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Original Article

Mapping of soil major and secondary nutrients status for site-specific fertiliser recommendation using GPS and GIS in the Rayalaseema region, India

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ABSTRACT

Better crop production mainly relies on the soil's ability to provide sufficient available nutrients for crop uptake, thereby achieving higher yields and higher-quality crops. The objective of the study was to determine the soil's available nutrient status and map for site-specific fertiliser recommendations. Thus, 87 surface soil (0-20 cm) samples were collected randomly from different farmlands using GPS in the Rayachoty mandal, Rayalseema region, Andhra Pradesh, representing all the major landforms. Soil samples were analysed for pH, electrical conductivity (EC), organic carbon, major and secondary nutrients using standard procedures, and were mapped through kriging and interpolation in ArcGIS. Results revealed that soils were moderately acidic to strongly alkaline in soil reaction and were non-saline. Organic carbon ranged from low to high (0.20 -2.11%); however, 25.50, 24.98 and 21.67 per cent of the area is under low, medium and high, respectively. About 66.46 per cent of the area was low in available phosphorus content. Available potassium levels varied from low to high (36-442 kg ha^{-1}). Available sulphur content varied from low to high (0.83 - 263.46 ppm). Mapping of soil fertility parameters has implications for site-specific and optimum fertiliser recommendations to maintain soil nutrient balance to achieve elevated yield and income, thereby improving the livelihood status of small and marginal farmers in the Rayalseema region.
Keywords: Mapping, Available nutrients, Rayalseema region, Soil test-based fertiliser recommendation, GPS and ArcGIS

1. INTRODUCTION

Information on soil available nutrients status was still very scarce as it changes in a short-term period thus it is very much needed for assessing, mapping and knowing the soil available nutrient status at a much larger scale to provide farmers with information on recommendations of nutrient/ fertilizer specific to land unit that will improve agricultural productivity, maintains soil health and controls chemical land degradation in a long run. There is an immense dependence of agricultural productivity on soil nutrient supply capacity. The better the available nutrient capacity, the better the crop nutrient uptake, and the better the yield and quality of crops. Knowing the available nutrient status is a prerequisite for the best management decisions, such as the selection of appropriate fertiliser dose, methods, and frequency of application. Generally, crop yield gaps could be related to inadequate replenishment and improper management of soil nutrients. The sustainability of a productive soil mainly depends on its ability to supply essential nutrients to the growing plants. With the above views, the present study has been undertaken at Rayachoty mandal, YSR Kadapa district, Rayalseema region, Andhra Pradesh, with the objective of knowing the soil available major and secondary nutrient status and mapping to recommend site-specific soil test-based fertiliser for crop production.

2. Status of soil available major and secondary nutrients and mapping in Rayachoty Mandal, Rayalseema region, India

2.1 Soil reaction (pH)

The soil reaction classes of Rayachoty mandal (Table 1 and Fig. 1) showed that the pH of the soils ranged from 5.44 to 9.05.

The soil pH indicated that 23.92 per cent of the area was neutral, followed by slightly acidic soils, which covered about 15.92 per cent of the area. Slightly alkaline soils occurred over 15.65 per cent of the area. 9.03 per cent of the area was moderately alkaline, and 6.15 per cent was moderately acidic. A small area, about 1.48 per cent, was strongly alkaline. It is important to have soil pH in a favourable range as it controls nutrient availability and microbial activity in the soil (Espinoza *et al*., 2010). The wide variation in soil pH might be due to the nature of the parent material, leaching and free calcium carbonate content in the soil. Higher soil reaction might be due to the presence of calcium carbonate in the soil (Shalima and Kumar, 2010).

