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Geospatial Status of Available Potassium and Sulphur in Low Base Status Soils

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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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Original Research Article

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ABSTRACT

Aim: This study aims to analyse the required parameters to determine the availability of potassium and sulphur in red soils representing low base status soils of Sivagangai block of Sivagangai district, Tamil Nadu.
Study Design: Survey.
Place and Duration of Study: Survey was conducted at Sivagangai block of Sivagangai district, representing the red soils of Tamil Nadu during the winter season of 2021.
Methodology: Geo-referenced surface soil samples representing one hundred red soils were collected from the plough layer (0 to 30 cm depth) at an estimated frequency of 1 km grid over the red soils of Sivaganga block in Tamil Nadu's Sivagangai district using a handheld global positioning system (GPS). The collected samples were processed and analysed for the necessary parameters and based on that data thematic maps were created by kriging the fertility status and then exhibiting the relevant legends.
Result: The physico chemical properties of soils indicated that soils were strongly acidic to acidic in soil reaction, non - saline and low in organic carbon content. The available potassium content of the Sivagangai block ranged from 101 kg ha^{-1} to 260.5 kg ha^{-1} with a mean value of 179.4 kg ha^{-1}. When categorised 26 per cent of samples were found low in available potassium content and the remaining 74 per cent of samples were medium. Soil available sulphur status in this block ranged from 3.10 mg kg^{-1} to 18.20 mg kg^{-1} with a mean value of 10.65 mg kg^{-1} indicating that 59 per cent of

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soil samples were found low in available sulphur status, 39 per cent of soil samples were medium status and 2 per cent of soil samples were under high status.

Conclusion: Using the geocoordinates, thematic maps for all the parameters were prepared, which indicated that the major area of the block was acidic in soil reaction, non-saline, low in organic carbon, low in free calcium carbonate, low to medium in available potassium and low in available sulphur. These maps will be useful in constructing homogenous units and assist farmers in determining the quantity and kind of potassium and sulphur fertiliser to be applied in order to optimize economic returns based on site-specific nutrient management.

Keywords: Potassium; Sulphur; low base status; organic carbon; calcium carbonate.

1. INTRODUCTION

Red and lateritic soils cover approximately 91 million ha (28 % of TGA) in India, primarily in the states of Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra, Goa, Orissa, West Bengal, Sikkim, the north-eastern parts of Andaman and Nicobar, and Pondicherry, and represent semi-arid, moist through sub-humid, humid/perhumid to coastal and island ecosystems. Transformation, translocation, and illuviation result in the release and dispersion of iron and aluminium hydroxides, which results in the development of soils. These soils have a coarse texture, well-drained, have honeycomb ferruginous concretion at a depth of 15 to 30 cm, prone to erosion, and acidic in reaction (pH 5.5 to 6.2). Because of variations in soil-forming factors and processes, such as rainfall, drainage, translocation, and oxidation, these soils are typically less productive due to coarse texture, low water holding capacity, acidity, poor availability of N, P, and K, both excessive and inadequate levels of several secondary and trace elements, low to moderate cation exchange capacity, and organic carbon content [1,2].

Indian soils are often low in fertility, as their restricted nutrient resources have been repeatedly exhausted through many centuries of continuous farming without sufficient fertilizer replacement. Sixty per cent of the soil has a poor to medium K status, according to soil tests [3]. Widespread sulphur deficiency has been documented in red and lateritic soils [4,5]. In the last half-century, a major increase in sulphur insufficiency has been documented in intensive cropping systems that use high-analysis fertilisers devoid of sulphur.

