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Preparation of Geo-spatial Soil Fertility Map of KVK Farm, Gariyaband, Chhattisgarh, India

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Authors' contributions

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

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ABSTRACT

The present study was carried out during the year, 2023-24 at KVK farm Gariyaband, Chhattisgarh with the objectives to study the soil available macro and micro nutrients status of KVK farm Gariyaband. GPS based surface soil samples (0-15) at random sampling of studied area in each plot with the goal to create a GPS-based soil fertility map. The soil samples were analysed by

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standard procedures with respect to pH, EC, OC, macronutrients (N, P, K, S) and micronutrients (Fe, Mn, Cu, Zn, and B). The pH of soils of research farm varied from 6.02-7.13 with a mean of 6.45. It indicates that the pH of the soil is in the slightly acidic to neutral range. The electrical conductivity of the soil ranged from 0.10-0.25 dSm^{-1} with a mean of 0.14 dSm^{-1}. This depicts that all of the samples were in fair range (<1.0 dSm^{-1}) with no harmful effect of soil salinity. The organic carbon ranged from 0.24-0.66 %, with mean value 0.43 %. The available nitrogen ranged from 150.44-188.16 kg ha^{-1}, with a mean of 170.95 kg ha^{-1}. The available phosphorus varied from 13.38-31.63 kg ha^{-1} with mean of 22.60 kg ha^{-1}. The available potassium varied from 335.10-440.72 kg ha^{-1}, with mean of 389.94 kg ha^{-1}. The available sulfur ranged from 22.5-53.48 kg ha^{-1}, with mean value of 35.55 kg ha^{-1}. Among micronutrients, the available iron, manganese, zinc, copper and boron varied from 8.84-35.90 mg kg^{-1} (mean 20.39 mg kg^{-1}), 6.20-27.74 mg kg^{-1} (mean 17.79 mg kg^{-1}), 0.60-1.44 mg kg^{-1} (mean 0.86 mg kg^{-1}), 1.04-2.74 mg kg^{-1} (mean 1.85 mg kg^{-1}), and 0.52-0.98 mg kg^{-1} (mean 0.71 mg kg^{-1}), respectively. All the samples were found under sufficient fertility classes for micronutrients.

Keywords: GPS based mapping; fertility status; nutrient status; organic matter.

1. INTRODUCTION

Soil is loose top layer of the Earth's surface, consisting of rock and mineral particles mixed with decayed organic matter (humus) and capable of retaining water, providing nutrients for plants, and supporting a wide range of biotic communities. Soil formed by a combination of depositional, chemical, and biological processes and plays an important role in the carbon, nitrogen and hydrologic cycles [1,2].

Soil fertility refers to the inherent capacity of the soil to provide macro and micronutrients in the soil. The physical, chemical and biological tests provide information about the capacity of soil to supply mineral nutrients [3,4].

Use of GIS with facilities like GPS (Global Positioning System) and soil fertility mapping are useful to know the fertility status of a particular village, district or even state and the country. Hence, Soil fertility maps prepared on the basis of analysed data of soil samples has greater use. It not only gives an idea about fertility status of the soil of a particular place under discussion, but also helps in monitoring the soil health from time to time. Soil testing and fertility maps provides information regarding nutrient availability in soils which forms the basis for the fertilizer's recommendations for maximum crop yield [5,6].

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out at Krishi Vigyan Kendra, Village-Kokdi, Gariyaband, Chhattisgarh. It is situated in mid-eastern part of Chhattisgarh state and comes under Chhattisgarh plains agro climatic zone. It situated at the latitude coordinate 20.63˚N longitude and 82.06˚E with altitude ranging from 260-271m above mean sea level (MSL).

2.2 Sample Collection and Analysis

Altogether 75 surface soil of the cultivated land of the Krishi Vigyan Kendra Farm of Gariyaband, were sampled to a depth of 0-15 cm by the help of khurpi. Spade was used to make a "V" shaped cut up to the plough depth and then a uniform 1-2 cm thick slice was taken out by removing any grass, stones, pebbles, or debris. The collected soil sample was carefully mixed over a clean piece of polythene sheet and kept secured safely in packets labelled with field number, sample number and GPS coordinates [7].