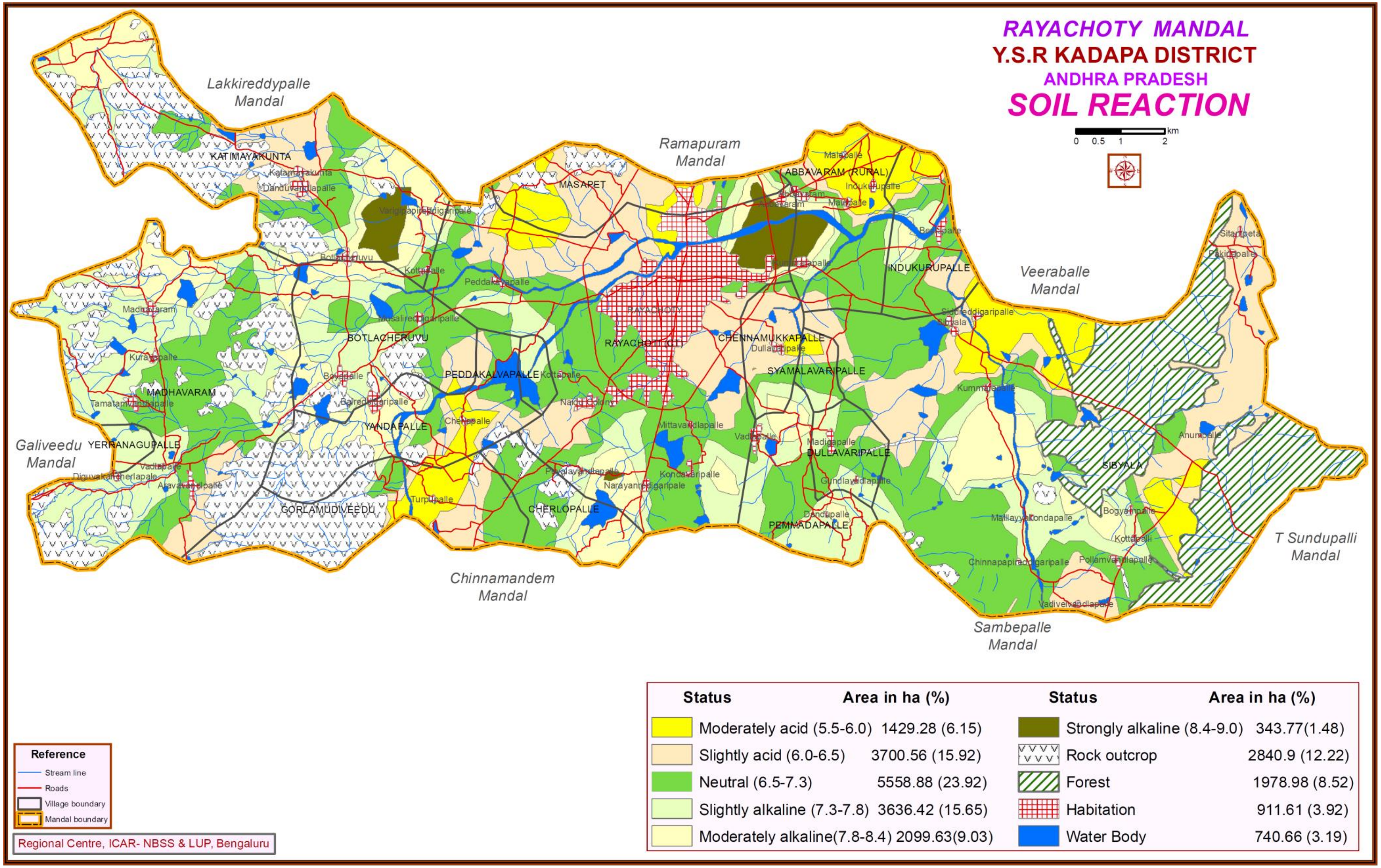

Fig. 1: Surface soil reaction status in Rayachoty mandal, Rayalseema region, India

Thus, for slightly acidic soils (pH 5.6 - 6.5), gradual and controlled application of lime can effectively elevate the pH towards neutrality. In strongly alkaline soils (pH 8.5 - 9.0), the use of acidifying agents like ammonium sulphate or elemental sulphur can progressively lower the pH over time. Whereas, for neutral soils (pH 6.6 - 7.3), the incorporation of organic amendments such as compost or well-decomposed manure can improve soil structure and augment the organic matter content.

