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Characterization of available Sulphur and micronutrient status in the soils of Perambalur district in Tamil Nadu

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Abstract
An investigation was carried out by collecting 507 geo-referenced surface soil samples from 127 panchayat villages at 4 samples per village along and analyzed for soil physico-chemical properties, available sulphur and DTPA extractable micronutrients. The overall soil reaction (pH) in the district varied from 6.90 to 9.00 with a mean of 8.23, indicating that the soils were alkaline in nature. The salt status was low with an electrical conductivity of 0.11 to 2.60 dS m^{-1} with the overall organic carbon content of low status. The available sulphur (CaCl$_2$- S) content in the soils of Perambalur district ranged from 10.8 to 127 mg kg^{-1} with a mean of 52.3 mg kg^{-1} indicating the sufficiency. The available micronutrients status in the soils varied from 2.42 to 34.9, 2.10 to 19.3, 0.14 to 8.75 and 0.20 to 7.70 mg kg^{-1} respectively for DTPA Fe, Mn, Zn and Cu. The soils of Perambalur district were very high in S and Mn fertility, adequate to high in Fe, low to very high in Zn, low to high in Cu and B availability. Zinc was predominantly deficient in the soils (45.4%) followed by Cu (39.3%) and Fe (4.59%). None of the soil samples collected from the district was deficient in Mn and S.

Keywords: Perambalur district, soil fertility assessment, deficiency, nutrient index ratings

Introduction

Increase in food grain production to meet the demand of the growing population in the present day agricultural greatly depends on technologies and natural resources available in the country. Among the natural resources, land and water are the two important sources decide the agricultural production in any country. Use of high yielding varieties coupled with reduced use of organic manures, imbalanced fertilization practices and continuous intensive mono cropping lead to the depletion of many soil nutrients. Land degradation in the country is estimated to be around 44% (Mythili and Goedecke, 2015) [4] which is increasing day by day in a alarming rate. Soil degradation is becoming a major issue across the country and requires proper evaluation for its suitability and management (Naveen Kumar *et al.*, 2018). In today's agriculture, reducing the cost of cultivation is one of the main strategies to get margins from cultivation. For this, region specific land resource inventory will be very much helpful to make specific recommendations. Micronutrients deficiencies are the major limitations across the world and threaten crop productivity and soil quality (Shukla *et al.*, 2014) [13].

Evaluation of soil fertility status is an important aspect in the context of sustainable agricultural production and for the sustenance of soil fertility. Soil resource inventory through characterization and assessment of secondary and micronutrients provides information about sufficiency/deficiency status of particular nutrients, which will be very much useful for the district level planning. Hence, soil fertility assessment is a prerequisite for crop cultivation to achieve higher crop productivity and in this context, ground truth soil survey was conducted in Perambalur district of Tamil Nadu, with an objective of assessing the micro and secondary nutrients fertility status so as to make specific recommendations for getting maximum crop yield and improved soil health.

Materials and Methods
Study area
Perambalur district occupies an area of 1752 km^2 and is bounded by Cuddalore in the north, Tiruchirappalli in south, Ariyalur in the east and Namakkal and Tiruchirappalli districts in the west.

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The district lies between 11°14'00.59"N North latitudes and 78° 52'59.85"E East longitudes. Wells and tube well are the main source of irrigation and the principle crops grown are maize, paddy, groundnut and sunflower. Major soil types are black and red soils.