The samples were analyzed for 12 chemical parameters *viz.* pH by pH meter, electrical conductivity (EC) by solu-bridge method [8] organic carbon (OC) by method of Walkley and Black [9] available nitrogen (N) using method described by Subbiah and Asija [10] phosphorus (P) using method of Olsen *et al.* (1954), available potassium (K) by method of Hanway and Heidal, [11] available sulphur (S) by method of Williams and Steinbergs (1959), available zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) using DTPA extractant method proposed by Lindsay and Norvell [12] and available boron (B) using hot water extractant method described by Berger and Troug [13]. The analytical results of each soil sample was categorized as low, medium and high categories for OC and macronutrients and as deficient and sufficient for micronutrient based on standard rating values.

2.3 Nutrient Index Values and Fertility Rating

According to Ramamoorthy and Bajaj [14] the nutrient index values (NIV) for various soil parameters were determined from the amount or proportion of samples with low, medium, or high usable nutrient status and classified into different fertility groups.

$$\text{NIV} = \frac{(1\ X\ PL)/+(2\ X\ PM)+(3\ X\ PH)}{100}$$

Where,

NIV = nutrient index value.
PL= % samples fall under low category.
PM= % sample es fall under medium category.
PM = % sample as fall under high category.

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

3. RESULTS AND DISCUSSION

Soil pH: The soil pH of the study region ranged from 6.02 to 7.13 with an average value of 6.45 and standard deviation 0.32 according to a study of soil response on collected samples from the study area. It indicates that the pH of the soil is in the slightly acidic to neutral range.Out of the total soil samples (75 samples) 60% of the soils were found Slightly acidic, 40% are neutral, in soil reaction. (Fig. 1) Similar results were reported by Kumar (2019) as they reported available N status is found to be varied from 6.79 to 7.81 %.

Electrical conductivity: The research area's soil EC ranged from 0.10 to 0.25 dSm^{-1}, with an average of 0.14 dSm^{-1}. All the soil samples fall under the normal range (<1.0 dSm^{-1}). indicated that the soils were good enough for growing of all types of crops. All soil samples i.e. 100 % were having low range, and is classed as "Safe" indicating that there is no requirement of the corrective measures. (Fig. 2) Similar results were reported by Chauhan [15] as they reported available EC status is found to be varied from 0.09 to 0.24 dSm^{-1}.

Organic carbon: The variations in the soil organic carbon content was 0.24 to 0.65 % with an average of 0.43 %. From all the soil samples, majority of the soil samples i.e. 78.66% were found to be in low in OC and 21.33% samples were in medium organic carbon status. (Fig. 3) Similar results were reported by Kumar (2019) as they reported available OC status is found to be varied from 0.27 to 0.71 %. Similar results were also reported by Kumar (2019) in Pahanda, Durg.

Available nitrogen: The available nitrogen in soils were ranged from 150.44 to 188.16 kg ha^{-1} with an average of 170.95 kg ha^{-1}. All the soil samples were found in low nitrogen category (Fig. 4). Similar results were reported by Sidar (2023) as they reported available N status is found to be varied from 87.8 -213.24 kg ha^{-1} KVK farm Jashpur Chhattisgarh.

Available phosphorus: The available phosphorus in soils ranged from 13.38 to 31.63 kg ha^{-1} with an average of 22.51 kg ha^{-1}. Among the collected soil samples, 69.33 percent were in medium category and 30.66 percent were in high category. Majority of the soil samples were found to be in medium range (Fig. 5). Similar results were reported by Sengar [16] as they reported available P status is found to be varied from 2.6 to 28.9 kg ha^{-1} KVK farm, Raipur.

