



ISSN Print: 2664-844X
 ISSN Online: 2664-8458
 NAAS Rating (2026): 4.97
 IJAIFS 2026; 8(10): 251-257
www.agriculturaljournals.com
 Received: 29-08-2026
 Accepted: 28-09-2026
 Published: 09-10-2026

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Soil fertility mapping and identification of soil constraints to crop production in Jashipur block of the North Central Plateau agroclimatic zone, Odisha

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DOI: <https://www.doi.org/10.33545/2664844X.2026.v8.i10d.2025>

ABSTRACT

A detailed soil fertility status of Jashipur was investigated. The soil reaction was found to be acidic in the entire farm varying between pH of 4.06 to 6.12. Electrical conductivity for all the surface soils was found to be less than 1 dS m⁻¹ and hence is safe for all types of crop production. Organic carbon status for the surface soil was found to vary between medium to high range (5.5 to 10.9 g kg⁻¹). Available N (135 to 363 kg ha⁻¹), Bray's P (6.3 to 36.7 kg ha⁻¹) of the study area were found to be low to medium in range and that of available K status was observed to be in medium to high range (237 to 495 kg ha⁻¹). Available S status was found to be of low range (3.7 to 15.6 kg ha⁻¹) in the entire study area. The major crop production limitation of the study area was soil acidity. Lime application along with applications of soil-based fertilizers and manures will help optimise crop productivity and maintain soil health.

Keywords: GPS, GIS, Jashipur, Mayurbhanj, Soil fertility maps, Odisha

Introduction

Soil is a precious resource that has been considered as "Soul of Infinite Life". Food sustainability, environmental protection and soil health are the three main problems of the twenty-first century. The ability of the soil to produce crops is the nature of life in the soil and soil productivity is primarily determined by soil fertility, management methods and climate. As a result, soil fertility is a key component of growth, as it relates to the soil's capacity to provide nutrients to plants in adequate amount and definite proportion. Soil samples obtained with GPS data assists in making crucial nutrient management decisions. The amount of fertilizer and organics needed must be determined in order to calculate the exact amount of plant nutrients. The KVK (Krishi Vigyan Kendra), Jashipur was established in the year 2012 in the North Central Plateau Agroclimatic Zone of Odisha at Angarapada village of Jashipur block of district Mayurbhanj. By conducting various On Farm Testing, Front Line Demonstrations and farmer training, KVK, Jashipur plays a critical role in transferring technologies to farmers in Mayurbhanj District. It has the main strengthening agricultural production in the district of Mayurbhanj by means of compulsory operations: on farm trials, on front line demonstration, in-service training, various extension activities, seed and seedling productions and the development of KVK information hub. However, a plot-by-plot GPS-GIS dependent soil fertility status of the farm has not been undertaken its establishment. Due to the lack of a systematic soil study in this region, an attempt was made in the current investigation to prepare plot-by-plot GPS and GIS based soil fertility maps of KVK farm, Jashipur. It will aid in identifying the farm's soil fertility-related crop production constraints and recommending remedial steps for optimal crop production and better scientific studies. This work would also serve as a base for future soil surveys and other research projects. There are three types of soil: upland, medium land and low land in the farm. As per the recent research conducted on soil fertility status of Mayurbhanj district (Dixit *et al.*, 2020) [1], taking into account of 3317 numbers of soil surface samples, collected from all the 26 blocks of Mayurbhanj, it was found that 97 % soil sample are acidic in nature. Likewise, 43% soil samples are deficient in organic carbon; 75% samples are deficient in available phosphorus; 46% samples are deficient in available potassium; 67% samples are deficient in available Sulphur. However, no such work has been done on plot wise soil fertility status of KVK Farm, Jashipur. Therefore, an attempt has been made in present investigation, to evaluate the fertilizer status of KVK Farm, Jashipur