Soil-test data from 500 districts across the country found that soils were low (120 kg ha^{-1}) to medium (120-280 kg ha^{-1}) in available K (NH_4OAc-K) in 51 per cent of the samples [6]. Also, according to a soil fertility survey conducted in 300 locations across Kerala, Karnataka, and Tamil Nadu, soils are acidic, extensively leached, and lacking in soil accessible K [7]. Out of 615 districts in 28 Indian states, more than half of the soils in agriculture areas in 101 districts were found to be insufficient in accessible S [8]. Sulphur deficiency was higher than 40 per cent in Madurai, Villupuram, Thiruvannamalai, and Thiruvallur districts in Tamil Nadu, 20 per cent to 40 per cent in Coimbatore, Erode, Trichy, and Dindugal districts, and less than 20 per cent in Thanjavur, Tuticorin, Kanyakumari, Ramnad, and Nilgiris districts. In red soils from the Coimbatore district, the available sulphur status was determined to be low to medium (Udic Haplustalf) [9].

Under these circumstances it may be worthwhile to conduct a soil fertility assessment of various red and lateritic soils covering selected villages in Tamil Nadu's Sivagangai district, with a focus on K and S.

As a result, when formulating fertiliser recommendations, spatial information on nutrient status should be considered. Recent technologies, such as the global positioning system (GPS) and geographic information system (GIS), make soil fertility mapping easier and give quantitative assistance for decision-making and policy-making to improve agricultural approaches to balanced nutrition. GPS and GIS aid in the collection of a systematic set of georeferenced samples and the generation of spatial data on nutrients which will be useful for planning soil fertility management [10].

2. MATERIALS AND METHODS

2.1 Soil and Climatic Resources

Red soils cover more than two-thirds of Tamil Nadu's entire land area. It is typically found in the state's central areas. It has a sandy, loamy texture. It is the most common type of soil in

Tamil Nadu, accounting for 62 per cent of the total. Sivagangai, Ramanathapuram, Chennai, Kancheepuram, Erode, Coimbatore, Tiruppur, Thanjavur, and Nagapattinam are among the districts where it is distributed. Red soils encompass 2,10,600 acres in the Sivagangai district, accounting for 50.2 per cent of the total area.

Tamil Nadu's Sivaganga district covers 4,189 square kilometres. Sivaganga district is located between 9° 43' and 10° 2' north latitude and 77° 47' and 78° 49' east longitude in the Indian subcontinent. Pudukkottai District borders it on the north and northeast, Ramanathapuram District on the southeast and south, Virudhunagar District on the southwest, Madurai District on the west, and Tiruchirappalli District on the northwest. The only hill area in the Sivagangai district is Piranmalai. The Vaigai River is a major river that runs through the Sivagangai district. The town experiences a tropical climate with both wet and dry seasons. In the summer, the maximum temperature is 37 °C (98.6 °F), while in the winter, it is 28 °C (82.4 °F). The minimum temperature ranges from 23.9 to 27.8 degrees Celsius (75.0 to 82.0 degrees Fahrenheit). The climate is temperate throughout the year has consistently pleasant weather. During the northeast monsoon, the town receives the majority of its rainfall. The yearly rainfall averages 931 millimeters (36.65 inches).

2.2 Soil Survey and Laboratory Analysis

With the use of a hand-held global positioning system (GPS), 100 soil samples were taken from the plough layer (0 to 30 cm depth) at an approximate frequency of 1 km grid over the red soils of Sivaganga block in Sivagangai district in Tamil Nadu. The village boundaries on the taluk map of the Sivagangai district were scanned in tiff format and loaded into a GIS system version 10.8. Air-dried soil samples were crushed to pass through a 2 mm sieve. In a 1:2.5 soil/water suspension, the pH and EC were measured with a glass electrode [11], Organic Carbon estimation [12] and free $CaCO_3$ by rapid titration method [13]. Potassium was extracted using 1N NH_4OAc [11] and then measured using a flame photometer. Sulphur was recovered from the soil using a 0.15 % $CaCl_2.2H_2O$ solution [14] and estimated by the turbidimetric method [15].

