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Research Article

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Soil resource inventory and land evaluation using GIS techniques of some black soils, red and red laterite soils in semi arid tropical region of Tamil Nadu

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Summary

The study was carried out in the three new research stations with varied soil types with an objective to develop a strong soil resource database for proper appraisal of their productivity potential and land use pattern by preparing thematic maps using GIS tools. The soils are shallow (27 cm) to very deep (>170 cm). The surface horizons exhibited mostly medium fine granular to weak sub angular blocky structures whereas in subsurface horizons have shown medium fine granular to medium strong sub angular blocky structures in red and red laterite soil pedons. The black soil pedons had coarse strong angular blocky structure. The textural class of fine earth fraction was clayey (52.9 to 64.3%) in black soils, whereas in red and red laterite soil pedons it was coarse textured gravelly sandy loam to sandy clay loam in the surface horizons, sandy loam, sandy clay loam and sandy clay in sub-surface horizons (54.5 to 73.7% sand and 16.5 to 40.9% clay). The moisture retention at field capacity (33 kpa), permanent wilting point (1500 kpa) and available water capacity were high in black soils. Thematic maps of three different Research Stations were prepared by employing GIS techniques for different classes *viz.,*on soil depth, gravelliness, bulk density, available water holding capacity, soil reaction, EC, soil organic carbon, CEC, BSP, available macro and micro nutrients status of surface soil classes were generated. The limitations in the soils of the study area were due to slope, shallow depth, soil erosion, gravelliness, low water holding capacity, low and high pH, calcareousness, low organic carbon, low CEC and low BSP and low availability of macro and micronutrients.

Key words : Soil resource inventory, Land suitability evaluation, GIS techniques, Red, Red laterite, Black soils, Semi arid tropical region

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Introduction

Soil resource information plays a key role in the management of natural resources and more specifically in the agriculture sector. Management of soil resources based on scientific principle is essential to maintain the present level of soil productivity and to prevent soil degradation. Therefore, in recent years increasing emphasis is laid on characterization of soils and developing rational and scientific criteria for land evaluation and interpretation of soils for multifarious land uses. This calls for comprehensive knowledge on soil resources in terms of types of soil, their spatial extent, physical and chemical properties and limitations or capabilities. Remote sensing technology emerged as a powerful tool for studying soil resources because it enables to study the soils in spatial domain in time and cost effective manner (Sharma *et al.*, 2004). The employment of GIS techniques enabled the generation of thematic maps on soil qualities and helps to develop soil and crop management strategies to increase the agricultural production. The results of this land evaluation can be directly used for alternate land use and also for selecting site specific crops and management options with respect to the limitations prevailing in the three research stations. Land evaluation is the process of estimating the potential of lands for alternate uses and also for land use planning and development. GIS is a very useful tool in storing the land resource information as a set of thematic maps. This provides a congenial environment for integrating the information, in order to facilitate decision-making process a dynamic one. Linking attribute information of soil resources and other resources related to agricultural activities helps to produce derived thematic maps and in the preparation of action plan maps.

Most of the studies conducted earlier were only broad based and were conducted as a part of their study of soils of country or state. So, it is essential to understand the land suitability for certain crops at farm levels which provide the representative information of that region. Considering this fact with a view to assess the site specific constraints and provide potential for development and remediation, the present study has planned taking Research Station as a unit. Approach is in consonance with the land use planning and land resources are systematically accounted and prepared a resource inventory, which act as ready reference reckoned for any planning activity for the development and improvement of research stations soil and land resources further. The entire study work encompass in accounting of the soil and land resources, which is providing a medium for the crop growth. In particular period of extension of land use over new surfaces and of reorganization of existing agriculture, a systematic knowledge of these resources is essential. Keeping this in view, due to diversified nature, the three research stations of Tamil Nadu Agriculrutal University (TNAU) with varied soil types *viz.*, Maize Research Station, Vagarai of Dindigul district, Cotton Research Station, Veppanthatai of Perambalur district and Dryland Agricultural Research Station, Chettinad of Sivagangai district of Tamil Nadu were selected for developing the strong soil resource database for proper appraisal of their productivity, potential and their rational use. It is also necessary to relate the information on crop requirements to units delineated on the soil map. This study is an embodiment with following objectives. To evaluate the spatial database on the land resources of the research stations farm to enable dynamic updating and thematic map generation using GIS techniques. To evaluate the land by identifying the potentials and limitations and suggest suitable management options.

Resource and Research Methods

Location and brief description of the study area:

The Maize Research Station is extending over an area of 22.94 acres and boundary is surrounded between 10.570' N latitude and 77.56' E longitudes and is situated at an altitude of 254.45 m above mean sea level (Table 1 and Fig.1). The physiography of study area was nearly level to gently sloppy in nature. The Cotton Research Station is extending over an area of 55.4 acres bounded in between 11^o.32656' N latitude and 78^o.832397'E longitudes and situated at an altitude of 147 m above mean sea level. Physiographically the land is characterized by flat terrain level to nearly level. The Dryland Agricultural Research Station is extending over an area of 317 acre and boundary is surrounded between 10.166 to 10.179 N latitude and 78.785 to 78.805 E longitudes and is situated at an altitude of 108 m above mean sea level. Nearly three fourth of the land is under Pedi plains and characterized by flat terrain nearly level to gently slope in nature. The soil moisture control section is dry for more than 90 cumulative days or 45 consecutive days in the months of summer solstice. The soil moisture and soil temperature regimes of the study area are Ustic and Iso-hyperthermic, respectively. The natural vegetation existing in the study area are grasses, shrubs, thorny bushes such as *Cynodon dactylon*, *Cyprus rotundus*, *Butea frondosa*, *Dalbergia latifolia*, *Azadirachta indica*, *Tectona grandis*, *Terminalia tomertose* and *Acacia* spp. *Prosopis juliflora,Cacia* sp., broad leaf weeds such as *Selotia*, *Parthenium*, *Eucalyptus*, *Euforbia* sps., etc. The principal crops cultivated and researches focused in this station are cotton, redgram and maize.

Collection and processing of soil samples:

Based on the morphological characteristics and physiography selected geo-referenced three pedons at Maize Research Station, Vagarai, two pedons at Cotton Research Station,Veppanthattai and eight pedons at Dryland Agricultural Research Station Chettinad. Horizon wise soil samples were collected from the representative thirteen pedons for laboratory analysis. Simultaneously field wise geo-referenced surface at a depth of 0-15 cm and subsurface (15-30 cm) soil samples numbering two hundred and fifty two were collected. A total number of 13 surface and 13 subsurface samples were collected from Maize Research Station, Vagarai, 38 surface and 38 subsurface samples from Cotton Research Station, Veppanthattai and 75 surface and 75 subsurface soil samples were collected from Dryland Agricultural Research Station, Chettinad. Five to six pits were dug for each sample in every field. From each pit, samples were collected at a depth of 0-15 cm and 15-30 cm. A composite sample of about 1kg was taken through mixing of representative soil samples. The soil samples were air-dried in shade, processed and screened through a 2 mm sieve. Particles greater than 2mm were considered as gravel. After sieving, all the samples were packed in the polythene bags for determination of physical, and physico-chemical and chemical properties by using standard procedures.

Land capability classification was done keeping in view of soil limitations and other soil related parameters like texture, depth, slope, erosion, drainage, and nature of the substrata (Klingebiel and Montgomery, 1961). Each soil was interpreted in relation to soil- site suitability of major crops of the area. The soil related characters *viz.*, topography (t) and drainage (d) are interrelated for assessing the suitability of particular land for different crops (Sys *et al.*, 1991) to prepare an action plan has been suggested for land use planning. Soil constraints for crop production were identified based on the laboratory and field analysis of the soil. Preparation of thematic maps was done by using Arc GIS 9.3 software. Database on soil properties were developed and updated with map unit symbols using Microsoft Excel package. Then the database was exported to Arc GIS 9.3 via dBase IV format and the attribute table was geo-coded using mapping unit as the key field. The thematic maps on soil qualities were generated from the attribute table (Brunt and Hauffman, 1994).

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Land capability classification:

Based on soil properties as per land capability classification quantification of the criteria (Table 1), the soils of MRS, Vagarai and CRS, Veppanthattai classified into land capability classes III whereas DARS, Chettinad classified into two land capability classes III and IV (Table 2). The pedon 1 and 3 were classified into IIItsef, land capability sub-class due to the limitations of slope, texture, soil depth, erosion and soil fertility whereas pedon 2 was classified into III swf, due to texture, wetness and soil fertility. The pedon 4 and 5 classified into III swef, land capability sub-class due to the limitations of imperfect poor drainage, clayey texture, moderate erosion and soil fertility. The red laterite soil pedons 5, 6, 7, 8 and 9 classified into land capability class and sub-class IIIstef, due to the limitations of soil texture, slope, erosion and fertility. The pedons 11, 12 and 13 were classified into IVtsef, land capability sub class due to limitations of slope, texture, erosion and fertility whereas the pedon 10 classified as IVtsdef, capability sub-class due to the limitations of slope, texture, soil depth, severe erosion, coarse fragments and soil fertility limitations. Similar observations were also made by Sarkar *et al.* (2002).