Materials and methods

1. Experimental site

The research area is in Odisha's North Central Plateau Agro Climatic Zone. It is approximately 105 kilometers from the district headquarters, Baripada, along the National Highway-6. It is 1427 feet above mean sea level and is located between Krishi Vigyan Kendra, Jashipur is the district's second KVK, being established 21056'16.1" N latitude and 86003'58.3" E longitude. The study location is near the Simlipal mountain range. The KVK farm is located along the top sequence and consists of primarily three distinct land types: upland (slope of 2-5 %), middle land (slope of 2-3 %), and low land (slope of 0-1 %). This region's climate is subtropical in nature. In 77 wet days, the annual average rainfall is 1648.2 mm. Mayurbhanj's climatic conditions are quite varied. It mostly has three seasons. It has a scorching summer from March to May, a humid monsoon from mid-June to mid-September and a very cold winter from December to February. The region's mean maximum and lowest temperatures, as measured by the local observatory, are 44.2 °C and 8.4 °C, respectively. The warmest month is May, with a mean maximum temperature of 44.2 °C, while the coldest month is December, with a mean minimum temperature of 8.40C.

In the research area's upland, an agroforestry model-based orchard is created. Orchard crops thrive in conditions that are well-drained and have adequate aeration. During the kharif season, medium and low lands are mostly used for paddy foundation seed production. Due to heavy flooding and water logging, certain low-lying areas are not cultivated. Green grams, black grams and to a lesser extent crops such as brinjal, tomato and chilli are produced in medium and low land during the rabi season. 2. Soil sampling and analysis. The landform of the study area was determined through traversing the area and elevations above MSL of different points were recorded using GPS instrument (Garmin make; model: 76MAPCSx). A Total of 40 numbers of composite surface (0–15 cm) soil samples were collected from the study area which includes 19 samples (plot no 1 to 19), 11 samples (plot no 20 to 30), 10 samples (plot no 31 to 40). From each plot, five to six soil samples were collected and thoroughly mixed to obtain a single composite sample. Soils were analysed for textural class by Bouyoucos Hydrometer method (Bouyoucos, 1962) [2]. Soil pH (1:2) and EC (1:2) were estimated following the procedures described by Jackson (1973) [3], organic carbon content was determined by the Walkley and Black method (1934) [4]. Available nitrogen was analysed using the alkaline KMnO_4 method (Subbiah *et al.*, 1956) [5], available phosphorus by the Bray and Kurtz method (1945) [6], available potassium by the method suggested by Hanway and Heidel (1952) [7] and available sulphur by Chesnin and Yien (1950) [8]. Base map of the study area was geo-referenced and digitized. Latitude, Longitude and soil analysis data were entered into attributed table and linked to ArcGIS software for making thematic soil fertility map.

Result and discussion

1. Soil texture

Texture of surface soil samples of the entire study area remained within sandy loam and sandy clay loam. The sand, silt and clay content in upland soils (plot 1 to 19) were found to vary in between 59 to