2.3 Generation of Maps

The district's Ground Control points were discovered, and the map was geo-referenced using them. The boundaries of the revenue villages were scanned in polyconic mode and saved in shape (shp) format. Following digitization, the necessary modifications to the clean block and revenue village layer were made in preparation for topology building. In the layer, distinct ids were assigned to the villages to assign various database properties. The point data was joined to the database file. Geo statistics was utilised to estimate and map soils in areas that were not sampled. Different thematic layers were classed from the attribute database to construct distinct thematic maps on pH, EC, OC, $CaCO_3$, and plant available potassium and sulphur values. On thematic maps, appropriate annotations such as legends, palettes, north arrows, and scale were created. As a result, thematic maps of available potassium and sulphur in the Sivagangai block were created and shown. To estimate values of soil chemical characteristics for unsampled places, ordinary kriging, an accurate interpolator, was used. Kriging was carried out with the help of a Geostatistical Analyst, which is integrated with Arc GIS 9.1. The available nutrient status thematic maps were created by kriging the fertility status as very low,' 'low,' and medium,' and then exhibiting the relevant legends 'very Deficient,' 'Deficient,' and 'Moderate'[16].

4. RESULTS AND DISCUSSION

In Figs. 1 to 6, soil fertility maps for six chemical parameters are displayed. The pH of the surface soil in the Sivagangai block's red soils ranged from 4.6 to 6.9, with a mean of 5.8. Ten per cent of the samples were strongly acidic, 45% were moderately acidic, and the remaining 45 per cent were slightly acidic, which appeared to be related to acidic parent materials and leaching of bases such as calcium, magnesium, potassium, and sodium from the soil, which resulted in high hydrogen ion concentrations due to heavy precipitation during the rainy season [17]. The soluble salts in the samples ranged from 0.01 to 0.39 dS m^{-1}, showing that these soils were non-saline [18]. The EC values suggest a low amount of soluble salts which could be attributed to the loss of bases due to heavy rainfall during monsoon [19].

The organic carbon content of the soils in this block was found to be low (0.3% -0.5 %) with a mean value of 0.44 %. This could be due to the fact that these soils have very little organic matter addition, to them, as well as the current warm and hot environment, which causes organic matter to decompose more quickly [20] [21]. The negative relationship between OC and pH may be due to the increased activity of microorganisms, particularly soil bacteria, with higher pH (not >8) [22].

Table 1. Per cent area under different fertility categories based on soil fertility maps

Parameters	**Strongly Acidic/Non-saline/ Low/ deficient**	**Per cent category Slightly Acidic/ Slightly saline/ Medium/ moderate**	**Moderately acidic /Saline / High / Sufficient**
pH	10	45	45
EC	100	0	0
Organic Carbon	100	0	0
Calcium carbonate	100	0	0
Available Potassium	26	74	0
Available Sulphur	59	39	2