3.1 Available Potassium

The available potassium in soils ranged from 335.10 to 440.72 kg ha^{-1} with an average of 389.94 kg ha^{-1}. It was found that 100 % of samples were fall under high category (Fig. 6). Similar results were reported by Sidar (2023) as they reported available K status is found to be varied from 128 to 434.45 kg ha^{-1} KVK farm, Jashpur Chhattisgarh.

3.2 Available Sulphur

The available sulphur ranged from 22.5 to 53.48 kg ha^{-1} with an average of 35.55 kg ha^{-1}. It was found that sulphur had 60 % and 40 % of samples were the medium and high in sulphur rating (Fig. 7). Similar results were reported by Sahu [17] as they reported available S status is found to be varied from 128 to 434.45 kg ha^{-1} in CoA and Research Station Katghora, Korba.

Available iron: The available iron in soils ranged from 8.84 to 35.90 mg kg^{-1} with an average of 20.39 mg kg^{-1} (Table 1) [18,19]. Among the collected samples,100 per cent samples were found sufficient in available iron, as the critical limit is 4.5 mg kg^{-1} (Fig. 8).

Available Manganese: The available manganese in soils ranged from 6.20 to 27.12 mg kg^{-1} with an average of 17.79 mg kg^{-1}. All the soil samples collected were sufficient in available manganese, as the critical limit of available manganese is 3 mg kg^{-1}, (Fig. 9).

Available Copper: The available copper in soils ranged from 1.04 to 2.74 mg kg^{-1} with an average value of 0.47 mg kg^{-1}. All the soil samples collected were sufficient in available copper as the critical limit is 0.2 mg kg^{-1} (Fig. 10).

Available Zinc: The available zinc in soils ranged from 0.60 to 1.44 mg kg^{-1} with an average of 0.86 mg kg^{-1}. Out of collected soil samples, 100 % were sufficient in available zinc as the critical limit is 0.6 mg kg^{-1} (Fig. 11).