Table 1: Soil reaction classes in Rayachoty Mandal

Soil reaction classes	Rayachoty mandal	
	Area (ha)	Per cent area
Moderately acid (5.5-6.0)	1429.28	6.15
Slightly acid (6.0-6.5)	3700.56	15.92
Neutral (6.5-7.3)	5558.88	23.92
Slightly alkaline (7.3-7.8)	3636.42	15.65
Moderately alkaline (7.8-8.4)	2099.63	9.03
Strongly alkaline (8.4-9.0)	343.77	1.48
Soil total	**16768.55**	**72.15**
Rock outcrops	2840.9	12.22
Forest	1978.98	8.52
Habitation	911.61	3.92
Water body	740.66	3.19
Total geographical area	23240.7	100.00

2.2. Organic carbon (OC)

The organic carbon content of the soils in Rayachoty mandal ranged from 0.20 to 2.11 per cent (Table 2 and Fig. 2). A total of 25.50 per cent of the area recorded low organic carbon content, 24.98 per cent had medium levels, and 21.67 per cent had high organic carbon content. Soil organic carbon is part of the soil organic matter (SOM), which includes other important elements such as calcium, hydrogen, oxygen and nitrogen (Espinoza et al., 2010). SOM serves as a reserve for many essential nutrients, especially nitrogen and also influences soil physical, biological and chemical properties (Tsheringl *et al*., 2020). The study area was well aerated with a warm arid climate, which led to the rapid decomposition of added materials, likely contributing to the low organic matter in most of the region (Raj *et al*., 2020).

The high organic carbon content in some areas was likely due to the addition of sufficient organic manure to the soil for crop cultivation/production. Addition of nutrients and organic manures stimulated the crop growth and higher biomass, which in turn enriched the organic matter and available nutrient contents of soil (Chandrakala *et al*., 2022).