72.2, 5.6 to 22.2 and 16.8 to 28.8 percent respectively; that of medium land (plot 20 to 30) varied between 59.8 to 72.2, 5.8 to 15.8 and 18.8 to 32.2 percent respectively; that of low land (plot 31 to 40) soils varied between 55.8 to 67.6, 3.7 to 21.6 and 16.8 to 32.6 percent respectively (Table 1, Fig 3). The average clay content in soils of upland, medium land and low land surface soils was found to be 20.82, 25.18 and 25.73 percent respectively. The results clearly showed a gradual increase in clay content from upland surface soils towards low land soils, which could be attributed to washing away of clay particles from upland and medium land along with runoff water during rain fall and their subsequent deposition in the low land. Similar findings have also been observed by Pattnaik *et al.* (2026) [9] (Pattnaik *et al.*, 2026) [9] and Barik *et al.* (2017) [10]. 2. Soil reaction Soil pH (1:2) of surface soil samples of the entire study area was found to vary in between 4.06 to 6.12 with a mean value of 5.2. The soil pH of upland, medium land and low land soils varied in between 4.06 to 5.93, 4.27 to 5.98, 5.23 to 6.12 respectively. The average soil pH values of the soil in upland, medium land and low land were found to be 5.10, 5.19 and 5.65 respectively (Table 2, Fig. 4.). The data showed that a gradual increase in soil pH observed from upland towards low land, which could be attributed to the removal of basic cations with runoff water from upland and medium land during intensive rainfall and their subsequent deposition in the low land. Hence, the soil acidity appears to be a major crop production constraint in the study area. Similar findings have also been reported earlier by Behera *et al.* (2016) [11] and Dash *et al.* (2018) [12]. 3. Electrical conductivity Electrical Conductivity (1:2) of surface soil samples of the entire study area was found to be less than 2 dS m^{-1} (Table 2). Hence, all the soils of the study area are safe for all types of crop production with respect to the soluble salt content. 4. Organic carbon Soil organic carbon (SOC) of surface soil samples of the entire study area was found to vary in between 5.5 to 10.9 g kg^{-1} with a mean value of 7.7 g kg^{-1} . The SOC in upland, medium land and low land varied between 5.5 to 8.9, 6.7 to 9.9, 8.1 to 10.9 g kg^{-1} respectively. The average SOC values of the soil of upland, medium land and low land were found to be 6.3, 8.3 and 9.4 g kg^{-1} respectively (Table 2, Fig. 5.). The results clearly showed a gradual increase in average SOC in upland towards low land surface soil samples which could be attributed to higher cropping intensity followed by crop residue incorporation in the low land. Again, due to higher water table in case of low land, the oxidation of organic matter is slower than that of upland. In the entire study area organic carbon status was found to be medium to high which sustains higher crop. Similar findings have also been reported by Mishra *et al.* (2014) [13] and Singh *et al.* (2021) [14]. 5. Available macro nutrients a) Available Nitrogen Soil available nitrogen content of surface soil samples of the entire study area was found to vary in between 135 to 363 kg ha^{-1} with a mean value of 246 kg ha^{-1} . The available N content in upland, medium land and low land soils was found to vary in between 135 to 225, 145 to 265, 227 to 365 kg ha^{-1} respectively. The average values of available N of the soils of upland, medium land and low land were found to be 182, 201, 286 kg ha^{-1} respectively (Table 3, Fig. 6.). In the entire study area available nitrogen was found to be in the range of low to medium. Similar results were also been observed by Nahak *et al.* (2016) [15] and Barik *et al.* (2017) [10].