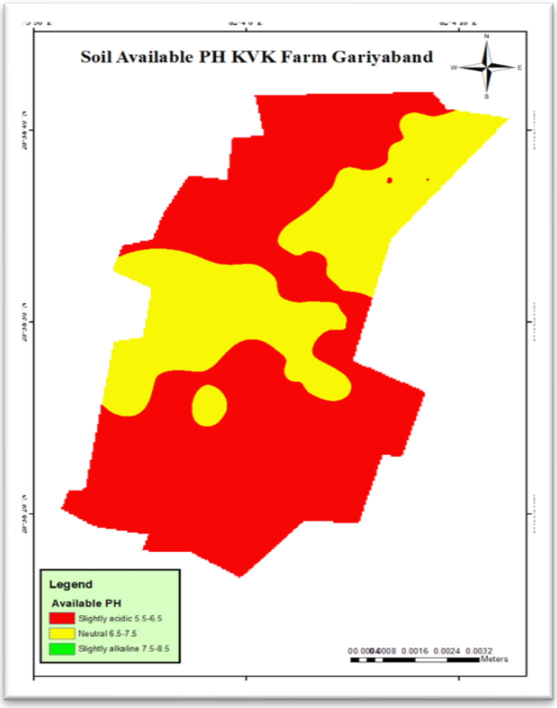

Fig. 1. Spatial distribution of Available pH

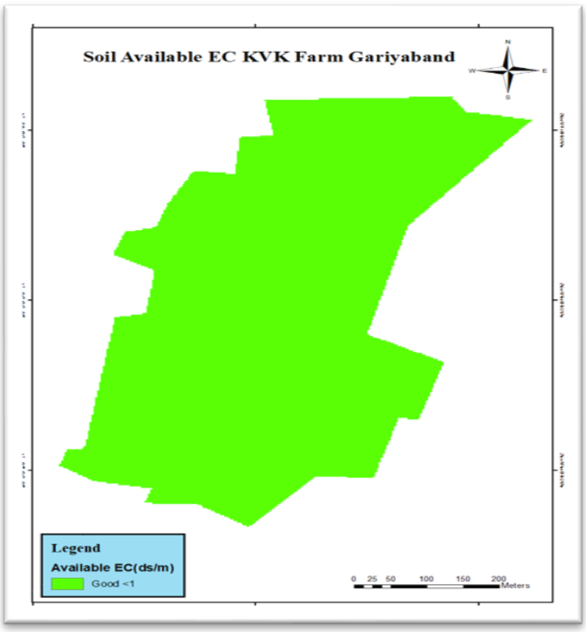

Fig. 2. Spatial distribution of Available EC

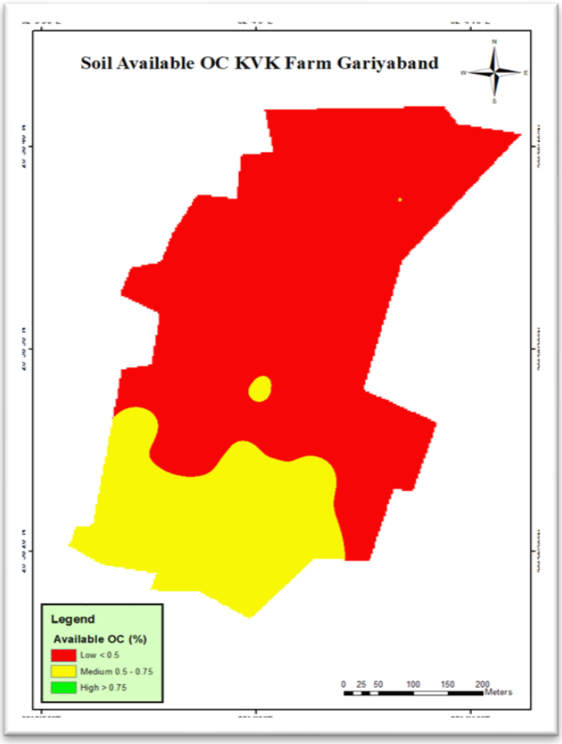

Fig. 3. Spatial distribution of Available OC

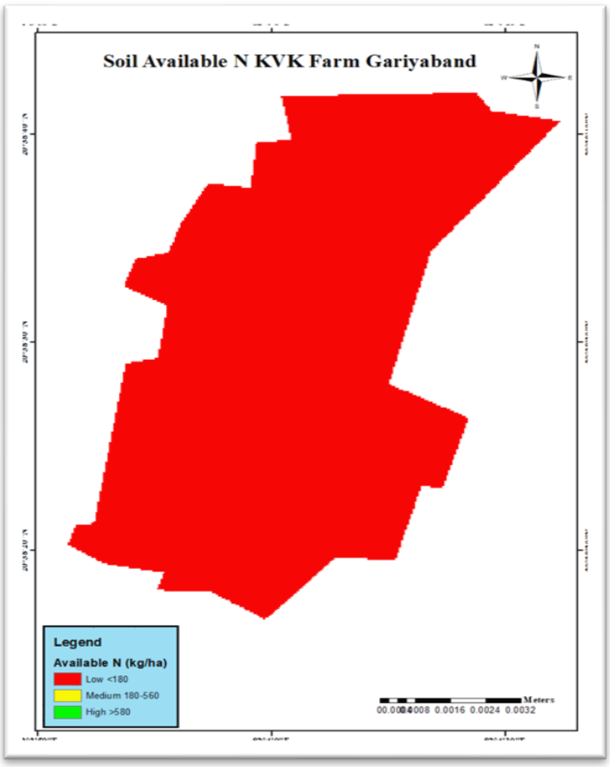

Fig. 4. Spatial distribution of Available N

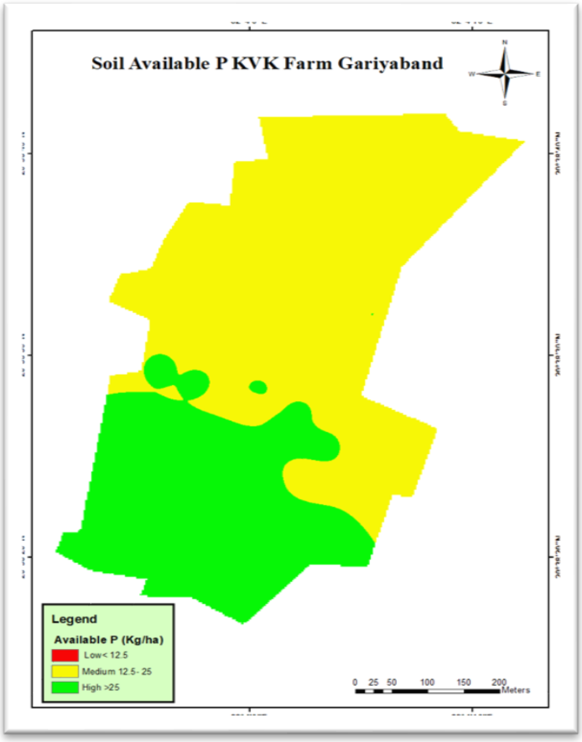

