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Application of Geographic Information System to Fertility Management of Tea Soils of Anamallais

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Abstract: Tea growers who have large area under tea find it difficult to manage land fertility solely with summary soil test reports and maps would be an ideal tool for them. Unlike ordinary maps, Geographic Information System (GIS) can manage large collection of land resources data necessary for tea production. The data on primary nutrients status and organic matter content are important for maintaining sustainable productivity. The Anamallais (Coimbatore District) has the second largest area under tea in Tamil Nadu, next only to the Nilgiris. The soil samples were analysed for pH, organic matter, phosphorus and potassium and the results were categorised in to low, medium and high. Digitized maps were prepared for individual tea estates using the Arc MAP software. It is indicated that fields having pH more than 5.5 may require measures to reduce the pH to the desired level. A few fields had low pH, which warranted application of dolomitic lime. Majority of the tea fields fell under the high category of available phosphorus content, because of the present practice of broadcasting of rock phosphate along with NK. Most of the tea fields were of medium category in potassium content, because the latosol tea soils easily release exchangeable potassium to available form of potassium. The fields at higher elevation have high organic matter content. Fields with low organic matter content needed improvement through external application of organic manures. The fields situated near forest area had high organic matter status The study revealed that 2% of the samples were under low and high categories each while the remaining 96% of the samples belonged to medium category.

Key words: GIS, soil fertility maps, pH, organic matter, phosphorus

INTRODUCTION

Optimal utilisation of soil resources is necessary maintain sustained productivity of soils over a long period of time. Information on soil resources relating to their spatial extent, variability, availability and usage of nutrients are required for optimum utilisation. Development of technology like Geographical Information System (GIS) is providing valuable support to handle voluminous data being generated through conventional and spatial format and for the integration of these data sets (Rao, 2007; Vadivelu, 2007).

In Tamil Nadu, Anamallais has the second largest area of tea, next only to the Nilgiris. The elevation of this range of hills varies from 900 to 1200 m above mean sea level. The

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weather, soil and lay of the land are extremely favorable for the cultivation of tea. The annual rainfall ranges from 2000 to 6000 mm and annual tea production is around 32 million kg. For the purpose of this study Anamallais region was divided into three agro climatic areas namely Eastern facing, Western facing and Intermediate.

Tea growers who have larger area under tea, find it difficult to manage soil fertility solely with summary soil test reports and maps would be an ideal tool for them. However, the change in soil fertility status over a period of two or three years makes the paper maps invalid. The GIS technique uses a digital map which allows the users to view, update, query, analyse and manipulate the spatial and tabular data either alone or together, within a few minutes. Unlike paper maps, GIS can manage large collection of land resource data necessary for tea production. The soil available nutrients and organic matter status are important for sustainable productivity. The variations occurring in these parameters will cause remarkable changes in soil fertility and affect the yield levels of tea. Continued use of nitrogenous fertilisers and high rainfall (>3000 mm $year^{-1}$) make the soil more acidic. However, the information available on GIS technique in tea is very much limited particularly in south India, while there are many studies using GIS on cultivation practices of various other crops (Deosthali *et al*., 2005; Rao *et al*., 1995; Osborne *et al*., 2002; Adams *et al*., 2000; Rao, 2007). The present study was aimed to create digitized maps of the tea estates of the Anamallais from the existing paper maps and documents. An attempt was also made to create the status maps of tea soils of the Anamallais on pH, potassium, phosphorus and organic matter, which would be beneficial to the tea growers for calculating the fertiliser requirements.

MATERIALS AND METHODS

Soil Sampling

Composite soil samples were collected using sampling auger, from each field of the selected estate, at the rate of one sample per hectare. The individual soil samples collected from a particular field were mixed together by hand on a polythene sheet. The bulk quantity of the collected samples was reduced to 1/3 of its volume by quartering method. The samples were air dried and passed through 2 mm sieve. The experiment was conducted during 2008 and 2009.