Table 1. Mechanical composition of the soils under study

Land type	Sand range (%)	Sand mean (%)	Silt range (%)	Silt mean (%)	Clay range (%)	Clay mean (%)
Upland	59–72.2	66.8	5.6–22.2	12.38	16.8–28.8	20.82
Medium land	59.8–72.2	66.89	5.8–15.8	8.47	18.8–32.2	25.18
Low land	55.8–67.6	60.04	3.7–21.6	11.17	16.8–32.6	25.73

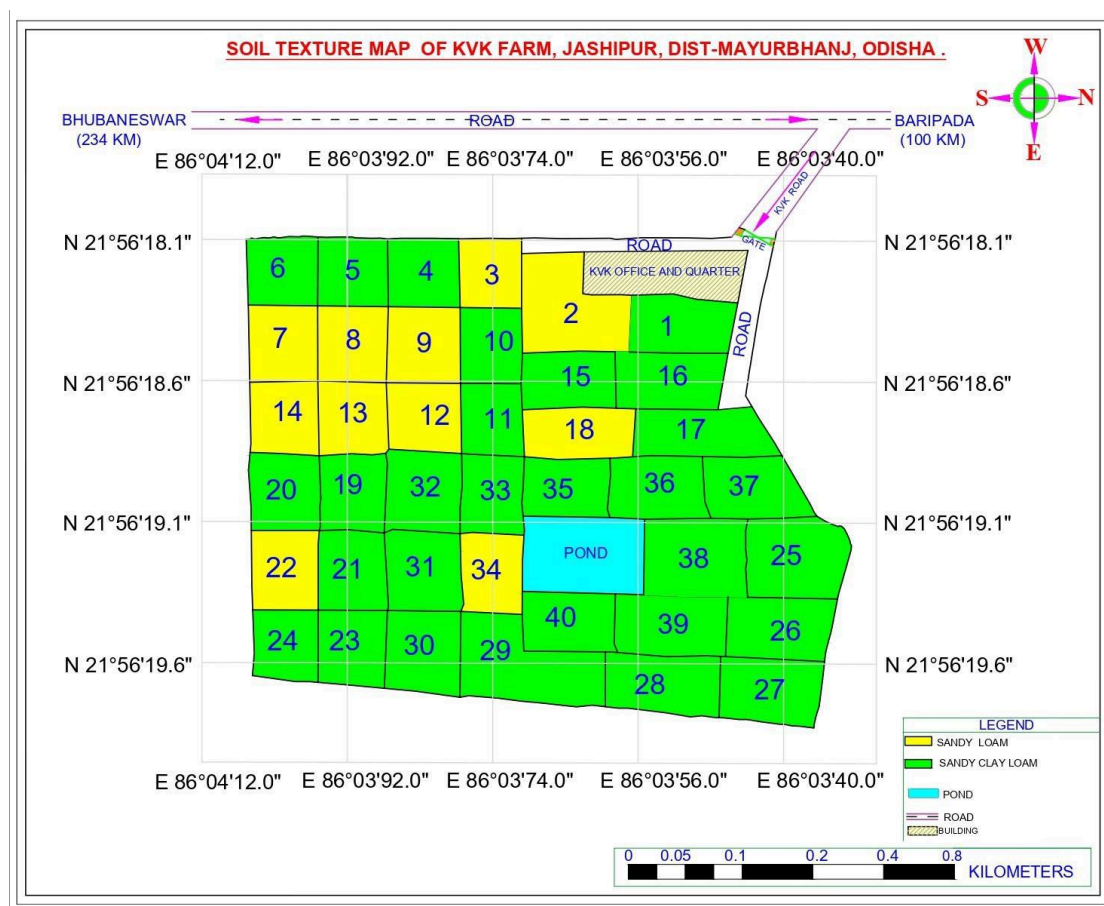
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Table 2. Chemical properties of the soils under study