Fig. 5 Spatial distribution of Available P

Fig. 6. Spatial distribution of Available P

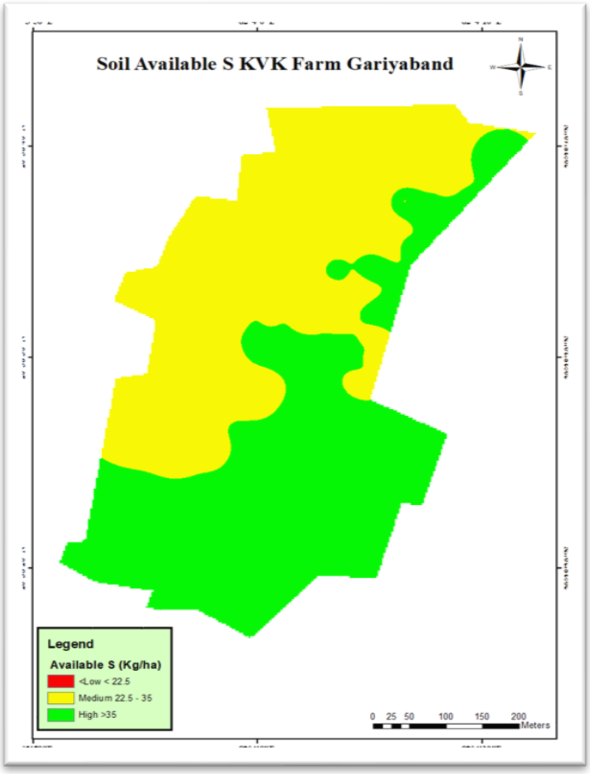

Fig. 7. Spatial distribution of Available S

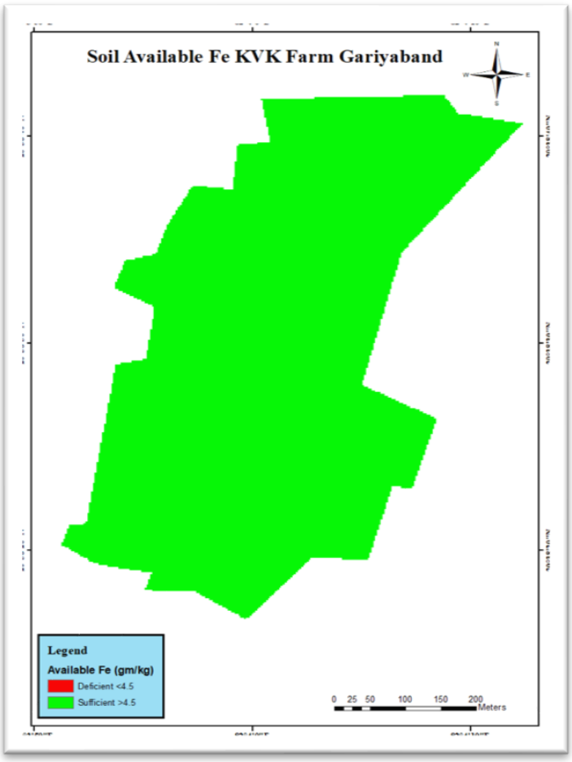

Fig. 8. Spatial distribution of Available Fe

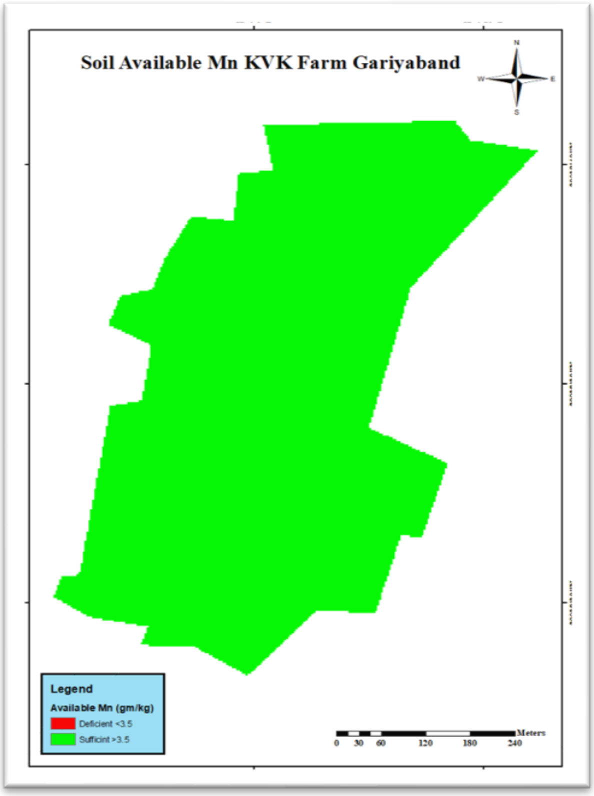

Fig. 9. Spatial distribution of Available Mn