Soil fertility maps of Sivagangai block

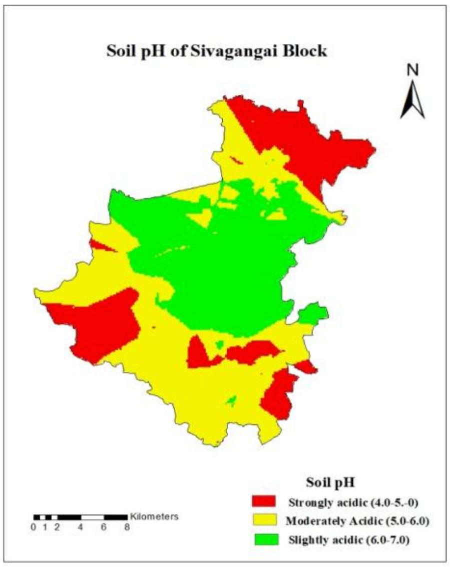

Fig. 1. pH

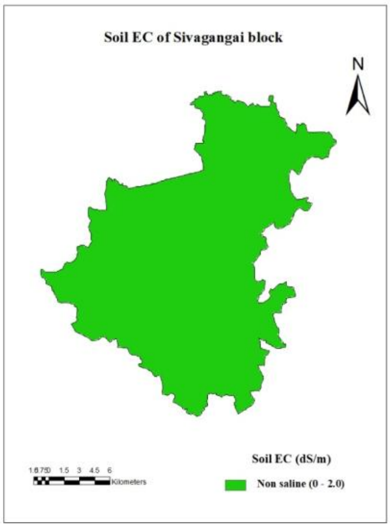

Fig. 2. EC

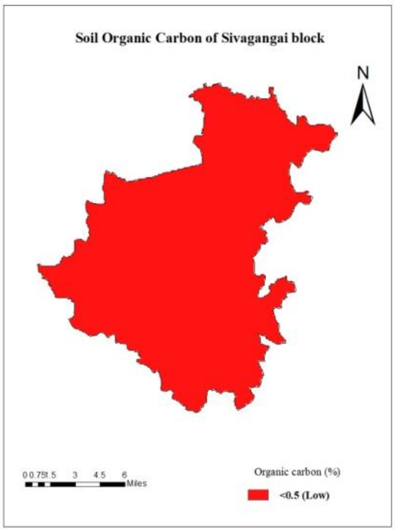

Fig. 3. Organic Carbon

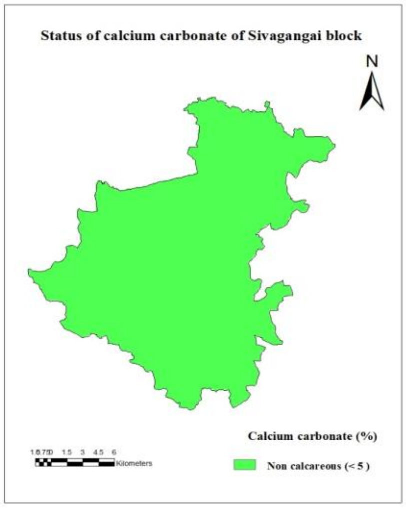

Fig. 4. Calcium Carbonate

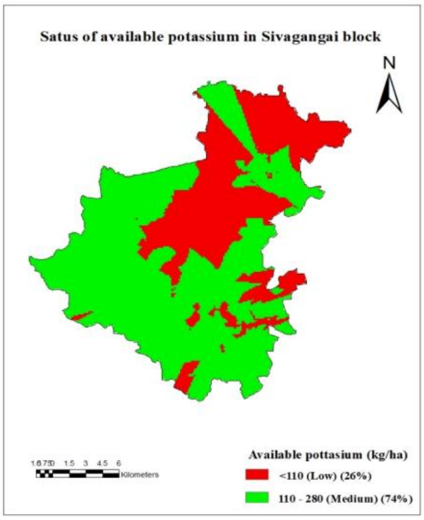

Fig. 5. Available Potassium

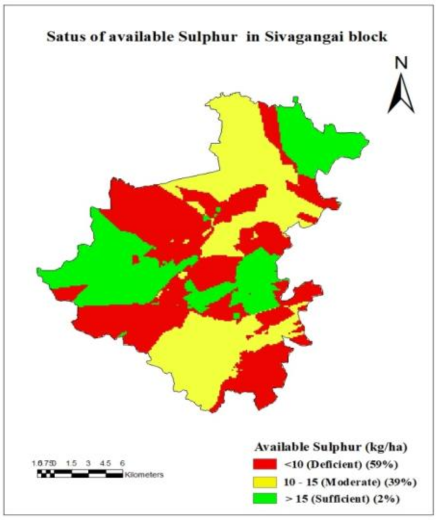

Fig. 6. Available Sulphur

The calcium carbonate content of Sivagangai blocks was found very low which is non-calcareous. The relation between pH and $CaCO_3$ was positively correlated. Similar types of correlations were found in the red soils of Andhra Pradesh [23,24].