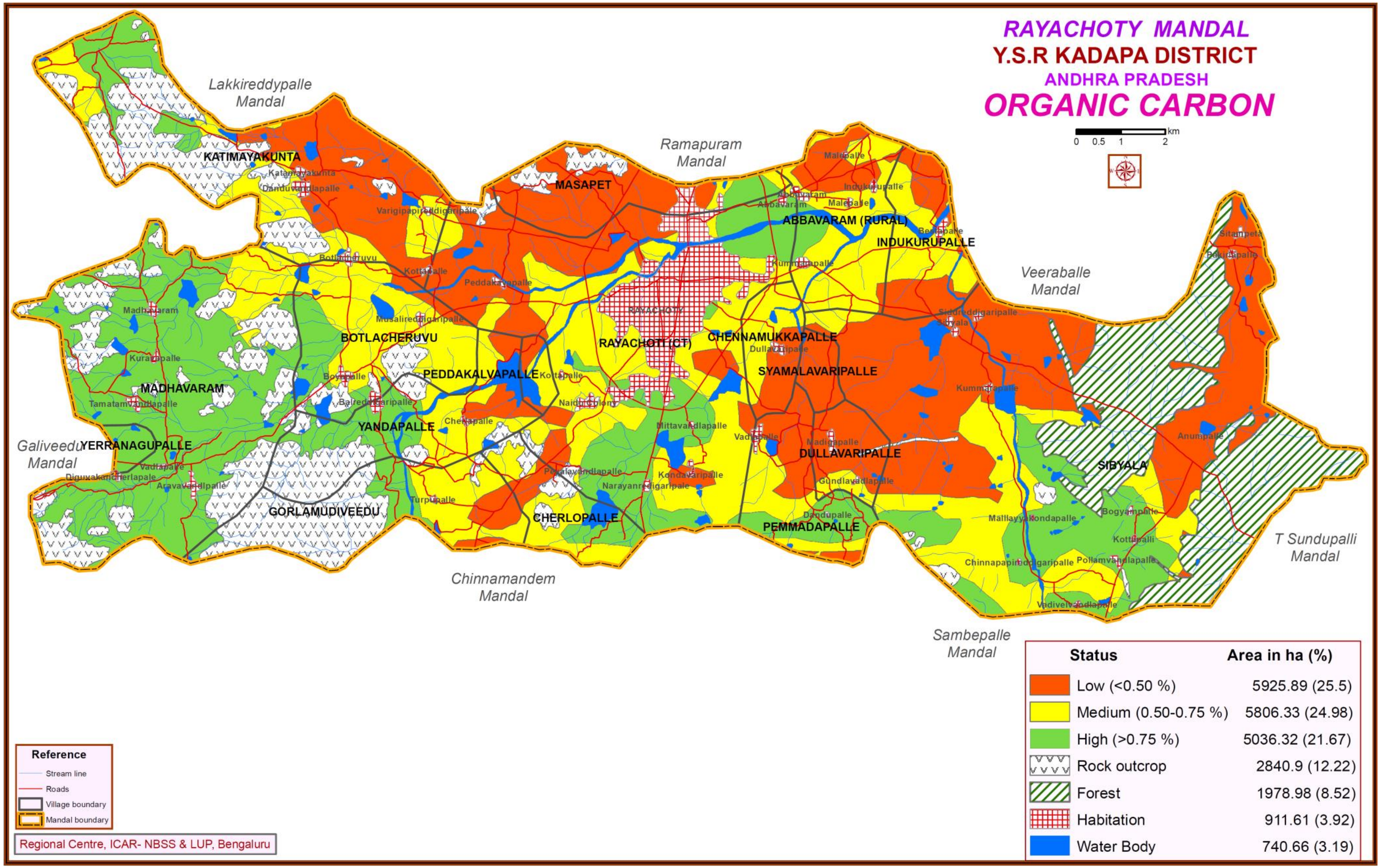

Fig. 2: Soil organic carbon status of Rayachoty mandal, Rayalseema region, India

Higher levels of organic carbon not only provide part of the nitrogen requirement of the crop plants but also enhance nutrient and water retention capacity of soils and create a favourable environment (Rajasekharan *et al*., 2013). The soils with low OC status, it is recommended to apply organic manures such as FYM, vermicompost, liquid organic manures such as panchagavya and jeevamruth to enrich the soil organic nutrient source (Chandrakala *et al*., 2023).

Table 2: Soil organic carbon classes in Rayachoty Mandal

Soil organic carbon classes	Rayachoty mandal	
	Area (ha)	Per cent area
Low (<0.50 %)	5925.89	25.5
Medium (0.50-0.75 %)	5806.33	24.98
High (>0.75 %)	5036.32	21.67
Soil total	**16768.55**	**72.15**
Rock outcrops	2840.9	12.22
Forest	1978.98	8.52
Habitation	911.61	3.92
Water body	740.66	3.19
Total geographical area	23240.7	100.00

2.3. Available phosphorus (P_2O_5)

The phosphorus content of the soils in Rayachoty Mandal ranged from 2.00 to 54.00 kg ha^{-1} (Table 3 and Fig. 3). Approximately 66.46 per cent of the study area had low available phosphorus content, while 5.69 per cent had medium levels of available phosphorus. Phosphorus availability was highly dependent on soil pH. In the strongly acidic soils of Rayachoty mandal, phosphorus tended to form insoluble compounds with iron and aluminium, making it less available to plants. Medium status of phosphorus in soils may be attributed to the arid environment due to low rainfall and also the continuous use of high-analysis phosphatic fertilisers, especially SSP (Nalina *et al*., 2016). This might also be due to the clay content, along with the CEC and phosphorus fixing capacity of the soils might be the reason behind the medium range of available phosphorus content (Rajshekhar, 2018). Phosphorus was considered as the second limiting nutrient for crop production, after nitrogen. Thus correction of soil acidity through liming can lead to the release of P fixed by soil constituents into the available pool. Hence, it is recommended to get the soils tested regularly and apply fertiliser accordingly (Mini and Usha Mathew). Thus, it is recommended to apply 125 per cent of the recommended dose of phosphorus to low P-containing soils (Chandrakala *et al*., 2023).