Soil site suitability for major crops :

The study of soil-site characterization for predicting the crop performance of an area forms land evaluation. Important parameters *viz.*, maximum and minimum temperature, relative humidity, slope, erosion, drainage, texture, coarse fragments, depth, soil reaction, EC, $CaCO_3$, organic carbon, CEC, ESP and BSP were taken into consideration for evaluating the suitability of crops (Table 3). The soils of the study area were evaluated for their suitability for growing different crops *viz.*, maize, blackgram, greengram, groundnut, redgram at MRS, Vagarai, cotton, sorghum, soybean, blackgram, greengram, redgram, pearlmillet and sesamum, sunflower and onion at CRS, Veppanthattai, pulses, pearlmillet (Table 4) and horticultural crops such as mango, cashew and tapioca, forest tree crops like teak and eucalyptus at DARS, Chettinad (Table 5). According to Van

Table 1 : Land capability classification – quantification of the criteria

Charecteristics	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI	Class-VII	Class-VIII
Topograhy (t)								
Slope (%)	0-1	1-3	3-8	8-15	Upto 3	15-30	30-50	>50
Erosion	Nill	Slight	Moderate	Severe	Nil	Severe	Very severe	extreme
Wetness (w)								
Flooding	Nil (F0)	Nil (F0/F1)	slight F1)	moderate (F3)	Mod.to severe (F0/F4)	Nil, severe (F0/F4)	Nil to very severe (F0/F4)	---------
Drainage (1)	Well	Mod. well	Imperfect	Poor	V.poor	Excessive	Excessive	Excessive
Permeability	Moderate	Mod. rapid	Rapid slow	V.rapid, v slow	--------	--------	-----------	--------
Infiltration rate (cm/hr)	2-3.5	1-2.0, 3.0-5.0	0.5-1, 5.0-10.0	<0.5, >10.0	2.0			
Physical soil characteristics (s)								
Surface texture	Loam	sil and cl	sl and c	scl	S,c (m)	ls -cl	1s, s, c	1s, s, c (m)
Sur.coarse frag (%)	1-3	3-15	15-40	40-75	15-75	75+		
Sur. stoniness (%)	<1	1-3	3-5	5-8	8-15	15-40	40-75	>75
Sub surface coarse fragments (%)	<15	<15	15-35	35-50	50-75	50-75	50-75	>75
Soil depth (cm)	>150	150-100	100-50	50-25	-	25-10	25-10	<10
Pedon development	Cambic/Argillic) hor.A-(B)-C	A-B-C A-B_t-C	Stratified A-C;A-B-C	Salic (z)/Calcic (k) hor.A-Bz-C/A-Bk-C	Az-C, A-B_Z- C	Gypsic (y) hor. A -C_y	A-C (stony	R (bouldry)
Fertility (f)								
CEC(cmol(p+)/kg)	40-16	16-12	16-12	12-8				
Base saturation (%)	80+	80+	80-50	50-35	50-35	35-15	<15	
OC (0-15cm) (%)	>1.0	0.75-1.0	0.5-0.75	0.3-0.5	<0.3			
Salinity EC(dS m^{-1})	<1.0	1-2	2-4	4-8	8-15	15-35	35+	
Gypsum (%)	0.3-2.0	2-5	5-10	10-15	15-25	>25		

Table 2: Land capability classification of research stations based on soil characteristics

Physiographic unit	Topography				Physical soil characteristics			Pedon development	Soil fertility factors			LCC
	Slope	Erosion	Drainage	Texture	Sur.coarse fragments	Sub.sur.coarse fragments	Soil depth		CEC	BS	OC	
MRS, Vagarai												
Pedon 1	II	III	I	IV	III	V	IV	I	II	III	III	IIItsef
Pedon 2	III	III	III	III	II	V	III	II	I	II	III	IIIswf
Pedon 3	III	IV	I	IV	III	V	IV	I	II	III	IV	IIIstef
CRS, Veppanthatai												
Pedon 4	II	III	III	III	II	II	I	I	I	I	III	IIIwef
Pedon 5	II	III	III	III	II	II	I	I	I	I	III	IIIwef
DARS, Chettinad												
Pedon 6	II	III	I	III	III	V	II	I	IV	IV	III	IIIstef
Pedon 7	II	III	I	III	III	V	III	II	V	IV	IV	IIIstef
Pedon 8	II	III	II	IV	III	V	II	II	V	IV	III	IIIstef
Pedon 9	II	III	II	IV	II	V	II	II	V	IV	III	IIIstef
Pedon 10	III	VI	I	III	VI	VII	IV	V	V	IV	IV	IVtsdef
Pedon 11	III	VI	I	III	III	VII	II	II	V	IV	III	IVtsef
Pedon 12	III	VI	I	III	III	VII	III	II	V	IV	III	IVtsef
Pedon 13	II	VI	I	III	II	VI	II	II	V	IV	III	IVtsef

Table 3 : Soil-site characteristics for land evaluation

Physiographic unit	Climate				Land form characteristics			Physico-chemical characteristics (weighted averages)						
	Rain fall (mm)	Max. temp (°C)	Min. temp (°C)	RH (%)	Slope (%)	Erosion	Drainage	Depth (cm)	Sur.coarse fragments (vol %)	texture	pH	OC (%)	CEC cmol (p+)/kg	B.S (%)
MRS, Vagarai														
Pedon 1	700	36.5	17.0	70.0	1-3	Severe	Well	47.0	25.0	scl	7.49	0.52	16.8	76.0
Pedon 2	700	36.5	17.0	70.0	3-8	Moderate	Imperfect	60.0	11.3	c	8.10	0.56	35.6	78.9
Pedon 3	700	36.5	17.0	70.0	3-8	Severe	Well	40.0	26.5	scl	7.60	0.49	16.5	72.9
CRS, Veppanthatai														
Pedon 4	908	40.0	21.3	75.0	1-3	Moderate	Poor	170.0	8.8	c	8.48	0.55	44.6	86.9
Pedon 5	908	40.0	21.3	75.0	1-3	Moderate	Poor	155.0	9.1	c	8.57	0.54	45.5	83.2
DARS, Chettinad														
Pedon 6	1080	36.8	19.8	72.8	1-3	Severe	Well	150.0	25.6	sl	7.03	0.65	8.5	36.0
Pedon 7	1080	36.8	19.8	72.8	1-3	Severe	Well	93.0	16.5	sl	4.85	0.49	6.1	38.0
Pedon 8	1080	36.8	19.8	72.8	1-3	Severe	Well	100.0	26.6	scl	5.03	0.55	6.3	41.4
Pedon 9	1080	36.8	19.8	72.8	1-5	Severe	Well	123.0	10.0	scl	5.02	0.53	6.2	48.7
Pedon 10	1080	36.8	19.8	72.8	3-8	Severe	Well	45.0	86.6	sl	5.08	0.28	5.5	48.6
Pedon 11	1080	36.8	19.8	72.8	3-8	Severe	Well	110.0	28.2	sl	4.72	0.50	6.8	36.7
Pedon 12	1080	36.8	19.8	72.8	3-8	Severe	Well	67.0	26.4	sl	4.71	0.51	6.4	41.2
Pedon 13	1080	36.8	19.8	72.8	1-5	Severe	Well	110.0	12.0	sl	4.76	0.53	7.1	38.2

Table 4 : Actual and potential soil suitability for different crops of research stations

Pedon	Cotton		Maize		Sorghum		Pearlmillet		Soybean		Groundnut		Horsegram		Blackgram		Greengram		Redgram		Sunflower		Sesame	
	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS
MRS, Vagarai																								
1	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2
2	S_3	S_2	S_2	S_1	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2
3	N_2	N_2	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_3
CRS,Veppanthattai																								
4	S_2	S_1	S_3	S_2	S_2	S_1	S_2	S_1	S_2	S_1	S_3	S_2	S_3	S_2	S_2	S_1	S_2	S_1	S_3	S_2	S_3	S_2	S_3	S_2
5	S_2	S_1	S_3	S_2	S_2	S_1	S_2	S_1	S_2	S_1	S_3	S_2	S_3	S_2	S_2	S_1	S_2	S_1	S_3	S_2	S_3	S_2	S_3	S_2
DARS, Chettinad																								
6	N_1	S_3	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3
7	N_1	S_3	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3
8	N_1	S_3	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3
9	N_1	S_3	S_3	S_3	S_3	S_3	S_3	S_2	S_3	S_3	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3
10	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1
11	N_2	N_1	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3
12	N_2	N_1	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3
13	N_2	N_1	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3	N_1	S_3

Soil suitability class : S_1 - Highly suitable; S_2 - Moderately suitable ; S_3 - Marginally suitable
Not suitability class: N_1- Temporarily not suitable N_2 - Permanently not suitable AS - Actual suitability PS - Potential suitability

Wambeke and Rossiter (1987) land evaluation is the rating of soil for optimum returns per unit area.