The available potassium content of red soils of Sivagangai block was low (26%) to medium (74%). The available potassium content in these soils ranged from 101 kg ha^{-1} to 260.5 kg ha^{-1} with an average of 179.4 kg ha^{-1}. High rainfall may have caused the leaching of bases in deeper strata, resulting in a low concentration of available potassium. The majority of soils in Jharkhand (approximately 51 % of TGA) have a medium K level, whereas roughly 18 per cent have a low K value [25]. These results corroborated in the Alfisols orders of Pamgarh block in Janjgir-Champa district (C.G.) [26].

From 6.6 to 16.1 kg ha^{-1}, the plant available sulphur level was determined to be low (59%), medium (39%), and high (2%) with an average content of 9.8 kg ha^{-1}. Low plant available sulphur has been reported in red and lateritic soils of West Bengal [4,5]. In the country's acid soil region, sulphur deficiency ranged from 17 to 87 per cent [27]. Farmers have transitioned from single super phosphate to DAP as a phosphorus source, resulting in a low sulphur status of soils due to the non-application of sulphur-based fertilisers due to a lack of recognition among farmers. To satisfy the positive charges, sulphur is also adsorbed by sesquioxides. Sulphur interacts with $CaCO_3$ to generate $CaSO_4$, which is less soluble in soil and reduces its availability. The continuous use of S-containing herbicides and fertilisers, which contain sufficient amounts of sulphur to suit the requirements of growing crops, could be related to the medium and high sulphur ratings in soils [28,29].