Digitizing Process

Soil samples were collected from 0-22.5 cm depth and GPS (Global Positioning System) coordinates of the sampling points were recorded using a GARMIN GPS Map 60 instrument. In each estate, 10 to 15 geo-coordinate points like estate boundary, division boundary, factory, estate corner, swamp, road junction, leaf shed, muster, school, temple, manager's bungalow, office and other important land marks, if any, were shown on the map. These geo-coordinates were used to digitize the maps. Initially all the minute geo-coordinates were subjected to degree conversion for uniform universal unit and then all the maps were geo-coordinated using R2V software. Each layer of individual estates like estate boundary, division boundary, buildings, contour lines and government road lines were traced with Easy Trace software 7.4 version and all the layers were merged and digitized using Arc Map software.

Physico-Chemical Analysis

The soil characteristics of the Anamallais site are given in Table 1. Soil pH was determined in 1: 2 soil : water mixture using Orion pH meter (Orion, 950) as per Schofield and

Table 1: Physico-chemical properties of Anamallais soils

	Zones		
Parameters	Eastern facing	Intermediate	Western facing
pH	4.8	4.4	4.5
EC (dS m^{-1})	0.12	0.15	0.15
OM (g kg^{-1})	59	68	69
K (mg kg^{-1})	286	217	265
P (mg kg^{-1})	58	56	63
Clay (g kg^{-1})	140	190	150
Silt (g kg^{-1})	80	100	260
Sand (g kg^{-1})	780	710	590

EC: Electrical conductivity, OM: Organic matter

Taylor (1955), electrical conductivity was measured using conductivity meter (Systronics, 304) following the method given by Mason and Obenshain (1939), organic matter by Wakley and Black (1934) procedure, available P by Bray and Kurtz (1945) method, K as per Hanway and Heidal (1952) and soil particle distribution (sand, silt and clay) by international pipette method (Baver *et al*., 1972).

Nutrient Status

The soil test results of the tea estates of the Anamallais were classified into low, medium and high category (Verma and Palani, 1997). The soil pH was classified in to; < 4.5 : Low; 4.5-5.5: Medium and >5.5: high, the organic matter of tea soils was classified as; <2.6%: Low; 2.6-7.8% Medium and >7.8% : High, potassium status as follows; <100 ppm: Low; 100-300 ppm: Medium and >300 ppm: High and phosphorus status as; <4.4 ppm: Low; 4.4-21.0 ppm: Medium; 22.0-44.0 ppm : High and >44 ppm: Very high.

RESULTS AND DISCUSSION

Physico Chemical Properties of Tea Soils in Anamallais

The soils of different zones in Anamallais showed differences in their physical and chemical properties (Table 1), which justified the need for a separate study at different locations of Anamallais. The geographical location of certain estates in Anamallais is provided in Table 2.

Soil pH

The ideal soil pH for growing tea is between 4.5 and 5.5. The results indicated that pH status of most of the fields fell under the ideal category while some of them had slightly higher pH. The fields with pH more than 5.5 required aluminium sulphate application to reduce the pH to desired level (Table 3). The soil pH was low in a few fields which warranted application of dolomitic lime. The nutrient uptake is optimum only when the soil pH is between 4.5 and 5.5 (Verma and Palani, 1997). About 17% of the soils from tea estates were under low category, 78% under medium (or) ideal category and the remaining samples had high pH.

Phosphorus

Majority of the tea fields fell under high category of available phosphorus content, because of the regular application of rock phosphate with citric acid along with NK broadcasting as recommended in the recent past (Venkatesan, 2006). A few fields fell under the low category of P status indicating the need for application of phosphorus through soil

Table 2: Geographical location of certain estates under tea cultivation in the Anamallais

Zones/Estate	Latitude	Longitude	Elevation (M) above MSL
Eastern facing			
Waterfall estate	10°24'-10°25' (N)	76°59'-77°00' (E)	1100-1250
Intermediate			
Iyerpadi estate	10°20'-10°22' (N)	76°58'-76°59' (E)	1050-1150
Paralai estate	10°20'-10°21' (N)	76°56'-76°58' (E)	1100-1200
Nadumalai estate	10°19'-10°20' (N)	76°57'-76°58' (E)	1050-1150
Velonie estate	10°16'-10°17' (N)	76°57'-76°58' (E)	1050-1200
Western facing			
Murugalli estate	10°17'-10°18' (N)	76°50'-76°51' (E)	1050-1150
Thaymudi estate	10°16'-10°17' (N)	76°55'-76°57' (E)	1150-1200
Mukkottumudi estate	10°15'-10°16' (N)	76°54'-76°55' (E)	1150-1250
Kallyar estate	10°16'-10°17' (N)	76°57'-76°58' (E)	1050-1200