Sample collection and analysis

Village wise surface samples @ 4 per village from 0 -15 cm depth were collected along with GPS coordinates from all the blocks of the district. Totally 507 surface samples were collected from four blocks, *viz.*, Perambalur, Veppur, Veppanthattai and Allathur. The collected soil samples were processed, air dried, sieved through 2.00 mm sieve and analyzed for available Sulphur and micronutrients (Zn, Fe, Cu, Mn and B) by adopting standard procedures. The pH of the soil sample was determined in 1: 2.5 soil-water suspensions with the help of glass electrode pH meter as described by Jackson (1973). Electrical conductivity (EC) was estimated by the method described by Jackson (1973) and Organic carbon (OC) by rapid titration method given by Walkley and Black (1934). Available sulphur was determined turbidimetrically using barium chloride (Williams and Steinbergs, 1959). Micronutrients were extracted with DTPA and quantified using Atomic absorption spectrophotometer as outlined by Lindsay and Norwell, (1978). Based on the fertility rating, the soil samples were grouped as specific nutrient deficient or sufficient using the critical limits established for Tamil Nadu soils. Per cent deficiencies of micronutrients in each block were also generated to know the extent of deficiencies in the district.

Categorization of sample based on critical limits

The analytical results of each soil sample were categorized in to low, medium and high status based on the critical limits and the per cent sample category and Nutrient Index values (NIV) were worked out using the following formula.

$$\text{Per cent sample category} = \frac{\text{Soil samples under low or medium or high category}}{\text{Total number of samples}} \times 100$$

$$\text{Nutrient Index Value (NIV)} = \frac{[(P_H*3+ (P_M*2) + (P_{L*}1)]}{100}$$

P_L, P_M and P_H are the percentage of soil sample falling in the category of Low, Medium and High nutrient status and given a weightage of 1, 2 and 3 respectively (Ramamoorthy and Bajaj, 1969). The index values were further rated in to very high (2.66), high (2.33 to 2.66), adequate (2.00 to 2.33), marginal (1.66 to 2.00), low (1.33 to1.66) and very low (<1.33) fertility (Ramamoorthy and Bajaj, 1969) to have an overall fertility rating of the soils in the district.

Results and Discussion

The overall soil reaction (pH) in all the blocks of Perambalur district ranged from 6.90 to 9.00 with a mean of 8.23, indicating that the soils are alkaline in nature (Table.2) and about 96.4% were found to be alkaline which might be due to high degree of base saturation (Sharma *et al.*2008). Continuous use of inorganic basic fertilizers, presence of parent materials rich in bases might also favoured the alkalinity in surface soils. All the samples analyzed from Veppur and Allathur block showed 100% alkalinity. The electrical conductivity (EC) of the soils in Perambalur district varied from 0.11 to 2.60 dSm^{-1} with a mean of 0.74 dSm^{-1} (Table 3). About 34.2 per cent samples were non saline in nature with 32.9 and 33.0 per cent falls under slightly saline and saline in nature. Lesser slat content in the soils might be due to inherent soil properties (Sharma *et al.*2008) [8]. The organic carbon content in the soil ranged from 0.06 to 1.21 % with a mean of 0.42% indicating that most of the soils were low in organic carbon in the district (Table 4). About 70.8, 18.9 and 10.3 % of the samples were low, medium and high in carbon status respectively. The NIV ranged from 1.17 to 1.61 and the fertility status varied from very low to low. More than 65 per cent of the soil under low status might be due to lesser or no organic matter application (Rego *et al.* 2003) [3] and rainfed farming.

Table 1: Critical limits of micronutrients (mg kg^{-1})

Element	Low (Deficient)	Medium (Moderate)	High (Sufficient)
Zinc	<1.20	1.20-1.80	>1.80
Iron	<3.70	3.70-8.00	>8.00
Manganese	<2.00	2.00-4.00	>4.00
Copper	<1.20	1.200-1.800	>1.80

Table 2: Range and mean values and per cent sample category for pH in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category		
				Acidic	Neutral	Alkaline
1	Perambalur	7.10-8.90	7.98	0.00	8.05	91.9
2	Veppur	7.80-8.90	8.40	0.00	0.00	100
3	Veppanthattai	6.90-9.00	8.20	0.00	6.20	93.8
4	Allathur	7.70-9.00	8.32	0.00	0.00	100
	Overall Mean	6.90-9.00	8.23	0.00	3.56	96.4