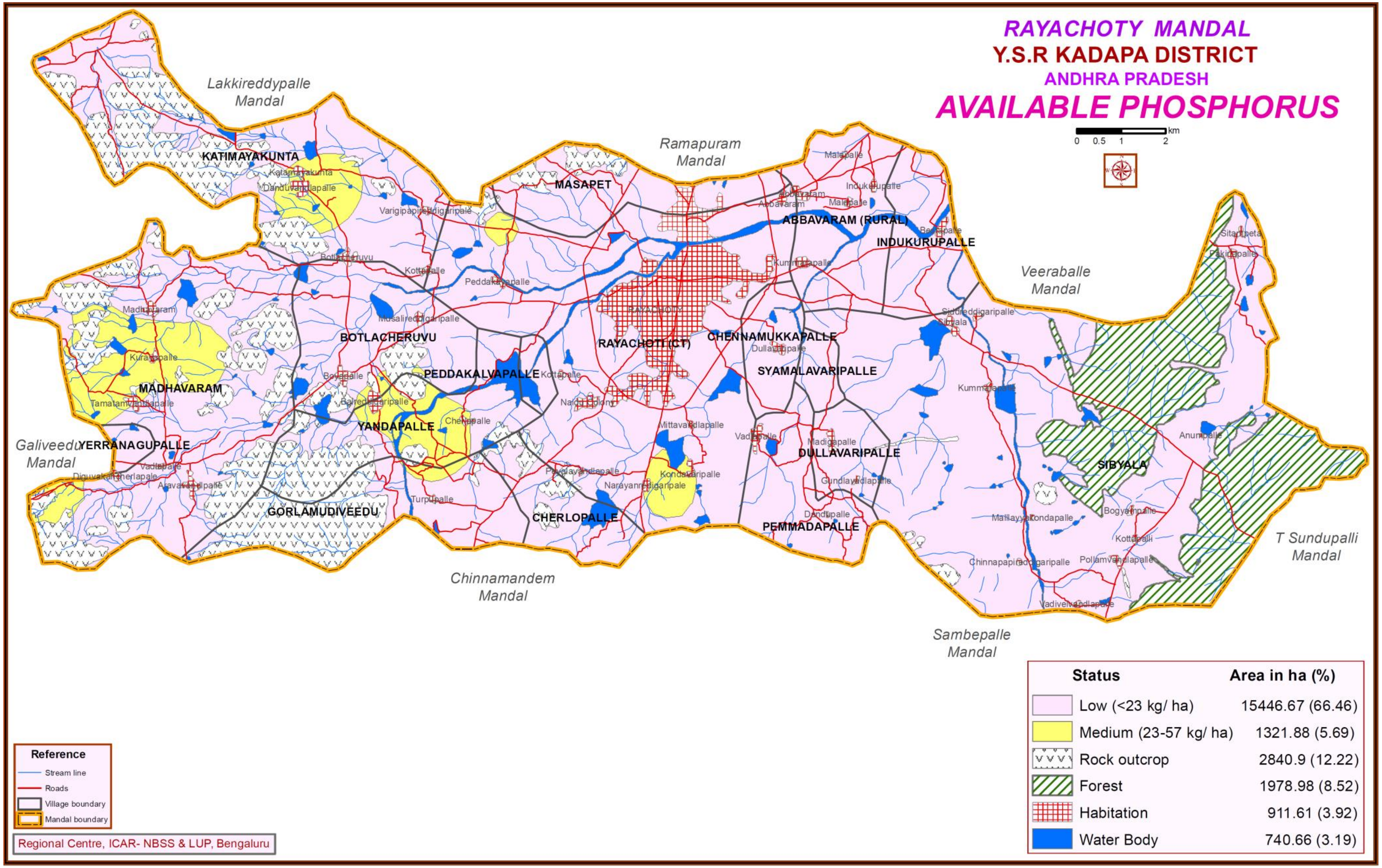

Fig. 3: Available phosphorus status of Rayachoty mandal, Rayalseema region, India

Table 3: **Available phosphorus (P_2O_5) status of Rayachoty mandal**

Available phosphorus classes	Rayachoty mandal	
	Area (ha)	Per cent area
Low (<23 kg ha^{-1})	15446.8	66.46
Medium (23-57 kg ha^{-1})	1321.8	5.69
Soil total	**16768.55**	**72.15**
Rock outcrops	2840.9	12.22
Forest	1978.98	8.52
Habitation	911.61	3.92
Water body	740.66	3.19
Total geographical area	23240.7	100.00

2.4. Available potassium (K_2O)

The potassium level in the soils of Rayachoty Mandal ranged from 36 to 442 kg ha^{-1} (Table 4 and Fig. 4). About 54.70 per cent of the area recorded low potassium levels, 15.69 per cent had medium levels and 1.77 per cent had high levels of available potassium. Low potassium content in the soil might be due to the presence of low potassium due to the leaching condition brought in by irrigation coupled with strong acidity which does not permit retention of potassium on the soil exchangeable complex (Kavitha and Sujatha, 2015). The higher status of available K is attributed due to the prevalence of potassium bearing minerals in these soils (Maragatham *et al*., 2015). Thus the regular application of potassium fertilizer to crop plants in many splits is necessary.

To maintain soil nutrient balance, it was recommended to apply 125 per cent of the recommended potassium dose in low potassium soils, 75 per cent in high potassium soils and the recommended dose in medium status soils (Chandrakala *et al*., 2023).