5. CONCLUSION

Based on the study results it was concluded that soils of Sivagangai block are strongly acidic to slightly acidic in soil reaction. All the soil samples in the study area had an EC of less than 0.4 dS m^{-1} and <1.5% calcium carbonate, showing that the soils were non-saline and noncalcareous. From all the samples collected, more than half of the soil samples were low in available potassium and sulphur indicating low base saturation of these samples. The maps created as part of the study will be beneficial in establishing management units and aiding farmers in determining the amount and kind of potassium and sulphur fertiliser needed to be applied in order to maximize the economic returns based on site-specific nutrient management.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raychaudhuri SP, Agarwal RR, Datta Biswas NR, Gupta SP, Thomas PK. Soils of India, 1st. EDN. 1963:469.
2. Sehgal J, Challa O, Thampi CJ, Maji AK, Bhushana SRN. Red and lateritic soils of India. A A Balkema Publishers. 1998;1-18.
3. Pathak R, Arya V, Shrivastava S, Dhakad H, Trivedi SK. Status of macro and micronutrients in inceptisol and vertisol of Gwalior district of Northern Madhya Pradesh. Int J Chem Stud. 2017;5(5):156-60.
4. Ghosh GK, Chattopadhyay GN, Chattopaddhyay S. Availability and forms of sulphur in red and lateritic soils of Birbhum district of West Bengal. Indian J Agric Sci. 2005;75:358-60.
5. Patra P, Mondal S, Ghosh GK. Status of available sulphur in surface and subsurface soils of red and lateritic soils of West Bengal. Int J Plant-Anim Environ Sci. 2012;2:276-81.
6. Muralidharudu Y, Sammi Reddy K, Mandal BN, Subba Rao A, Singh KN, Sonekar S. GIS based soil fertility maps of different states of India. Bhopal: Indian Institute of Soil Science; 2011.
7. Sadanandan AK, Peter KV, Hamza S. Role of potassium nutrition in improving yield and quality of spice crops in India. Switzerland: Haryana and International Potash Institute. 2002;445-54.
8. Shukla AG. Evaluation of soil fertility in soils of Pamgarh blocks, district Janjgir-Champa of Chhattisgarh, M. Sc.. Agriculturists [thesis], IGKV Raipur, (Chhattisgarh). 2011;63-4.
9. Sankaran K, Savithri P, Poongothai S, Sakthikumaran S. Direct and residual effect of sulphur application on Maize-green gram cropping system. Fertil Mark News. 2002;33:1-8.
10. Sharma PK. Emerging technologies of remote sensing and GIS for the development of spatial data structure. J Indian Soc Soil Sci. 2004;52(4):384-406.
11. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Private Limited. 1973;134-82.
12. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Sci. 1934;37(1):29-38.
DOI: 10.1097/00010694-193401000-00003.
13. Piper C. Soil and plant analysis. Australia: University of Adelaide. Bombay, India: Hans Publishers; 1966.
14. Williams CH, Steinbergs A. Soil sulphur fractions as chemical indices of available sulphur in some Australian Soils. Aust J Agric Res. 1959;10(3):340-52.
DOI: 10.1071/AR9590340.
15. Hesse PR. Soil chemical analysis. John Murray publication Ltd., Londan; 1971.
16. Krige DG. A statistical approach to some basic mine valuation problems on the Witwatersrand. J South Afr Inst Min Metall. 1951;52(6):119-39.
17. Nayak RK, Sahu GC, Nanda SSK. Characterization and classification of the soils of Central Research Station, Bhubaneswar. Agropedology. 2002;12(1):1-8.
18. Sitanggang M, Rao YS, Ahmed N, Mahapatra SK. Characterization and classification of soils in watershed area of Shikohpur, Gurgaon district, Haryana. J Indian Soc Soil Sci. 2006;54(1):106-10.
19. Raj K, Nayyar VK, Sidhu GS, Deshmukh SN. Distribution of available micronutrient cations in some dominant soil series in different physiographic units of Bundelkhand region of Madhya Pradesh. J Indian Soc Soil Sci. 1990;38(3):410-5.
20. Kameriya PR. Characterization of soils of agro climatic zone of transitional plain of in land drainage Zone 11-A, of Rajasthan ([doctoral dissertation] [Ph.D. thesis]. Bikaner: RAU); 1995.
21. Rego TJ, Nageswara Rao V, Seeling B, Pardhasaradhi G, Kumar Rao JVDK. Nutrient balances—a guide to improving sorghum- and groundnut-based dryland cropping systems in semi-arid tropical India. Field Crops Res. 2003;81(1):53-68.
DOI: 10.1016/S0378-4290(02)00199-5.
22. Rousk J, Brookes PC, Bååth E. Contrasting soil pH effects on fungal and bacterial growth suggest functional redundancy in carbon mineralization. Appl Environ Microbiol. 2009;75(6):1589-96.
DOI: 10.1128/AEM.02775-08, PMID 19151179.
23. Malavath R, Mani S. Differences in the distribution of Physicochemical properties and available nutrients status in some red, red laterite and black Soils in the semi-arid region of Tamil Nadu. J Pharmacogn Phytochem. 2018;7(2):451-9.
24. Thangasamy A, Naidu MVS, Ramavatharam N, Reddy CR.

Characterisation, classification and evaluation of soil resources in Sivagiri micro-watershed of Chittoor District in Andhra Pradesh for sustainable land use planning; 2015.
25. Sarkar AK. Acid soils: their chemistry and management. Nipa Genx Electronic Resources & Solutionsp. Ltd; 2013.
26. Shukla AK, Behera SK, Prakash C, Tripathi A, Patra AK, Dwivedi BS et al. Deficiency of phyto-available sulphur, zinc, boron, iron, copper and manganese in soils of India. Sci Rep. 2021;11(1): 19760.
DOI: 10.1038/s41598-021-99040-2, PMID 34611190.
27. Singh MV. Problems of micro and secondary nutrients in acid soils of India and their management. Bull Indian Soc Soil Sci. 2007;25:27-58.
28. Wagadre N, Patel MV, Patel HK. Response of summer greengram (*Vigna radiata* L.) to vermicompost and phosphorus with and without PSB inoculation. 2010;111-4.
29. Jamal A, Fazli IS, Ahmad S, Abdin MZ, Yun SJ, editors (2005). Effect of sulphur and nitrogen application on growth characteristics, seed and oil yields of soybean cultivars. Korean Journal of Crop Science State level seminar on organic farming, Navsari, Gujarat. 2010';50(5):340-345.

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