Table 3: Range and mean values and per cent sample category for EC in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category		
				Non- Saline	Slightly saline	Saline
1	Perambalur	0.15-2.60	0.79	31.0	27.6	41.4
2	Veppur	0.15-1.82	0.67	28.4	43.3	28.4
3	Veppanthattai	0.11-1.74	0.68	36.4	32.6	31.0
4	Allathur	0.11-1.67	0.62	40.8	28.0	31.2
	Overall Mean	0.11-2.60	0.74	34.2	32.9	33.0

Table 4: Range and mean values, per cent sample category and NIV for organic carbon in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	0.09-1.21	0.39	72.4	25.3	2.30	1.30	Very Low
2	Veppur	0.06-1.06	0.36	86.6	9.70	3.73	1.17	Very Low
3	Veppanthattai	0.06-1.02	0.43	65.1	19.4	15.5	1.50	Low
4	Allathur	0.13-1.03	0.48	59.2	21.0	19.6	1.61	Low
	Overall Mean	0.06-1.21	0.42	70.8	18.9	10.3	1.40	Low

Available Sulphur

The available sulphur ($CaCl_2$- S) content in the soils of Perambalur district ranged from 10.8 to 127 mg kg^{-1} with a mean of 52.3 mg kg^{-1} (Table 5). None of the soil samples collected from the district posses deficient sulphur status and almost all the samples have high sulphur content (98.5%). The nutrient index value for the soil available S varied between 2.97 to 3.00 with a district mean of 2.99 which indicated very high sulphur fertility in the soils of all the blocks. Higher sulphur status in the soils of all the blocks might be due to the continuous addition of S containing agrochemicals, which contain sufficient quantity of S to meet the crop requirement (Patel and Patel, 2008) [5] and similar such findings were reported by Jegadeeswari et al., (2017) [2] in the soils of Dharmapuri district in Tamil Nadu.

Table 5: Range and mean values, per cent sample category and NIV for sulphur in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	13.6-127	59.8	0	1.15	98.9	2.99	Very high
2	Veppur	13.6-93.0	50.6	0	2.99	97.0	2.97	Very high
3	Veppanthattai	18.8-97.5	51.4	0	0	100	3.00	Very high
4	Allathur	10.8-116	47.5	0	1.91	98.1	2.98	Very high
	Overall Mean	10.8-127	52.3	0	1.51	98.5	2.99	Very high

Available micronutrients

The available Mn content in the soils ranged from 2.10 to 19.3 mg kg^{-1} with a mean of 8.63 mg kg^{-1} (Table 6). Most of the soils in Perambalur district were having high DTPA-Mn status (97.9 %) and 100 per cent sufficiency of Mn was observed in Perambalur block. Higher availability might also be due to the inherent parent material present in the region (Vijay Kumar et al., 2008) [15].

The DTPA extractable Zn status in the soils varied from 0.14 to 8.75 mg kg^{-1} with a mean value of 1.73 mg kg^{-1} (Table 7). About 45.4 % samples collected had deficient Zn status with 21.0 and 33.7 % samples under medium and high Zn availability. The overall Zn fertility rating in the soils of Perambalur district was low which are in conformity with the findings reported by Velu et al.(2008) [16], which might be apparently due to continuous cropping with intensive application of major nutrient fertilizers and less adequate supply of micronutrients and organic manures. Increasing cropping intensity in marginal lands and lesser use of micronutrients in the district further enhanced the magnitude of zinc deficiency (Singh et al., 2009) [7].

The DTPA extractable Cu status in the soils varied from 0.20 to 7.70 mg kg^{-1} with a mean value of 1.73 mg kg^{-1} (Table 8) and its deficiency was noted in 39.3 per cent samples collected from the district. About 22.8 and 37.0 per cent of the soil samples were found to be medium and high categories respectively. The nutrient index value computed ranged from 1.36 to 2.47 with a mean of 1.98 mg kg^{-1} which indicated the marginal fertility status. Increase in soil pH and EC decreased the availability of micronutrients, but where ever addition of organic matter has been followed, there was an increase in the Cu availability was observed. This was in line with the findings of Reza et al, (2012) [11], Rao et al., (2013) [9] and Ravi et al., (2014) [8].