Table 4: Available potassium (K_2O) status of Rayachoty mandal

Available potassium (K_2O) classes	Rayachoty mandal	
	Area (ha)	Per cent area
Low (<145 kg ha^{-1})	12711.62	54.7
Medium (145-337 kg ha^{-1})	3645.75	15.69
High (>337 kg ha^{-1})	411.17	1.77
Soil total	**16768.55**	**72.15**
Rock outcrops	2840.9	12.22
Forest	1978.98	8.52
Habitation	911.61	3.92
Water body	740.66	3.19
Total geographical area	23240.7	100.00

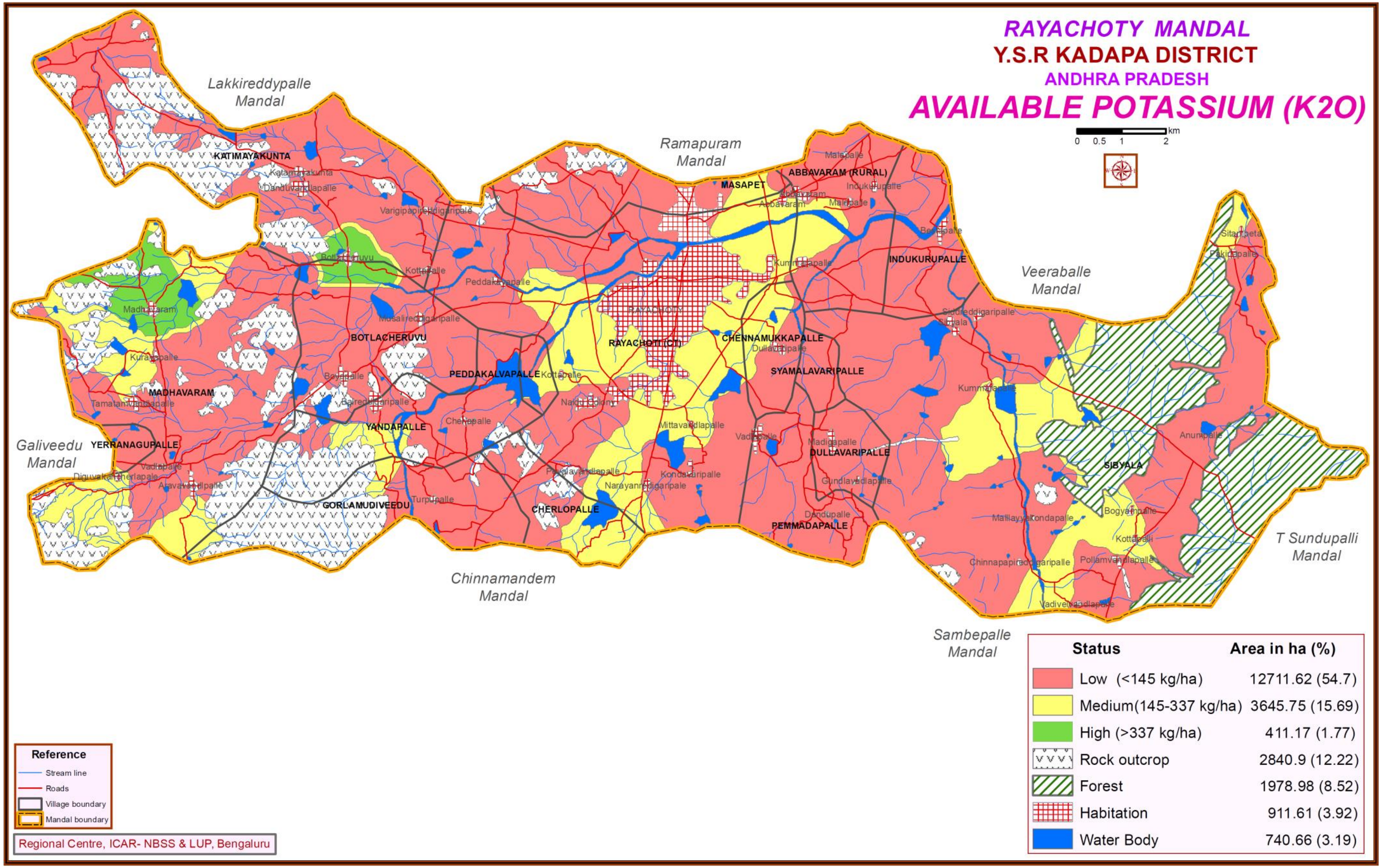

Fig. 4: Available potassium status of Rayachoty mandal, Rayalseema region, India

2.6 Available sulphur (S)

The available sulphur content in the soils of Rayachoty mandal ranged from 0.83 to 263.46 ppm (as shown in Table 5 and Fig. 5). About 26.75 per cent of the area had low sulphur levels, 22.98 per cent had high levels, and 22.42 per cent had medium levels of available sulphur. The low sulphur in soils might be attributed to continuous use of high analysis sulphur free fertilizers, inclusion of high yielding varieties in the intensive cropping system and restricted use of organic manures.

Sulphur is a limiting factor for plant growth. It is essential to supply sulphur through fertilizers. Sulphur fertilizers like gypsum ($CaSO_4$), bentonite sulphur or elemental sulphur should be applied at around 20–40 kg ha^{-1} to meet the crop's requirements if the available sulphur content is low (less than 10 ppm) in soils. In medium sulphur content areas (22.42 % of the region) supplementary sulphur application of 10–20 kg ha^{-1} could be beneficial to avoid any deficiency during critical growth phases.

Table 5: Available sulphur status of Rayachoty Mandal

Available sulphur classes	Rayachoty mandal	
	Area (ha)	Per cent area
Low (<10 ppm)	6216.93	26.75
Medium (10-20ppm)	5209.95	22.42
High (>20 ppm)	5341.66	22.98
Soil total	**16768.55**	**72.15**
Rock outcrops	2840.9	12.22
Forest	1978.98	8.52
Habitation	911.61	3.92
Water body	740.66	3.19
Total geographical area	23240.7	100.00