Thematic maps on soils qualities:

Thematic maps on soil quality of the study area were prepared by employing GIS techniques. The study area was digitized in ARC GIS 9.3 software and the digitized data formed the spatial database. The attribute database comprised of soil quality characteristics which were stored in dBase IV format. By linking these two data sets (spatial and attribute data) under GIS domain, thematic maps were prepared. Thematic maps on soil depth, gravelliness, bulk density, available water holding capacity, soil reaction, EC, soil organic carbon, calcareousness, CEC, BSP, status of available macro and micro nutrients classes in surface soils were generated. The criteria advocated by Brunt and Hauffman (1994) were used to categorize most of the soil parameters. Five depth classes *viz*., shallow (25-50 cm), moderate (50- 75 cm), moderately deep (75-100 cm), deep (100-150 cm) and very deep (>150 cm) were recognized in the study area (Fig.1). The deep class occurred in larger area of DARS, Chettinad and very deep class found in whole CRS, Veppanthattai followed by moderately deep class, deep class and moderate class (Table 6). Depth of the soil determines the effective rooting zone for plants based on which crop selection can be made for particular area. Shallow soils require frequent light irrigation and moisture conservation measures for reducing erosion and to increase the productivity of these shallow soils. Management practices for controlling excessive leaching of nutrients is advocated for deep and very deep soils with light texture.

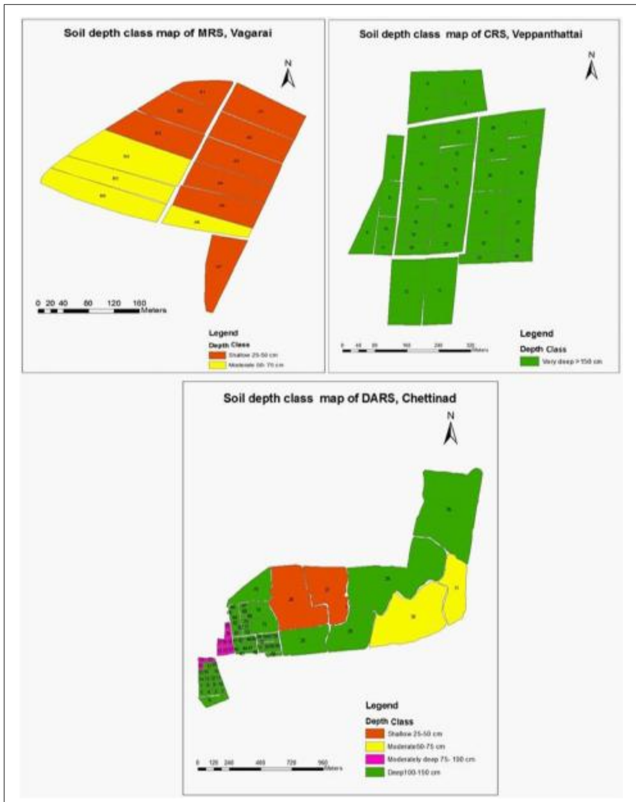

Fig. 1: Soil depth class map of three Research Stations

Gravel was observed in all the horizons and their distribution varied widely with depth and among the pedons (Fig. 2). The process like erosion and physical weathering are responsible for different proportions of gravel content in the pedons (Table 6). The soils of the study area were classified into four classes based on the gravel content *viz.*, slightly gravelly (5 to15 %), gravelly (15-45 %) and very gravelly (>45 %). Major area was occupied by gravelly class (MRS, Vagarai and DARS, Chettinad) followed by slightly gravelly class (CRS, Veppanthattai) and very gravelly class (DARS, Chettinad). Medium and high bulk density classes were observed in the study area (Fig.3). The high bulk density class of 1.40 to 1.53 Mg m^{-3} was observed in an area of CRS, Veppanthattai and medium class of 1.10 to 1.40 Mg m^{-3} was observed in an area of MRS, Vagarai and DARS, Chettinad. High bulk density of the soil was associated with poor organic matter content. Hence, the

Table 5 : Actual and potential soil suitability for different horticultural crops and forest tree crops fallow land of DARS, chettinad

Pedon	Tapioca		Cashew		Mango		Sapota		Teak		Eucalyptus	
	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS	AS	PS
10	N_2	N_2	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3
11	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3	S_2	S_2	S_2	S_1
12	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3	S_2	S_2	S_2	S_1
13	S_3	S_2	S_3	S_2	S_3	S_2	S_3	S_3	S_2	S_2	S_2	S_1

Soil suitability class : S_1 - Highly suitable; S_2 - Moderately suitable ; S_3 - Marginally suitable
Not suitability class: N_1- Temporarily not suitable N_2 - Permanently not suitable AS - Actual suitability PS - Potential suitability

Table 6: Physical characteristics of pedons of the research stations

Pedon	Horizon	Depth (cm)	Gravel (%)	Particle size distribution* (%)					B.D (Mg m^{-3})	Pore space (%)	Water retention (kg kg^{-1})		AWC (%)	W.H.C (%)	Volume expansion (%)	COLE
				Coarse sand	Fine sand	Total sand	Silt	Clay			33 kpa	1500 kpa				
MRS, Vagarai																
1	Ap	0-11	25.0	41.3	22.0	63.3	13.8	22.9	1.43	42.1	17.8	7.1	10.7	33.2	3.70	-
	Bt1	11- 23	20.3	38.5	26.1	64.6	12.0	23.4	1.44	43.4	18.0	6.9	11.1	35.2	4.35	-
	Bt2	23-40	38.8	43.3	14.5	59.8	12.5	27.7	1.45	43.7	18.3	7.0	11.3	35.5	4.90	-
	C	40-47	62.2	52.4	13.2	65.6	17	17.4	1.48	40.0	15.6	8.1	7.5	27.5	3.82	-
2	AP	0-20	11.3	19.8	16.9	36.7	17.5	45.8	1.47	37.4	32.4	15.1	17.3	43.8	21.70	-
	A1	20-31	19.3	37.9	18.0	55.9	19.4	24.7	1.45	41.8	23.2	9.9	13.3	34.5	5.10	-
	Bwk	31-50	13.0	38.7	15.8	54.5	18.3	27.2	1.46	43.6	24.6	10.9	13.7	35.9	5.22	-
	Ck	50-60	73.7	42.5	13.1	55.6	15.5	28.9	1.46	40.9	26.8	13.3	13.5	28.3	4.75	-
3	AP	0-10	26.5	42.3	21.5	63.8	14.0	22.2	1.45	43.6	20.9	9.8	11.1	32.6	3.61	-
	Bt	10 -28	38.4	43.1	16.4	59.5	15.2	25.3	1.46	43.2	20.3	9.2	11.3	36.5	4.55	-
	C	28-40	60.0	53.8	12.3	66.1	17.4	16.5	1.47	42.8	15.4	7.6	7.8	23.8	3.90	-
CRS,Veppanthattai																
4	Ap	0-31	8.8	21.3	8.8	30.1	17.0	52.9	1.49	35.3	48.4	30.6	17.8	52.2	23.10	0.13
	Bss1	31-73	7.2	19.5	9.8	29.3	15.5	55.2	1.50	35.2	56.5	37.4	19.1	54.7	26.24	0.14
	Bss2	73-101	6.1	15.5	9.1	24.6	16.8	58.6	1.53	31.3	60.9	41.1	19.8	56.0	27.13	0.16
	Bss3	101-134	5.7	14.9	6.9	21.8	19.3	58.9	1.55	30.9	57.6	36.6	21.0	56.8	29.14	0.17
	Ck	134-170	7.1	15.7	6.4	21.1	19.5	59.4	1.56	32.8	60.0	37.9	22.1	58.4	29.93	0.19
5	Ap	0-25	9.1	20.9	8.3	29.2	16.0	54.8	1.53	36.5	46.9	28.2	18.7	53.2	23.40	0.14
	Bss1	25-71	7.5	17.5	8.9	26.4	18.0	55.6	1.54	34.7	55.7	34.3	21.4	56.2	24.36	0.16
	Bss1	71-100	6.4	15.4	8.4	23.8	19.0	57.2	1.54	33.5	55.6	33.8	21.8	59.2	28.18	0.18
	Bss2	100-125	4.9	13.6	6.1	20.7	15.0	64.3	1.56	30.4	61.5	38.5	23.0	61.5	30.41	0.20
	Ck	125-155	7.3	15.9	6.5	22.4	20.0	57.6	1.57	34.4	58.8	35.9	22.9	57.2	29.22	0.19
DARS, Chettinad																
6	Ap	0-14	25.6	52.9	17.8	71.7	7.3	20.5	1.30	47.5	11.8	6.0	5.8	21.5	3.07	-
	A	14-25	17.1	51.5	16.9	68.4	9.5	22.1	1.30	44.6	12.4	6.1	6.3	22.7	3.17	-
	Bt1	25-39	19.0	53.3	14.4	67.7	6.9	25.4	1.32	43.8	16.3	7.2	9.1	23.5	3.30	-
	Bt2	39-63	32.0	52.1	15.5	67.0	6.5	26.5	1.34	43.5	16.8	7.7	9.1	23.8	3.53	-
	Bt3	63-97	79.5	48.4	15.7	64.1	8.0	27.9	1.37	42.6	24.6	13.2	11.4	24.4	3.55	-
	Bt4	97-143	74.1	49.3	14.6	63.9	6.1	30.0	1.38	38.8	25.7	14.1	11.6	24.4	3.56	-
	C	143-150	54.4	51.2	11.4	63.6	10.0	26.4	1.38	38.3	25.9	14.8	11.1	22.5	3.20	-
7	Ap	0-20	16.5	57.5	13.2	70.7	8.5	20.8	1.30	45.5	9.3	4.7	4.6	20.9	3.06	-
	Bt	20-51	50.6	55.2	6.7	61.9	10.2	27.9	1.38	44.3	10.7	4.5	6.2	22.7	3.10	-
	C	51-93	71.7	59.3	7.7	67.0	10.3	22.7	1.35	46.5	14.4	8.3	6.1	19.6	3.05	
8	Ap	0-25	26.6	50.3	20.1	70.4	4.7	24.9	1.34	43.5	18.0	7.6	10.4	24.4	3.20	-
	Bt1	25-32	23.1	44.3	19.2	63.5	5.3	31.2	1.34	42.8	18.6	7.7	10.9	26.8	3.41	-
	Bt2	32-56	28.6	35.7	18.8	54.5	7.1	38.4	1.36	41.9	22.5	11.9	10.6	29.7	3.46	-
	Bt3	56-82	29.5	36.6	15.3	51.9	7.2	40.9	1.41	40.6	24.5	13.1	11.4	31.2	3.91	-
	C	82-105	78.7	42.8	17.8	60.6	9.0	30.4	1.43	40.1	21.7	15.0	6.7	25.7	3.42	-
9	Ap	0-10	10	50.9	22.1	73.0	8.5	18.5	1.35	43.2	20.1	13.5	6.6	17.3	3.14	-
	Bt1	10-31	12.2	45.2	21.3	66.5	9.1	24.4	1.35	42.7	23.5	14.5	9.0	18.9	3.17	-