The DTPA Fe content in the soils varied from 2.42 to 34.9 mg kg^{-1} with a mean of 7.68 mg kg^{-1} (Table 9). Soil of Perambalur district were found to be deficient in DTPA Fe to an extent of 4.59 per cent only while 62.8 and 32.7 per cent of the samples were with medium and high Fe status respectively. Similar sufficient Fe availability in the soils was reported by Verma et al., (2007) [14]. The nutrient index values for Fe availability ranged from 2.14 to 2.43 with adequate to high fertility status.

Table 6: Range and mean values, per cent sample category and NIV for Mn in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	4.50-17.3	9.70	0	0	100	3.00	Very high
2	Veppur	2.10-14.7	7.50	0	2.24	97.8	2.98	Very high
3	Veppanthattai	3.40-19.3	8.70	0	3.10	96.9	2.97	Very high
4	Allathur	2.72-17.1	8.60	0	3.18	96.8	2.97	Very high
	Overall Mean	2.10-19.3	8.63	0	2.13	97.9	2.98	Very high

Table 7: Range and mean values, per cent sample category and NIV for Zn in different blocks of Perambalur district

S. No.	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	4.50-17.3	9.70	60.9	29.9	9.20	1.48	Low
2	Veppur	2.10-14.7	7.50	58.9	18.7	22.4	1.63	Low
3	Veppanthattai	3.40-19.3	8.70	0	8.50	91.5	2.91	Very high
4	Allathur	2.72-17.1	8.60	61.8	26.8	11.5	1.50	Low
	Overall Mean	2.10-19.3	8.63	45.4	21.0	33.7	1.88	Marginal

Table 8: Range and mean values, per cent sample category and NIV for Cu in different blocks Perambalur district

S. No	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	0.70-7.30	2.10	14.9	39.1	46.0	2.31	Adequate
2	Veppur	0.40-7.70	1.60	53.0	17.2	29.9	1.77	Marginal
3	Veppanthattai	0.50-6.60	2.20	17.1	18.6	64.3	2.47	High
4	Allathur	0.20-2.70	1.00	72.0	20.4	7.64	1.36	Low
	Overall Mean	0.20-7.70	1.73	39.3	22.8	37.0	1.98	Marginal

Table 9: Range and mean values, per cent sample category and NIV for Fe in different blocks of Perambalur district

S. No	Name of the Blocks	Range	Mean	Per cent sample category			NIV	Fertility rating
				Low	Medium	High		
1	Perambalur	2.80-32.9	8.30	5.75	59.8	34.5	2.29	Adequate
2	Veppur	3.10-16.2	7.20	2.24	69.4	28.4	2.26	Adequate
3	Veppanthattai	2.90-34.9	8.90	4.65	47.3	48.1	2.43	High
4	Allathur	2.42-2.02	6.30	5.73	74.5	19.8	2.14	Adequate
	Overall Mean	2.42-34.9	7.68	4.59	62.8	32.7	2.28	Adequate

Conclusions

Soil fertility plays a vital role in enhancing the crop yield hence fertility assessment of the land is need of the hour to address the nutrient deficiencies. A soil resource inventory was made in Perambalur district to assess the soil fertility status by collecting 507 surface soil samples from all the panchayat villages and analyzed for available S and micronutrients status. The results showed that Zn, Cu and B were found deficient in all blocks and the overall per cent sample deficiency in the soils accounts for 45.4, 39.3 and 40.6 respectively with very less samples under Fe deficiency (4.59%). As a whole, the soils of Perambalur district were very high in S and Mn fertility, adequate to high in Fe, low to very high in Zn, low to high in Cu and B availability. Information on the soil sulphur and micronutrient status will be highly useful for planning and organizing soil fertility improvement programmes at block level. It will be also helpful to plan balanced nutrient management to achieve more yield and net returns by avoiding yield loss due to nutritional deficiency.

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