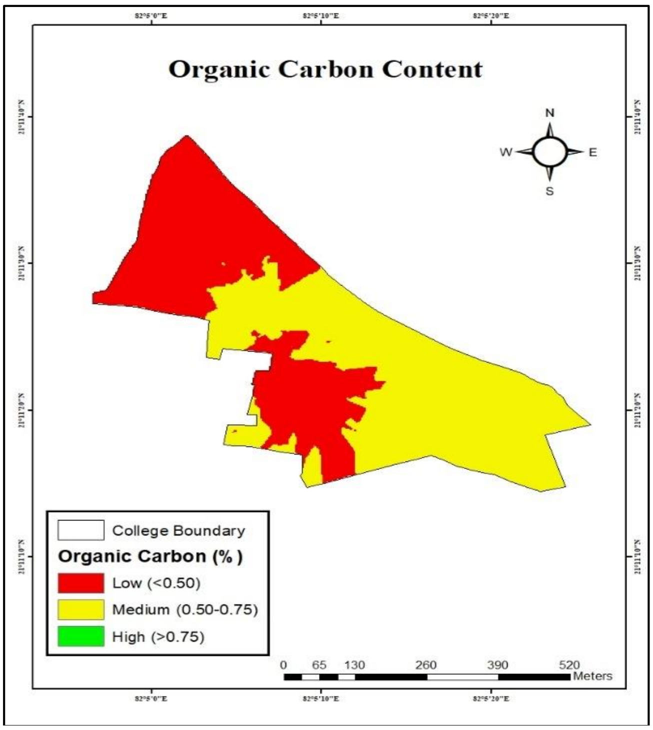

Fig 4: Spatial distribution of soil organic carbon

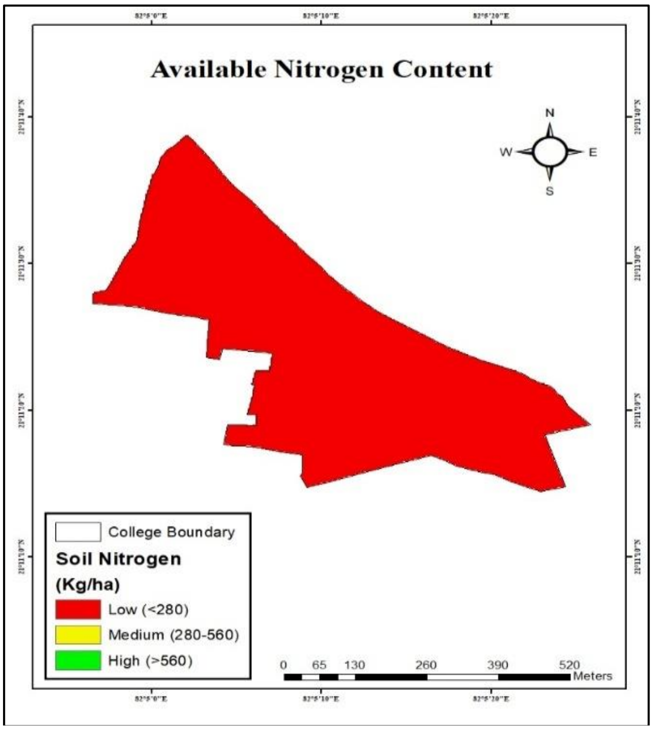

Fig 5: Spatial distribution of soil available Nitrogen

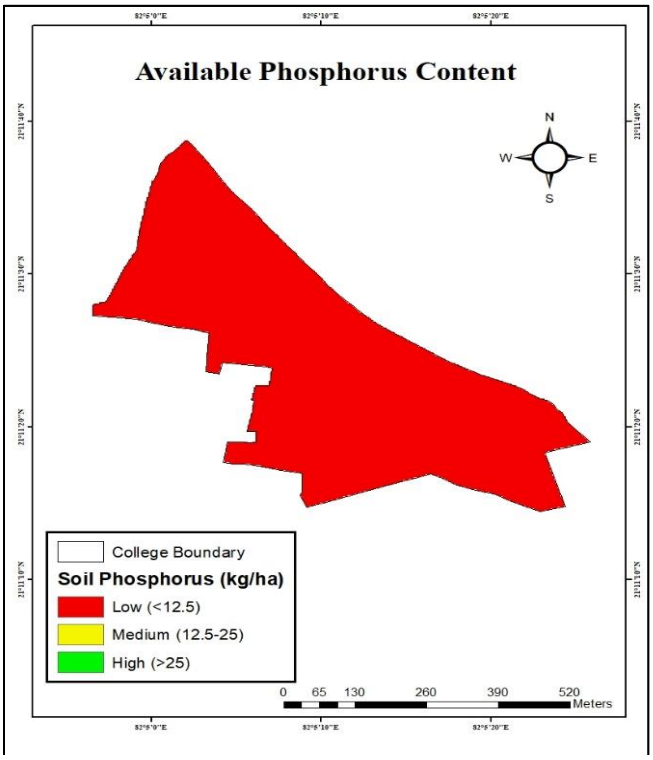

Fig 6: Spatial distribution of soil available phosphorus.