Table 6: Contd……….

Table 6: Contd……….

	Bt2	31-64	19.3	42.0	16.4	58.4	7.2	34.4	1.36	42.1	24.7	14.4	10.3	25.7	3.24	-
	Bt3	64-98	80.5	40.6	16.1	56.7	7.1	36.2	1.37	41.1	22.2	11.1	11.1	27.2	3.43	-
	C	98-123	87.2	48.8	15.5	64.3	8.8	26.9	1.38	42.8	24.4	15.1	9.3	24.8	3.04	-
10	A	0-15	86.6	59.8	10.6	70.4	10.2	19.4	1.43	47.3	8.5	4.7	4.8	12.9	2.97	-
	C	15-27	93.0	65.9	7.8	73.7	9.5	16.8	1.45	48.3	10.8	6.5	4.3	12.6	2.80	-
11	A	0-18	28.2	54.1	14.9	70.3	7.2	22.5	1.36	44.6	10.4	4.5	5.9	14.9	3.05	-
	Bt1	18-44	79.9	54.5	13.5	67.9	7.4	24.7	1.36	42.8	19.2	13.1	6.1	19.6	3.18	-
	Bt2	44-80	83.7	49.8	11.9	65.7	7.5	26.8	1.37	42.1	21.3	14.3	7.0	23.8	3.50	-
	C	80-110	94.2	51.7	11.9	65.6	8.5	25.9	1.42	42.6	21.9	15.3	6.9	22.7	3.10	-
12	A	0-10	26.4	51.7	19.5	71.2	6.6	22.2	1.34	46.6	11.8	5.2	6.6	17.6	3.11	-
	Bt1	10-41	72.4	49.2	16.9	66.1	7.5	26.4	1.36	43.2	23.5	13.5	10.0	21.8	3.30	-
	BC	41-67	94.5	55.3	12.8	68.1	8.5	22.4	1.40	44.3	22.8	13.0	9.8	19.4	3.22	-
	C	67+	Weathered granite-gneiss over lateritic parent material													
13	A	0-10	12.0	53.8	14.3	68.1	7.5	24.4	1.33	45.1	20.4	14.9	5.5	17.8	3.04	-
	Bt1	10-32	14.4	50.7	12.1	62.8	6.8	30.4	1.35	43.9	12.4	5.8	7.6	20.3	3.48	-
	Bt2	32-80	82.8	51.0	9.8	60.8	5.9	33.3	1.39	42.6	11.6	4.7	7.9	24.4	3.67	-
	C	80-110	93.1	59.6	13.7	73.3	5.3	21.4	1.40	43.3	11.4	4.5	6.9	21.3	3.17	-

*Coarse sand (0.2- 2mm); Fine sand (0.02- 0.2mm); Total sand (<2.0mm); Silt (0.002- 0.02mm)

application of organic manures can be advocated to reduce the bulk density. The low and medium group warrants less and frequent water supply through drip irrigation for better crop productivity.

Three classes of available water holding capacity *viz.*, low (5-10 %), medium (10-15 %) and high (15-20 %) were identified in the soils of the block (Fig. 4). The low water holding capacity class found in DARS, Chettinad followed by medium and high available water holding capacity classes of the soils found in MRS, Vagarai and CRS, Veppanthattai. The high available water holding capacity was attributed to the fine to loamy

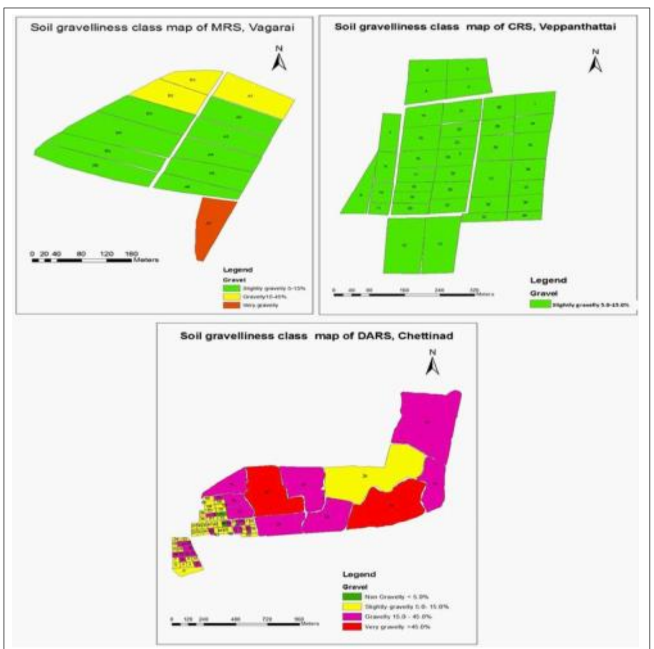

Fig. 2: Soil gravelliness class map of Research Stations

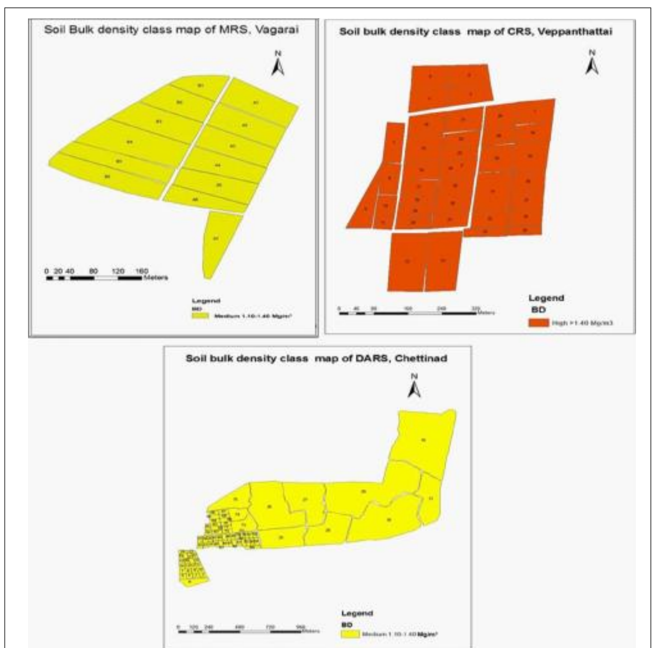

Fig. 3: Soil bulk density class map of Research Stations

textural composition of soil in the study area.

There were five reaction classes (Moderately acidic, slightly acidic, neutral, slightly alkaline and strongly alkaline) in the study area (Fig. 5). Moderately acidic to slightly acidic in reaction covered entire DARS, Chettinad followed by slightly alkaline to strongly alkaline coverers an entire area of CRS, Veppanthattai and neutral to slightly alkaline reaction classes coverers an area of MRS, Vagarai (Table 7). Chemical amendments like gypsum in alkaline soils and lime in acid soils have to be applied for reclamation. Low EC classes were found in all three research stations. The low EC class (<1 dSm^{-1}) occupied the entire study area (Fig. 6).