Fig. 10. Spatial distribution of Available Cu

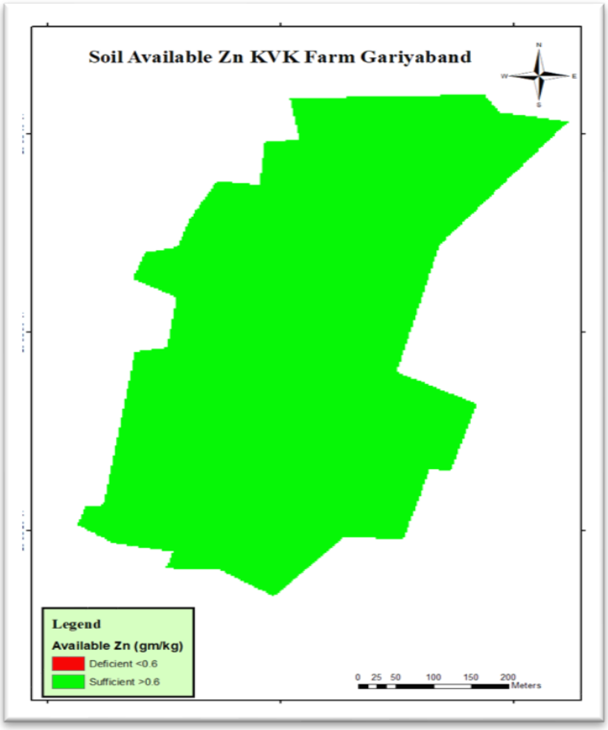

Fig. 11. Spatial distribution of Available Zn

Available boron: The available boron in soils ranged from 0.52 to 0.98 mg kg^{-1} with an average of 0.71 mg kg^{-1}. Out of collected soil samples, 100% were sufficient in available boron as the critical limit is 0.5 mg kg^{-1} (Fig. 12).