Land type	EC range (dS m ⁻¹)	EC mean	pH range	pH mean	Organic C range (g kg ⁻¹)	Organic C mean
Upland	0.011–0.039	0.022	4.06–5.93	5.10	5.5–8.9	6.3
Medium land	0.028–0.082	0.054	4.27–5.98	5.19	6.7–9.9	8.3
Low land	0.042–0.099	0.075	5.23–6.12	5.65	8.1–10.9	9.4

Table 3. Available macronutrient status of the soils under study (kg ha⁻¹)

Land type	N range	N mean	P range	P mean	K range	K mean	S range	S mean
Upland	135–225	182	6.3–22.8	14.2	237–368	306	3.7–8.7	6.2
Medium land	145–265	201	17.1–26.2	18.3	334–399	368	6.4–9.8	8.4
Low land	227–365	286	21.5–36.7	24.9	378–495	430	9.8–15.6	12.8

**Figure 1.** Soil Texture Map of KVK Jasipur block in Mayurbhanj district, Odisha

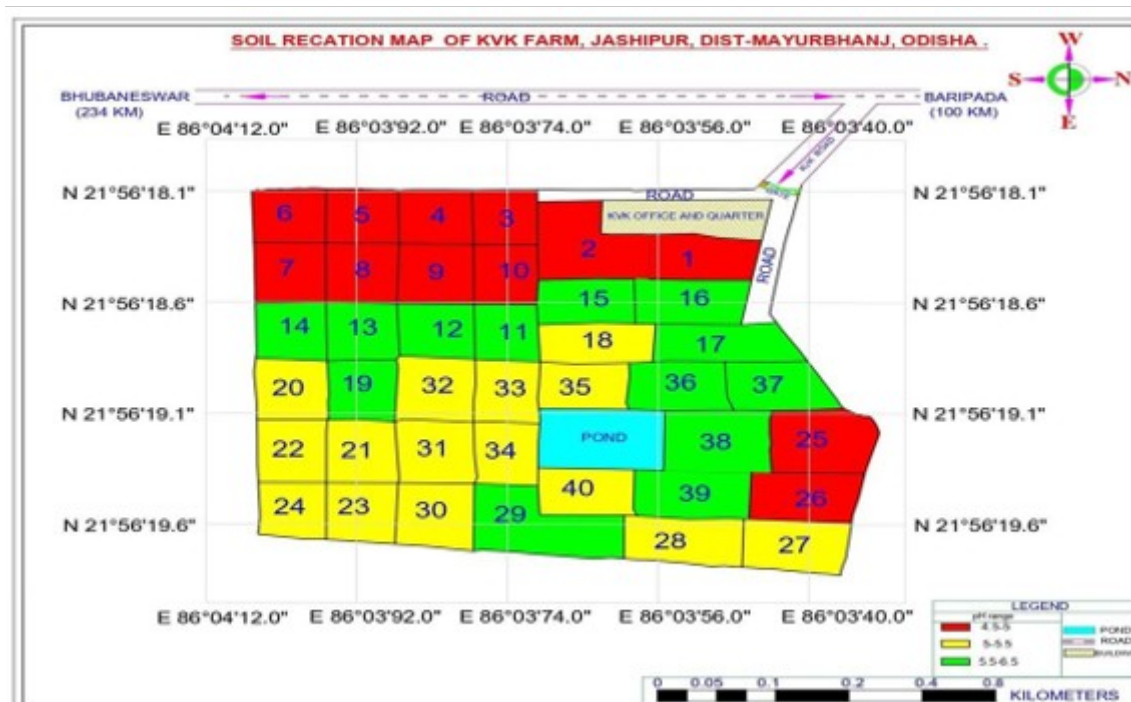


Figure 2. Soil pH map of the KVK Farm, Jashipur.

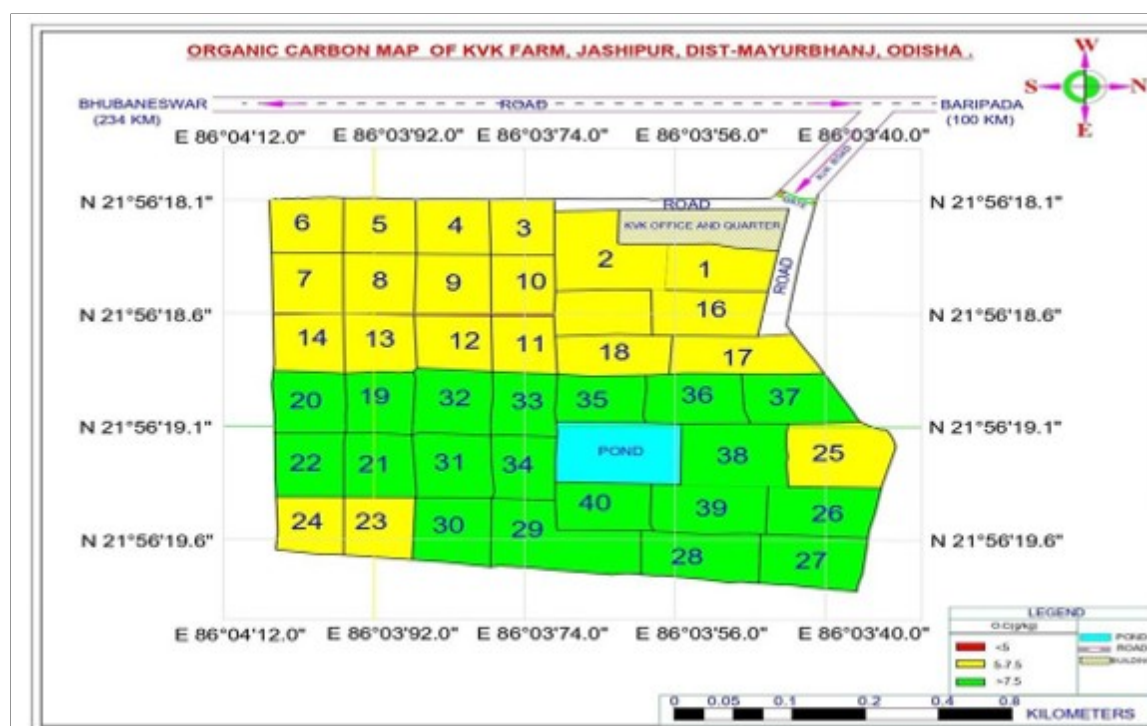


Figure 3. Soil organic carbon map of the KVK Farm, Jashipur.