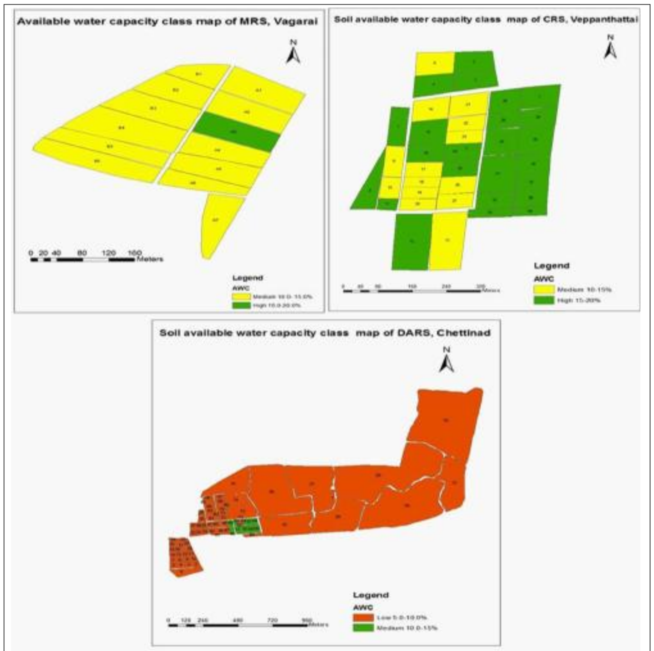

Fig. 4: Available water capacity class map of three Research Stations

Two OC classes such as low (<0.5 %) and medium (0.5-0.75 %) were observed in the study area (Fig.7). The OC status was low in larger parts of the research stations followed by medium class. The low to medium status of organic carbon could be attributed to the rapid oxidation and decomposition of added organic matter under tropical condition and lesser addition of organic manures (Mustapha *et al.*, 2011).There were four $CaCO_3$ calcareousness classes (Fig. 8). *viz.*, non-calcareous (nil) and slight calcareous (<5 %) classes were found in DARS, Chettinad and MRS, Vagarai. Moderate calcareous (5 to 10 %) to highly calcareous

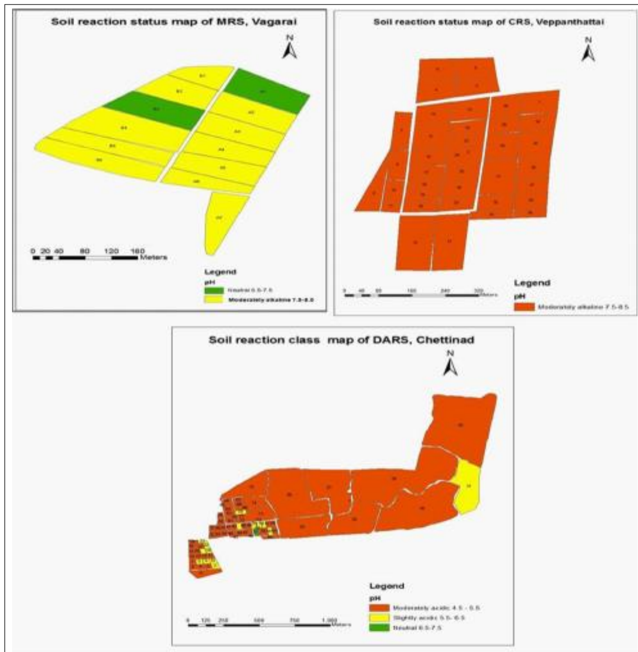

Fig. 5: Soil reaction status map of three Research Stations

Fig. 6: Soil EC status map of three Research Stations

(10-15 %) classes were observed in CRS, Veppanthattai which might be attributed due to the limestone deposits in the soils or the presence of calcification process in the soils as appended by Pandey *et al.* (2000).Very low, low, medium, high and very high cation exchange capacity classes were observed in the study area. The

Table 7: Physico-chemical characteristics of pedons of the research stations

Pedon	Horizon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Exchangeable cations [c mol (p+) kg^{-1}]				Total exchangeable bases	BSP (%)	CEC [cmol (p+) kg^{-1}]	$CaCO_3$ (%)
						Ca	Mg	Na	K				
MRS, Vagarai													
1	Ap	0-11	7.49	0.08	5.2	7.1	3.1	0.69	0.88	12.77	76.0	16.8	0.5
	Bt1	11- 23	7.58	0.09	3.9	7.4	3.3	0.52	0.79	12.01	77.0	15.6	0.7
	Bt2	23-40	7.85	0.11	2.7	7.5	3.4	0.43	0.64	11.97	78.8	15.2	0.9
	C	40-47	7.88	0.18	2.4	8.1	3.7	0.42	0.54	12.76	85.6	15.0	1.5
2	AP	0-20	8.10	0.25	5.6	14.4	7.8	1.14	0.74	24.08	67.6	35.6	2.6
	A1	20-31	8.00	0.20	4.5	6.9	3.6	0.76	0.78	12.04	73.4	16.4	1.2
	Bwk	31-50	8.50	0.31	3.6	10.2	5.7	0.58	0.69	17.17	89.4	19.2	7.3
	Ck	50-60	8.80	0.46	3.0	14.4	5.6	0.61	0.47	21.08	94.5	22.3	15.3
3	AP	0-10	7.45	0.15	4.9	7.2	3.2	0.92	0.71	12.03	72.9	16.5	0.7
	Bt	10 -28	7.56	0.18	3.5	7.8	3.4	0.66	0.65	12.51	75.4	16.6	1.2
	C	28-40	7.86	0.27	3.2	8.2	3.5	0.54	0.57	12.81	84.3	15.2	1.4
CRS,Veppanthattai													
4	Ap	0-31	8.48	0.14	5.5	27.2	8.2	2.32	1.04	38.76	86.9	44.6	9.8
	Bss1	31-73	8.87	0.16	4.6	27.8	9.2	2.81	0.91	39.72	85.4	46.5	8.2
	Bss2	73-101	8.97	0.28	3.5	28.3	9.8	2.84	0.83	41.77	87.9	47.5	7.3
	Bss3	101-134	8.98	0.44	1.5	28.9	9.9	3.34	0.77	42.91	89.0	46.2	9.7
	Ck	134-170	9.13	0.72	0.7	29.2	9.4	3.41	0.56	42.57	92.1	48.2	15.0
5	Ap	0-25	8.57	0.21	5.4	26.8	8.4	1.71	0.95	37.86	83.2	45.5	9.6
	Bss1	25-71	9.04	0.23	4.2	27.9	9.8	1.86	0.75	40.31	86.9	46.4	8.1
	Bss1	71-100	8.96	0.38	3.6	27.8	9.8	3.13	0.77	41.50	88.8	46.7	8.6
	Bss2	100-125	9.08	0.46	1.8	28.4	10.3	3.41	0.81	42.92	89.8	48.8	11.5
	Ck	125-155	9.10	0.68	1.5	29.8	9.8	3.45	0.68	43.73	91.4	47.9	15.5
DARS, Chettinad													
6	Ap	0-14	6.59	0.20	6.5	1.85	0.84	0.09	0.28	3.06	40.8	7.5	-
	A	14-25	6.32	0.14	5.0	1.34	0.61	0.08	0.31	2.34	36.0	6.5	-
	Bt1	25-39	6.10	0.05	4.8	1.48	0.65	0.05	0.31	2.49	37.7	6.6	-
	Bt2	39-63	6.06	0.05	3.0	1.32	0.62	0.05	0.32	2.31	35.5	6.5	-
	Bt3	63-97	6.23	0.07	1.7	1.41	0.64	0.04	0.33	2.42	39.6	6.1	-
	Bt4	97-143	6.25	0.05	1.4	1.31	0.57	0.04	0.34	2.26	32.7	6.9	-
	C	143-150	5.94	0.04	1.0	0.99	0.43	0.03	0.38	1.83	32.6	5.6	-
7	Ap	0-20	4.85	0.03	4.9	1.41	0.63	0.06	0.22	2.32	38.0	6.1	-
	Bt	20-51	5.12	0.03	3.6	1.72	0.51	0.04	0.25	2.52	41.3	6.1	-
	C	51-93	4.78	0.04	2.9	1.76	0.39	0.03	0.27	2.45	39.5	6.2	0.3
8	Ap	0-25	5.03	0.04	5.5	1.31	0.93	0.06	0.31	2.61	41.4	6.3	-
	Bt1	25-32	5.07	0.03	3.5	1.61	0.81	0.05	0.28	2.75	43.6	6.3	-
	Bt2	32-56	5.33	0.04	2.4	1.81	0.89	0.06	0.31	3.07	46.5	6.6	-
	Bt3	56-82	5.44	0.04	1.7	1.84	0.96	0.04	0.34	3.18	48.1	6.7	-
	C	82-105	5.28	0.05	1.4	1.94	1.01	0.04	0.36	3.35	50.0	6.6	-
9	Ap	0-10	5.02	0.04	5.3	1.8	0.98	0.03	0.21	3.02	48.7	6.2	-
	Bt1	10-31	5.48	0.05	3.3	2.1	1.08	0.04	0.28	3.50	53.0	6.6	0.2

Table 7: Contd…

Table 7 : Contd….