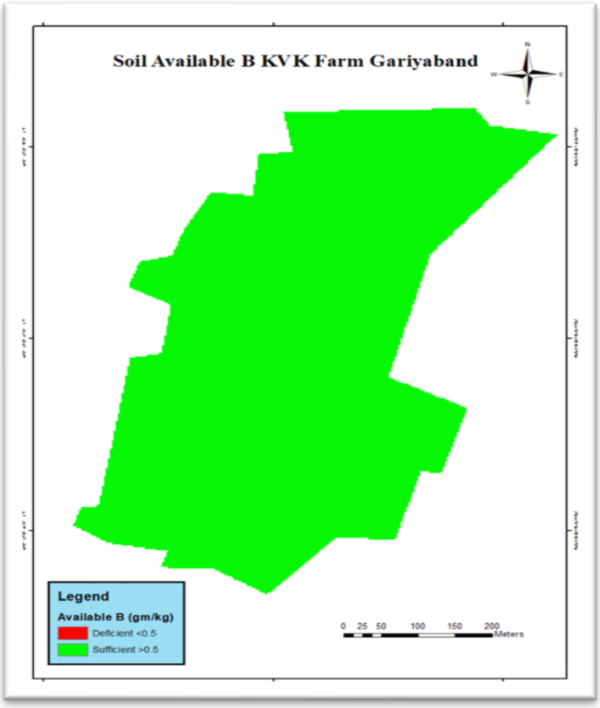

Fig. 12. Spatial distribution of Available B

Table 1. Nutrient status of soil in the study area KVK Farm Gariyaband (C.G)

S. No.	Parameters	Range	Average	Standard Deviation
1	pH	6.02-7.13	6.45	0.32
2	EC (dSm^{-1})	0.10-0.25	0.14	0.03
3	Organic Carbon (%)	0.24-0.66	0.43	0.11
4	Nitrogen (kg ha^{-1})	150.44-188.16	170.95	11.17
5	Olsen's Phosphorus (kg ha^{-1})	13.38-31.63	22.60	4.97
6	Potassium (kg ha^{-1})	335.10-440.72	389.94	29.82
7	Sulphur (kg ha^{-1})	22.5-53.48	35.55	9.69
8	Iron (mg kg^{-1})	8.84-35.90	20.39	7.06
9	Manganese (mg kg^{-1})	6.20-27.74	17.79	5.96
10	Copper (mg kg^{-1})	1.04-2.74	1.85	0.47
11	Zinc (mg kg^{-1})	0.60-1.44	0.86	0.20
12	Boron (mg kg^{-1})	0.52-0.98	0.71	0.13

Table 2. Overall fertility classes based on the NIV of KVK farm Gariyaband (C.G)

S. No	Soil parameters	Range	Average	% Samples Category			NIV	Fertility Class
				Low	Medium	High		
1	N (kg ha^{-1})	150.44-188.16	170.95	100	0	0	1.00	Low
2	P (kg ha^{-1})	13.38-31.63	22.60	0	69.33	30.66	2.30	Medium
3	K (kg ha^{-1})	335.10-440.72	389.94	0	0	100	3.00	High
4	S (kg ha^{-1})	22.5-53.90	35.55	0	60	40	2.40	High

4. CONCLUSIONS

Based on the analysis it can be concluded that the study area comes under slightly acidic to neutral in soil reaction, safe in electrical conductivity, low to medium in organic matter, low in nitrogen, medium to high in phosphorus and high in potassium. Regarding to sulphar majority of samples were medium to high and micronutrient comes under sufficient level. As per the NIV values available nitrogen and phosphorus were obsereved low and medium respectively whereas available potassium and sulpher classified as high fertility class. ArcGIS based soil fertility map was prepared for KVK Farm, Gariyaband and based on map soil test based fertilizer are recommended for different crop on the basis of fertility grouping method for N, P, K and critical limit approach for S and micronutrients. The ArcGIS based generated maps would help farm manager and researchers in the precise management of nutrients (major and micronutrients) and fertilizer recommendation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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