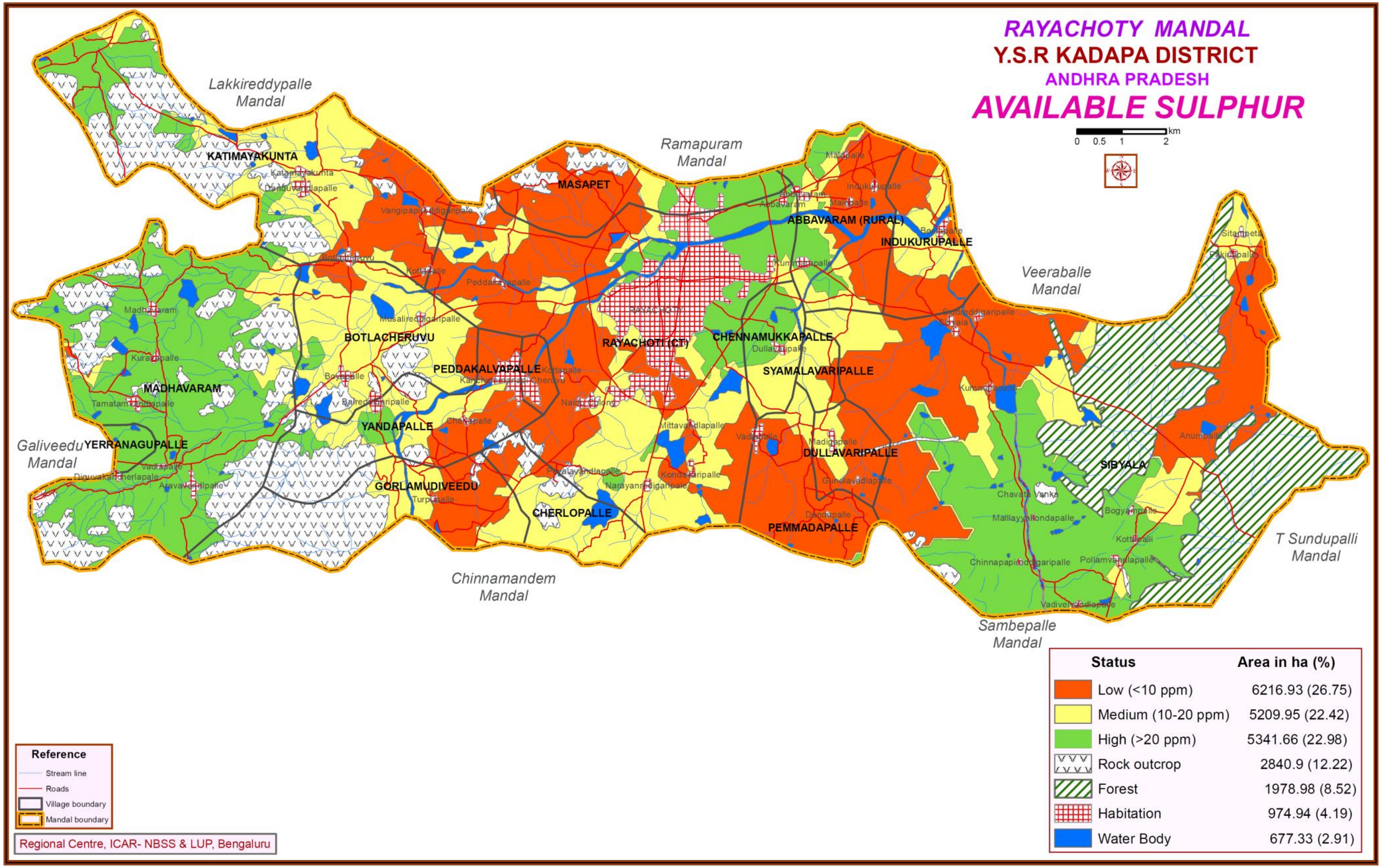

Fig. 5: Available Sulphur status of Rayachoty mandal, Rayalseema region, India

3. CONCLUSION

The soil analysis of Rayachoty Mandal in the Rayalseema region of Andhra Pradesh revealed a wide range of soil fertility status. The soil pH was found to be moderately acidic to strongly alkaline. Organic carbon content varied significantly, with 25.50 per cent of the area exhibiting low levels, while 24.98 per cent showed medium levels, and 21.67 per cent had high organic carbon. A considerable portion, 66.46 per cent, was found to be deficient in available phosphorus. Available potassium levels ranged from low to high, with values ranging from 36 to 442 kg ha^{-1}. Sulphur content was similarly variable, with concentrations ranging from 0.83 to 263.46 ppm. Mapping of soil available nutrients has implications on knowing the status of specific soil nutrient in a specific land unit which further helps to soil test based, site-specific, optimum fertilizer recommendations to maintain soil nutrient balance to achieve elevated yield and income, thereby improving the livelihood status of small and marginal farmers in the Rayalseema region.

4. REFERENCES

Chandrakala, M., Maske, S.P., Karthika, K.S., Rani, S.S., Niranjana, K.V., Srinivasan, R., Kumar, S.R., Bhaskar, B.P., Ramamurthy, V. and Patil, N.G., (2023). An evaluation of mango cultivation soils and identification of potentially suitable lands upon conversion of agricultural crop land to mango plantations in semi-arid land of south Telangana plateau, Andhra Pradesh. Indian Journal of Soil Conservation, 51(2), pp.132-143.