	Bt2	31-64	5.65	0.13	3.1	2.3	1.14	0.04	0.32	3.80	56.7	6.7	0.2
	Bt3	64-98	6.07	0.11	2.6	2.5	1.16	0.06	0.32	4.04	59.4	6.8	0.2
	C	98-123	6.37	0.06	1.5	3.0	1.21	0.11	0.38	4.70	66.1	6.7	0.4
10	A	0-15	5.08	0.04	2.8	1.65	0.66	0.05	0.22	2.58	46.9	5.5	-
	C	15-27	4.41	0.09	1.4	1.48	0.43	0.04	0.22	2.17	40.9	5.3	-
11	A	0-18	4.72	0.03	5.0	1.49	0.75	0.02	0.24	2.50	36.7	6.8	-
	Bt1	18-44	4.69	0.03	3.8	1.49	0.73	0.04	0.26	2.52	36.5	6.9	-
	Bt2	44-80	4.47	0.04	3.0	1.81	0.87	0.14	0.35	3.17	45.9	6.9	-
	C	80-110	4.40	0.04	1.2	2.11	1.01	0.09	0.31	3.52	49.5	5.9	-
12	A	0-10	4.71	0.03	5.1	1.56	0.71	0.06	0.31	2.64	41.2	6.6	0.2
	Bt1	10-41	4.82	0.04	3.2	1.75	0.66	0.04	0.36	2.81	42.5	6.9	0.3
	BC	41-67	4.77	0.04	1.9	1.81	0.83	0.07	0.36	3.07	44.5	6.4	0.2
	C	67+	Weathered granite-gneiss over lateritic parent material										
13	A	0-10	4.76	0.04	5.3	1.61	0.66	0.07	0.37	2.71	38.7	7.0	-
	Bt1	10-32	4.98	0.03	2.6	1.69	0.58	0.06	0.41	2.74	38.6	7.1	0.3
	Bt2	32-80	5.01	0.02	1.7	1.75	0.56	0.07	0.42	2.80	38.9	7.2	0.2
	C	80-110	5.26	0.03	1.4	1.81	0.71	0.05	0.45	3.02	41.4	7.0	0.2

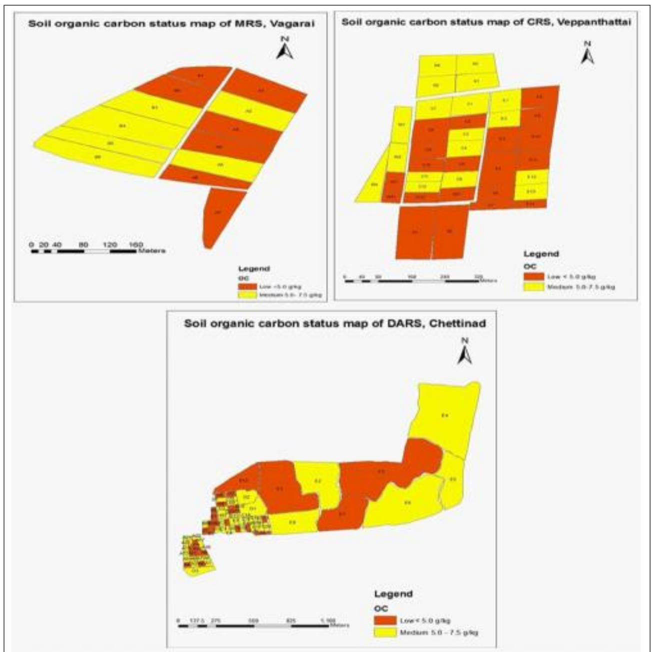

Fig. 7: Soil organic carbon status map of three Research Stations

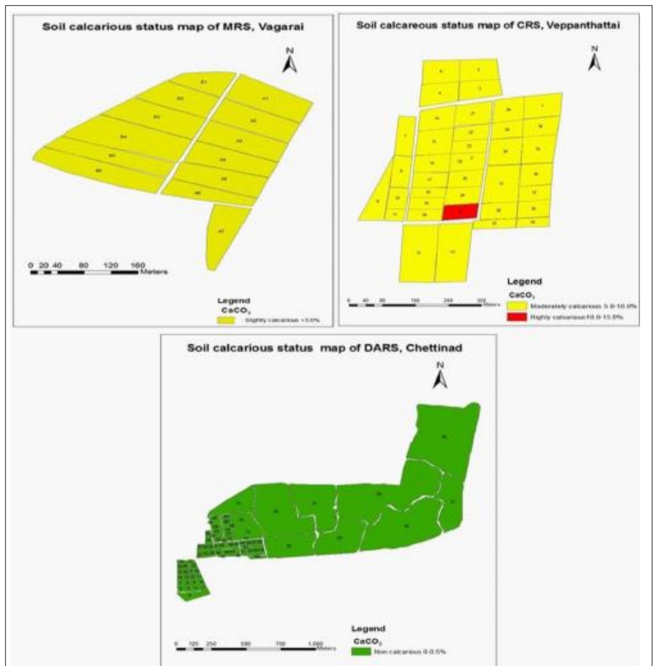

Fig. 8: Soil calcareous status map of three Research Stations

very low CEC class [<10.0 c mol (p+) kg^{-1}] occupied larger area of DARS, Chettinad followed by very high class [> 40 c mol (p+) kg^{-1}] of CRS, Veppanthattai and the low CEC class [10.0 to 20.0 c mol (p+) kg^{-1}] and high class [30.0 to 40.0 c mol (p+) kg^{-1}] at MRS, Vagarai (Fig. 9). Base saturation percentage of the study area was classified in to low class (<50 %) occupied in DARS, Chettinad, high classes (50 to 80 %) and very high class (>80%) occupied in MRS Vagarai and CRS, Veppanthattai (Fig. 10).

The available nitrogen classes (Fig. 11) were found in entire study area of the three research stations were