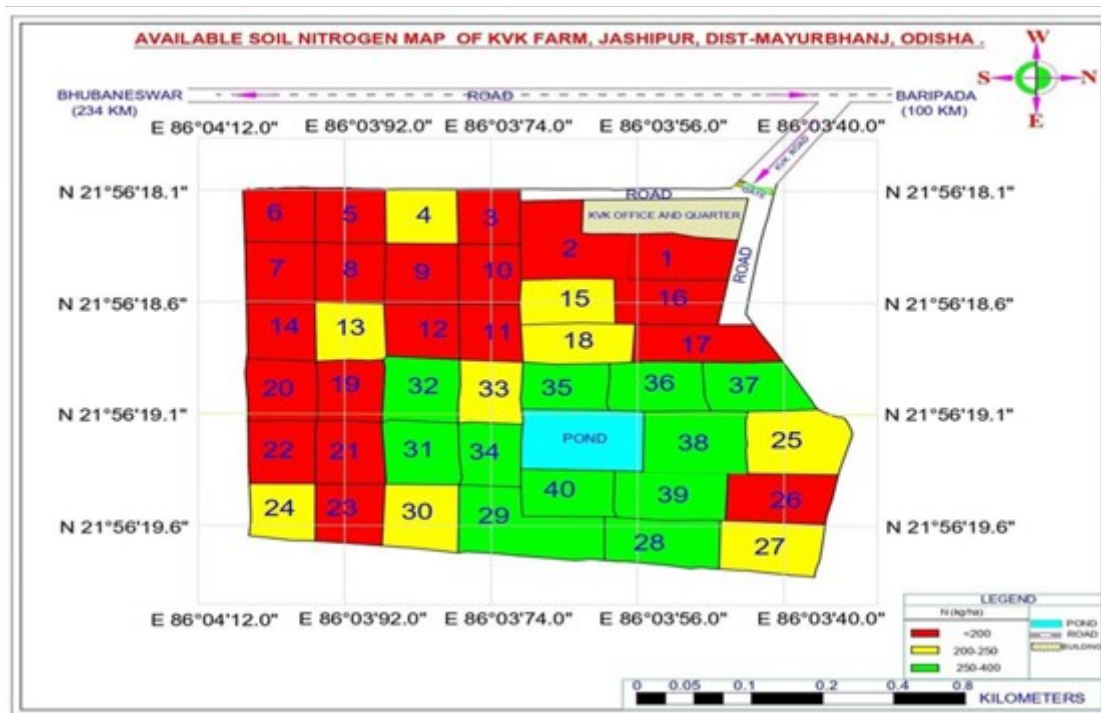


Figure 4. Map of soil available nitrogen at the KVK Farm, Jashipur.

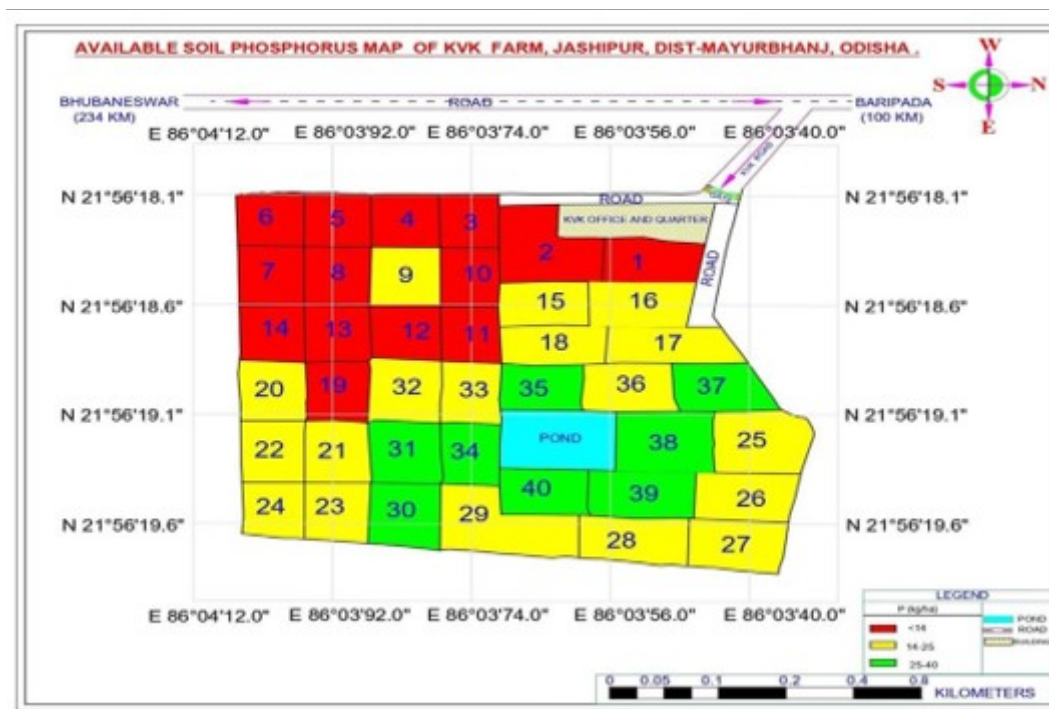


Figure 5. Map of soil available phosphorus at the KVK Farm, Jashipur.