Espinoza, L., Slaton, N.A. and Mozaffari, M., (2006). Understanding the numbers on your soil test report. Cooperative Extension Service, University of Arkansas, US Department of Agriculture, and county governments cooperating.

Maragatham, S., Santhi, R., Radhika, K., Sivagnanam, S., Rajeswari, R., Hemalatha, S., Kanimozhi, A., Pradip Dey, P.D. and Rao, A.S., (2014). An appraisal of available nutrients status and soil fertility mapping for Salem district of Tamil Nadu. Madras Agricultural Journal, 101 (1-3), pp. 51-58.

Rajasekharan P, Nair K.M, Rajasree G, Sureshkumar P, Narayana kutty M.C., (2013). Soil fertility assessment and information management for enhancing crop productivity in Kerala. Kerala state planning board, Government.

Rajshekhar, L., (2018). Soil resources characterization, classification and productivity assessment of sigehadlu micro watershed of Chikkamagaluru district, PhD thesis, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga.

Shalima Devi, G.M. and Anil Kumar, K.S., (2010). Characterization and classification of coffee-growing soils of Karnataka. Journal of the Indian Society of Soil Science, 58(1), pp.125-131.

Tsheringl, K., Zangpo, Y., Chofil, P., Phuntsho, T. and Dorji, U., (2020). Assessment of Soil Nutrients Status of Mandarin Orchards in Dagana. Bhutanese Journal of Agriculture, 2(1), pp. 73-86.