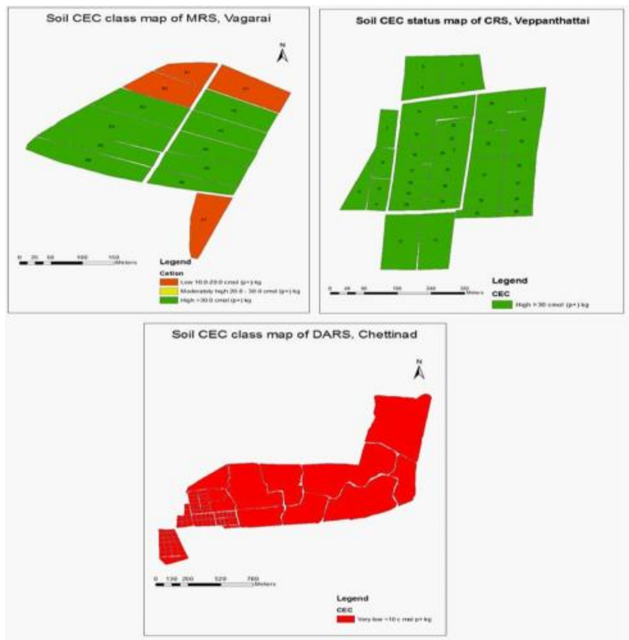

Fig 9: Soil CEC status map of three Research Stations

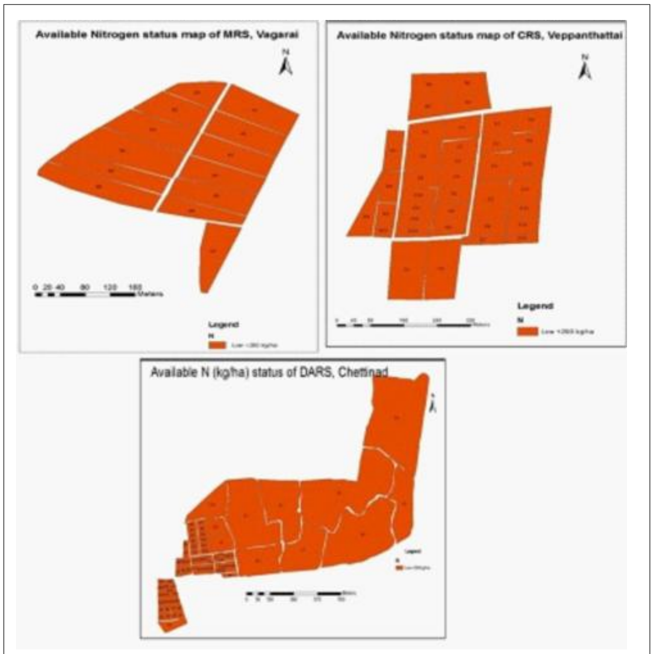

Fig 11: Available nitrogen status of three Research Stations

Fig. 10: Soil BSP status map of three Research Stations

low (<280 kg ha^{-1}) (Table 8). The high temperature prevailing in the study area may induce rapid decomposition of organic matter, thus, resulting in low available N content of these soils. Similar results were reported by Verma *et al*. (2005). Low, medium and high available phosphorus classes were observed in the study area (Fig. 12). The availability of in red laterite soils of DARS, Chettinad, categorized in to two classes such as low <24.2 kg ha^{-1} and medium 24.2-49.7 kg ha^{-1} due to acidic pH. The red soils of MRS, Vagarai and black soils of CRS, Veppanthattai categorized in to two classes (medium 11-22 kg ha^{-1} and high >22 kg ha^{-1}) where the soil pH was neutral to alkaline in range. The low P class (<24.2 kg ha^{-1}) occupied larger area of DARS, Chettinad whereas medium (medium 11-22 kg ha^{-1}) P class was occupied in red soils of MRS, Vagarai. The high class (> 22 kg ha^{-1}) occupied in black soils of CRS, Veppanthattai. The low P status of the soils could be attributed to fixation of released P by clay minerals and oxides of Fe and Al. This is in line with the observations of Gomathi (2007).The available potassium of the study area was classified in to medium class (<118-280 kg ha^{-1}) and high classes (>280 kg ha^{-1}).The high availability of K occupied entire area of MRS, Vagara (Fig. 13). The relatively higher content of available K was attributed due to hyperthermic temperature regime and the prevalence of K rich minerals increased the availability of K in these soils (Singh and Sawhney, 2006).The available sulphur (Fig. 14) of the study area was classified in to low (<10 mg kg^{-1}), medium class (10-15 mg kg^{-1}) and high classes (>15 mg kg^{-1}). All the soils of the three research stations were sufficient in S status which might be due to soil

Table 8 : Available nutrient status of pedons of the research stations

Pedon	Horizon	Depth (cm)	Available macronutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micronutrients (mg kg^{-1})				
			N	P	K		Zn	Cu	Mn	Fe	B
MRS, Vagarai											
1	Ap	0-11	180.0	20.0	488.0	52.12	1.09	2.06	17.09	9.72	1.72
	Bt1	11- 23	100.0	16.0	330.0	40.25	0.67	1.28	16.06	5.12	1.62
	Bt2	23-40	81.0	14.7	208.0	38.32	0.66	0.95	15.06	4.90	1.75
	C	40-47	50.0	10.6	159.0	31.25	0.64	0.58	9.95	4.04	1.54
2	AP	0-20	200.0	23.0	598.0	54.51	0.87	2.18	14.65	6.53	1.71
	A1	20-31	112.0	20.8	390.0	51.75	0.69	1.95	13.74	4.38	1.91
	Bwk	31-50	90.0	19.4	168.0	47.52	0.54	1.53	9.15	3.56	1.98
	Ck	50-60	65.0	12.2	158.0	46.25	0.52	1.04	6.61	3.23	1.84
3	AP	0-10	150.0	16.3	404.0	53.75	0.66	1.94	15.69	8.97	1.43
	Bt	10 -28	65.0	13.7	292.0	48.22	0.42	1.81	14.29	7.99	1.15
	C	28-40	52.0	7.8	104.0	43.75	0.36	1.67	12.04	4.85	1.01
CRS,Veppanthattai											
4	Ap	0-31	168.0	23.2	257.0	68.85	1.51	1.81	11.02	7.03	1.95
	Bss1	31-73	110.0	18.0	180.0	47.72	0.74	1.05	8.24	3.27	1.89
	Bss2	73-101	92.0	16.1	163.0	47.54	0.54	1.01	8.03	2.65	1.68
	Bss3	101-134	84.0	12.3	114.0	42.22	0.27	0.78	7.96	2.84	1.41
	Ck	134-170	50.0	9.2	100.0	41.91	0.25	0.64	5.15	2.40	1.11
5	Ap	0-25	188.0	20.8	244.0	59.85	1.46	1.03	9.27	3.79	1.95
	Bss1	25-71	118.0	16.9	202.0	59.19	0.84	0.95	8.23	2.67	1.64
	Bss1	71-100	101.0	14.5	147.0	59.15	0.51	0.85	7.40	2.13	1.58
	Bss2	100-125	69.0	12.1	113.0	48.25	0.48	0.71	6.81	2.08	1.47
	Ck	125-155	48.0	9.9	103.0	43.36	0.41	0.68	5.17	1.45	1.27
DARS, Chettinad											
6	Ap	0-14	200.0	24.0	210.0	25.51	2.62	1.92	19.60	26.96	0.51
	A	14-25	115.0	13.0	171.0	20.54	1.13	1.64	22.54	22.61	0.49
	Bt1	25-39	106.0	10.0	140.0	23.21	0.62	1.62	24.26	16.55	0.48
	Bt2	39-63	90.0	13.0	100.0	23.54	0.58	1.57	27.30	14.51	0.48
	Bt3	63-97	77.0	11.0	91.0	22.25	0.39	1.32	22.88	15.06	0.46
	Bt4	97-143	60.0	10.0	57.0	17.25	0.24	1.04	13.58	10.78	0.38
	C	143-150	44.0	9.0	48.0	18.26	0.22	0.83	8.358	8.85	0.39
7	Ap	0-20	114.0	14.0	147.0	26.56	0.25	1.58	13.93	8.18	0.62
	Bt	20-51	98.0	15.0	80.0	24.75	0.23	0.50	13.24	5.02	0.44
	C	51-93	55.0	8.0	50.0	17.32	0.20	0.46	9.81	7.54	0.36
8	Ap	0-25	108.0	20.0	180.0	27.62	0.38	1.74	18.32	9.50	0.63
	Bt1	25-32	107.0	14.0	150.0	27.52	0.35	1.68	18.12	9.42	0.61
	Bt2	32-56	102.0	12.0	132.0	31.61	0.30	1.53	21.08	9.38	0.56
	Bt3	56-82	80.0	10.0	70.0	37.22	0.28	1. 22	21.90	8.11	0.45
	C	82-105	74.0	9.0	42.0	35.23	0.21	0.71	8.32	6.57	0.39
9	Ap	0-10	108.0	19.0	174.0	25.27	0.80	3.13	28.22	19.13	0.59
	Bt1	10-31	103.0	12.0	155.0	21.12	0.61	2.65	30.84	18.09	0.55

Table 8 : Conted………

Table 8: Contd…………

	Bt2	31-64	94.0	15.0	113.0	25.55	0.43	1.92	27.31	17.69	0.43
	Bt3	64-98	71.0	13.0	55.0	21.12	0.34	1.54	16.06	11.78	0.37
	C	98-123	55.0	7.0	50.0	17.71	0.23	1.01	15.68	8.88	0.35
10	A	0-15	104.0	11.0	101.0	26.42	0.30	1.09	25.89	17.61	0.44
	C	15-27	40.0	13.0	86.0	24.81	0.26	0.82	24.28	14.47	0.35
11	A	0-18	110.0	20.0	157.0	28.72	0.50	1.58	17.23	18.39	0.61
	Bt1	18-44	107.0	16.0	130.0	27.25	0.35	0.62	20.45	19.21	0.57
	Bt2	44-80	90.0	12.0	100.0	22.22	0.23	1.01	25.08	19.73	0.47
	C	80-110	40.0	10.0	51.0	20.12	0.20	0.95	21.29	23.61	0.36
12	A	0-10	128.0	19.0	118.0	29.28	0.67	1.60	14.70	17.51	0.64
	Bt1	10-41	115.0	17.0	98.0	26.22	0.46	0.63	24.40	13.05	0.58
	BC	41-67	70.0	9.0	62.0	24.12	0.29	0.79	16.96	12.49	0.50
	C	67+	Weathered granite-gneiss over lateritic parent material								
13	A	0-10	140.0	29.0	146.0	45.21	0.81	1.80	15.80	17.33	0.49
	Bt1	10-32	113.0	22.0	93.0	36.55	0.41	0.75	21.53	16.87	0.48
	Bt2	32-80	90.0	20.0	64.0	22.52	0.29	0.53	28.17	16.64	0.42
	C	80-110	47.0	8.0	44.0	17.32	0.24	0.48	14.99	12.14	0.33

sulphur is continuously cycled between inorganic and organic forms of sulphur (Pasricha and Fox, 1993).