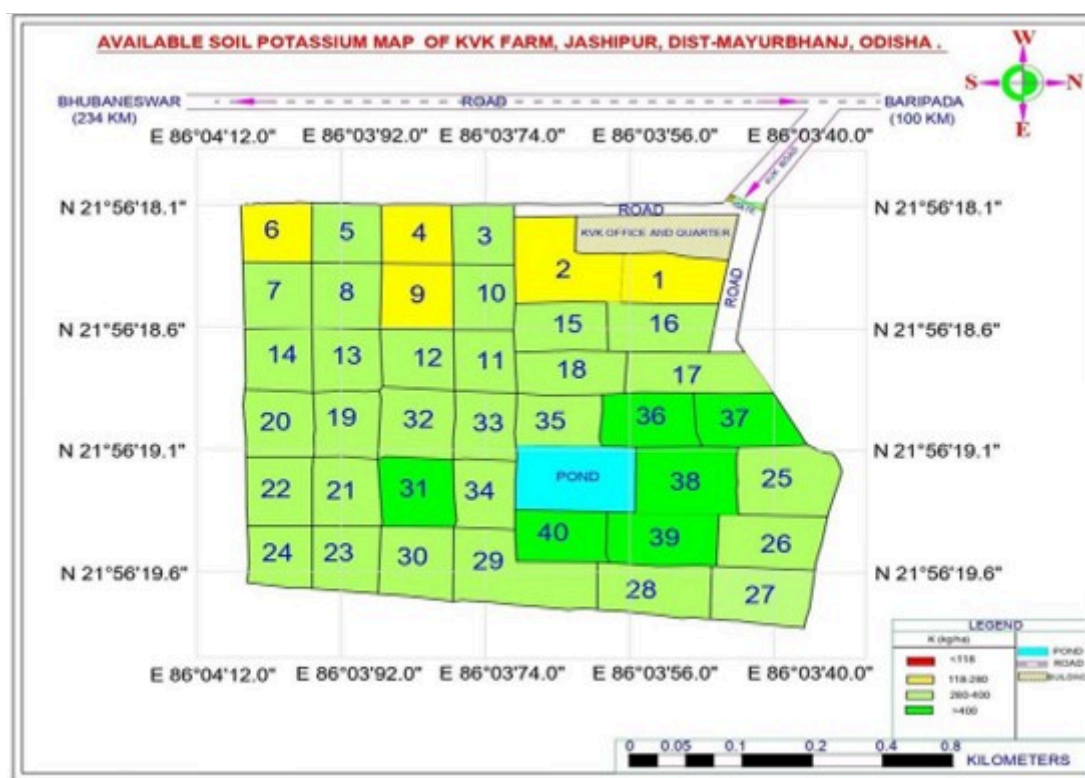


Figure 6. Map of soil available potassium at the KVK Farm, Jashipur.