Table 3: Soil pH and Organic matter status of certain estates under tea cultivation in the Anamallais

	pH status (%)			Organic matter status (%)		
Zones/Estate	Low	Ideal	High	Low	Medium	High
Eastern facing						
Waterfall estate	0	80	20	0	92	8
Intermediate						
Iyerpadi estate	3	91	6	0	100	0
Paralai estate	0	98	2	0	98	2
Nadumalai estate	76	18	6	0	100	0
Velonie estate	17	83	0	3	86	11
Western facing						
Murugalli estate	36	62	2	8	92	0
Thaymudi estate	20	65	15	0	98	2
Mukkottumudi estate	22	74	4	0	100	0
Kallyar estate	6	80	14	0	100	0

pH status: <4.5-Low; 4.5-5.5: Ideal; >5.5-High, Organic Matter Status: 0-2.6 (%): Low; 2.6-7.8 (%): Medium; >7.8 (%): High for 500-1500 m above MSL

Table 4: Soil potassium and phosphorus status of certain estates under tea cultivation in the Anamallais

	Potassium status (%)			Phosphorus status (%)			
	Low	Medium	High	Low	Medium	High	Very high
Eastern facing							
Waterfall estate	0	36	64	0	12	20	68
Intermediate							
Iyerpadi estate	0	86	14	0	9	20	71
Paralai estate	2	82	16	9	22	22	47
Nadumalai estate	6	76	18	6	24	29	41
Velonie estate	3	86	11	0	0	26	74
Western facing							
Murugalli estate	0	70	30	0	28	26	46
Thaymudi estate	0	93	8	0	14	23	63
Mukkottumudi estate	0	100	0	0	4	26	70
Kallyar estate	6	89	6	0	9	20	71

Potassium status: 0-100 ppm: Low; 100-300 ppm: Medium and >301 ppm: High. Phosphorus status: 0.0-4.4 ppm: Low; 4.4-21.0 ppm: Medium; 22.0-44.0 ppm: High and >44: Very high.

(Table 4). About 2% of the soils were under low category, 13% samples fell under the medium category, 24% of under high category and the remaining 61% samples were under very high P category.

Potassium

The tea soils are highly weathered with kaolinite as predominant clay mineral, where there is hardly any binding site for potassium. Hence, it is necessary to apply potassium

fertiliser frequently. Certain fields belonged low potassium category, which required immediate attention for the application of NK fertilizer. Most of the tea fields had potassium content in medium category and few fields were of low and high category (Table 4). Since south Indian tea soils are laterite, most of the applied potassium was in available pool which could be the main reason for most of the fields coming under medium potassium category (Venkatesan and Senthurpandian, 2006). About 2% of the soils were under low category, 80% samples fell under the medium (or) ideal category and the remaining 18% of the samples were under high category.

Organic Matter Status

The variations occurring soil available micro nutrient and organic carbon will cause remarkable changes in soil fertility and affect the yield levels of tea. Most of the tea fields were at medium organic matter content and a few fields were in high category. The higher elevation fields had high organic matter content. Similar observation on high elevation fields were made by Verma and Venkatesan (2001), Deosthali *et al.* (2005) and Rao *et al.* (1995). The organic matter content was low in some of the fields which indicated the need for the improvement of organic matter through external application of organic manure. Organic matter content was higher in the fields nearer to forest area (Table 3). This study revealed that 2% of the fields were under low and high categories each while the remaining 96% of the samples fell under the medium category (Table 3).

CONCLUSION

This study revealed that most of the soils of Anamallais have ideal pH range suitable for growing tea and the nutrient contents were in medium and high category. This work proved the feasibility of using GIS as a technique to study the nutrient status of individual fields to arrive at specific requirements for external application of nutrients. This study assumes significance in view of the possibility to update the data based on the exact soil test value once in three to four years. Although current study has dealt with only pH, P, K and OM status, it can be taken as a model for studying the status of other nutrients.

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