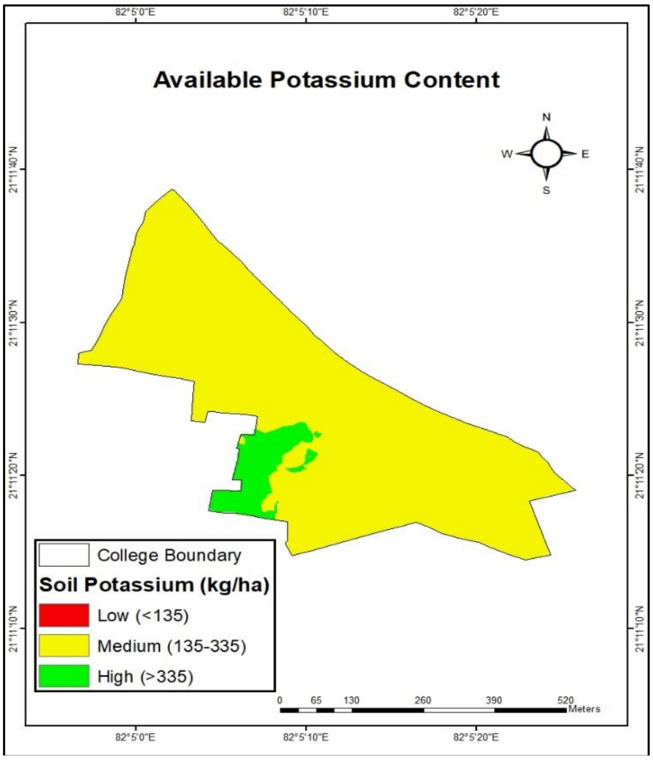

Fig 7: Spatial distribution of soil available potassium.

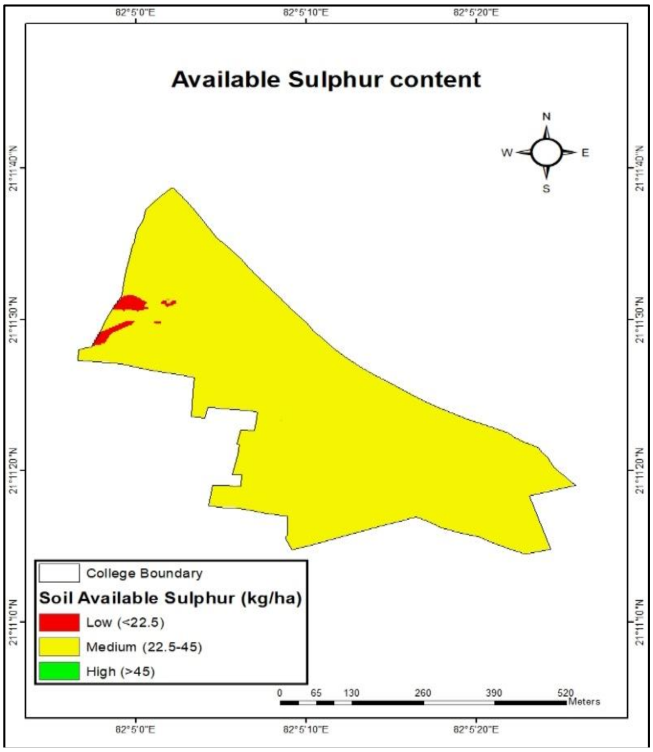

Fig 8: Spatial distribution of soil available sulphur

4. Conclusion

A total of 77 soil samples (0-15) were taken from the study area from Research farm of college of Agriculture and Research, Kanpa, Mahasamund, (C.G) for the analysis of the chemical properties of soil. The findings are summarized as the soils of research farm are extremely to slightly acidic with normal electrical conductivity and organic carbon status was found to be in low to medium in categories. The average values of macronutrients were found as 173.6, 7.06, 276.6, 31.67 kg/ha soil available N, P, K and S, respectively. As per NIV criteria, the available nitrogen and phosphorus are observed in low fertility whereas available potassium and sulphur classified as medium fertility class. The soils of study area are classified as slightly acidic to neutral which indicated that lime application is beneficial to crop production. Soil nitrogen status was evaluated as low status, 25% extra of general recommended dose (GRD) can be suggested for nitrogenous fertilizer. Area for S is medium to low hence, GRD dose of sulphur in the form of either sulphur powder or bentonite S, should be applied and also recommended use of single super phosphate in place of DAP or complex fertilizers

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