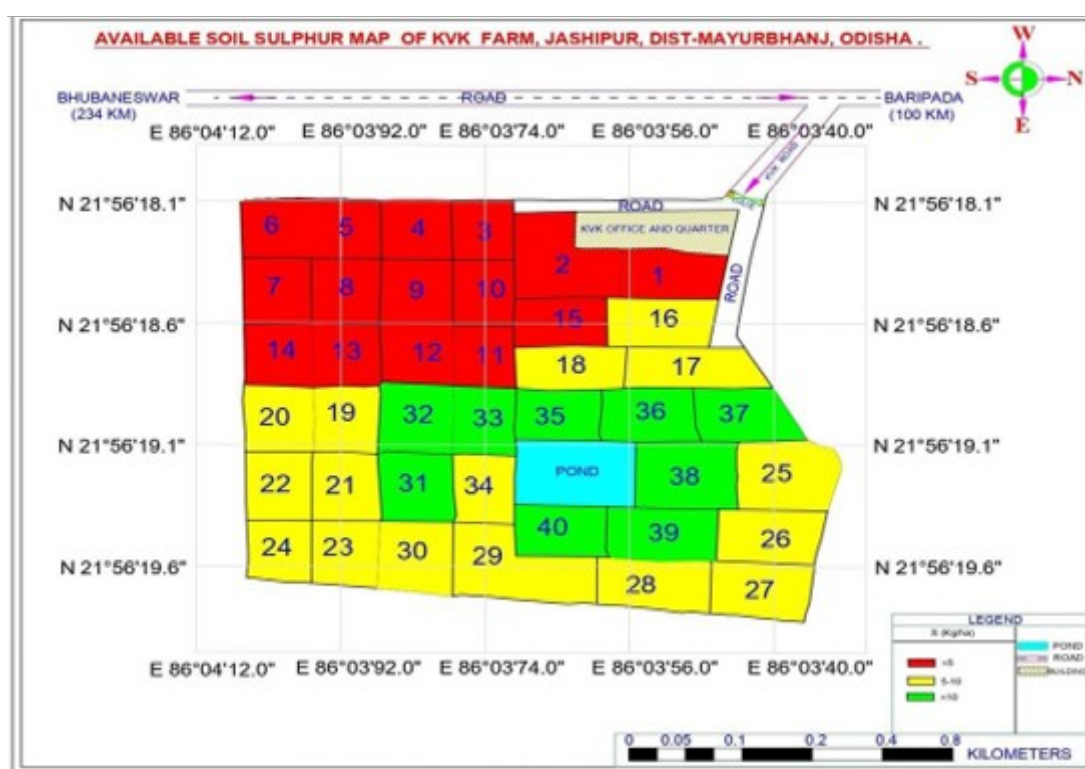


Figure 7. Map of soil available sulphur at the KVK Farm, Jashipur.

It was observed that 30 percent of the soils in the study area were strongly acidic in reaction, whereas the remaining plots were moderately acidic in nature. With respect to soil organic carbon, 47 per cent of the soils were categorized as high, 53 per cent as medium. The available nitrogen status was found to be medium in 22 per cent of the soils, while the rest of the plots exhibited low nitrogen levels. Therefore, plots having low nitrogen status should receive 25 percent higher doses of nitrogenous fertilizers than the recommended level, whereas the remaining plots may be fertilized with the recommended dose. The available phosphorus status revealed that 35 per cent of the

soils were low and 65 per cent were in the medium range. Accordingly, plots with low phosphorus status should be supplied with 25 per cent more phosphatic fertilizers than the recommended dose, while the remaining plots should receive the recommended fertilizer dose. About 12 per cent of the soils were found to be medium in available potassium, whereas the rest of the farm plots recorded high potassium status. Hence, 25 per cent less potassic fertilizer than the recommended dose should be applied in plots with high potassium status. All the plots of the farm were found to be low in available sulphur.

Conclusion

The surface soil samples of the study area were found to vary in texture from sandy loam and sandy clay loam. The clay content was comparatively higher in medium-land and low-land soils than in up-land soils. Electrical conductivity values of all surface soils were below 2 dsm^{-1} , indicating their suitability for the cultivation of all types of crops. The surface soil pH ranged from strongly acidic to moderately acidic throughout the study area, while the soil organic carbon content varied from medium to high. The available nitrogen and phosphorus status of the study area ranged from low to medium, whereas potassium content was high. Overall, the available nitrogen status of the farm was found to be low, indicating the need for greater emphasis on the application of nitrogenous fertilizers. Optimal land use can be achieved when land-use objectives are met with minimal adverse effects, which is possible through the integration of farmers' experience with scientific knowledge of soil resources. Therefore, the application of fertilizers and organic manures based on soil fertility status, along with the use of liming materials, will help optimize crop productivity while maintaining soil health in the study area.

Acknowledgement

The authors are thankful to the Senior Scientist and Head of OUAT, Bhubaneswar for providing the necessary facilities and technical support and Mrs. Priyanka Ray, Cartographer, for preparing thematic soil fertility maps.

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How to cite this article: Pattnaik T, Acharya BP, Mishra A, Saren S, Sahoo SK, Biswas S. Soil fertility mapping and identification of soil constraints to crop production in Jashipur block of the North Central Plateau agroclimatic zone, Odisha. *International Journal of Agriculture and Food Science*. 2026;8(10):251-257. doi: <https://www.doi.org/10.33545/2664844X.2026.v8.i10d.2025>