The available zinc of the study area was classified in to low (<1.2 mg kg^{-1}), medium (1.2-1.8 mg kg^{-1}) and high classes (>1.8 mg kg^{-1}). This low available Zn content (Table 8) might be due to the low organic carbon content, coarse textured nature of soils that is derived from granite and gneiss, low Zn bearing minerals and intensive cultivation. The finding corroborates the work of Gajanan *et al.* (1987). This suggested the need for application of Zn fertilizers and Zn chelates to improve the fertility status of these soils (Fig. 15).The available copper of the study

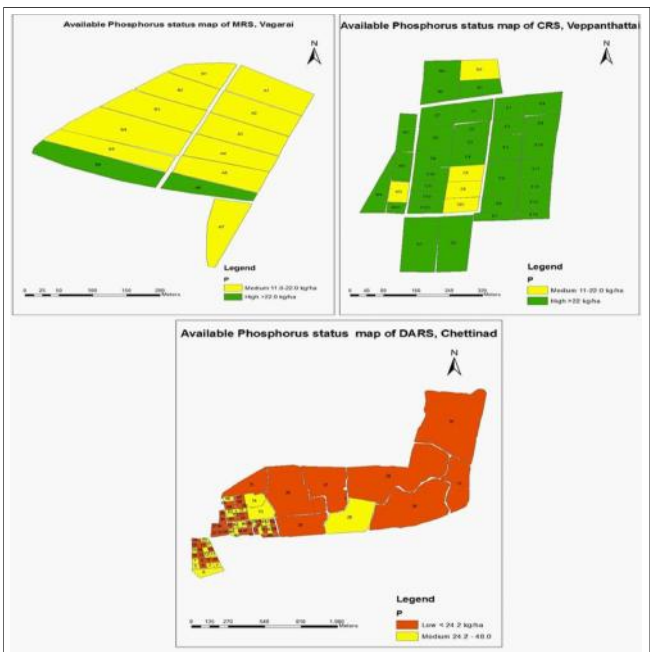

Fig. 12: Available phosphorus status map of three Research Stations

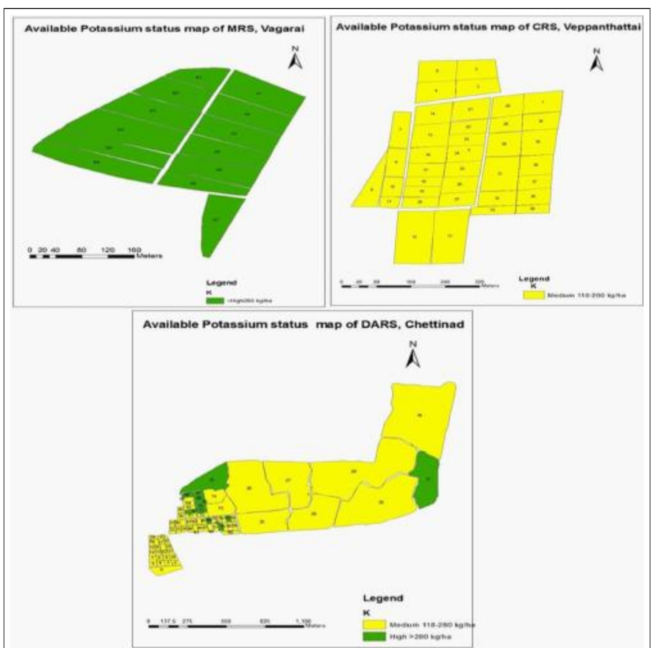

Fig. 13: Available potassium status map of three Research Stations

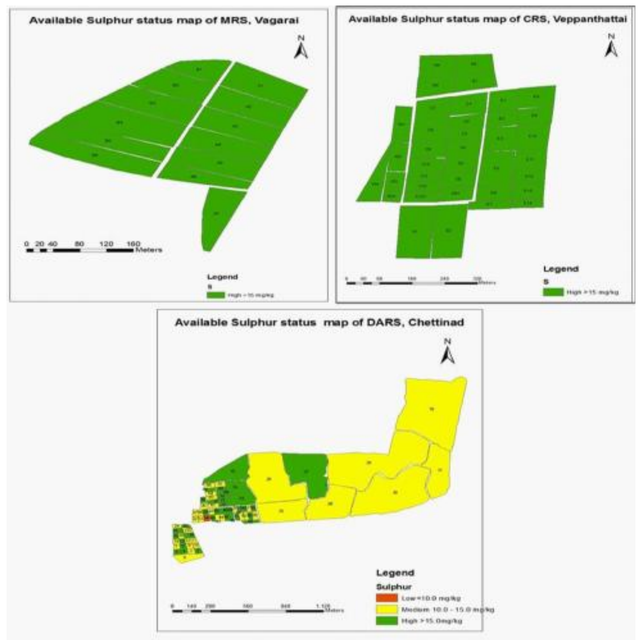

Fig. 14: Available sulphur status map of three Research Stations

Fig. 15: Available zinc status map of three Research Stations

area was classified in to low (<1.2 mg kg^{-1}), medium (1.2-1.8 mg kg^{-1}) and high classes (>1.8 mg kg^{-1}). The availability of Cu (Fig. 16) was deficient in the area of CRS, Veppanthattai and DARS, Chettinad. The availability of micronutrients is governed by number of factors like particle size fractions, pH, EC, organic carbon, $CaCO_3$, CEC and weathered soil conditions (Muthumanicakam, 2004).The available manganese (Fig. 17) of the entire study area was classified in to high classes (> 4.0 mg kg^{-1}). Very high fertility rating of Mn in the soils could be attributed to the oxidation of divalent Mn^{++} to trivalent Mn^{+++} by certain fungi and by the organic compounds synthesized by micro- organisms and plants (Vijay Kumar *et al.*, 2011). The available iron of the study area of DARS, Chettinad and MRS, Vagarai was classified in to low (<3.7 mg kg^{-1}), medium (3.7-7.5 mg kg^{-1}) and high classes (>7.5 mg kg^{-1}) due to non calcareous to slightly calcareous nature of soils (Fig. 18). The black soils of CRS, Veppanthattai was classified in to low (<6.4 mg kg^{-1}) and medium (6.4-8.0 mg kg^{-1}) and 90% of the area was deficient in available iron due to soils are moderately calcareous to highly calcareous nature.Similar findings were reported by Kumaraperumal (2006). The available boron of the study area was classified in to low (<0.5 mg kg^{-1}), medium (0.5-1.0 mg kg) and high classes (>1.0 mg kg^{-1}).The availability of

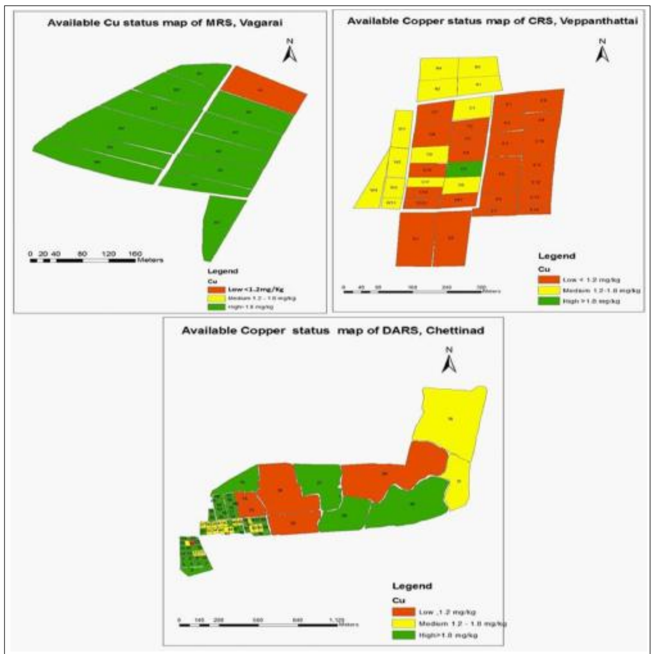

Fig. 16: Available copper in status map of three Research Stations

boron (Fig.19) was low to medium in red laterite soils of DARS, Chettinadu whereas medium to high in red soils of MRS, Vagarai and high in black soils of CRS, Veppanthattai. The higher B availability in the soils might be due to inherent higher B content of the soils and higher

Fig. 17: Available mangenese status map of three Research Stations

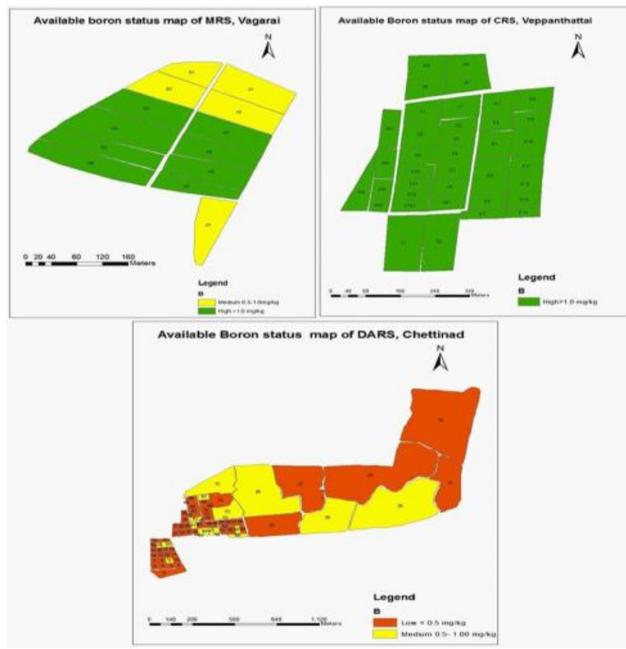

Fig. 19: Available boron status map of three Research Stations

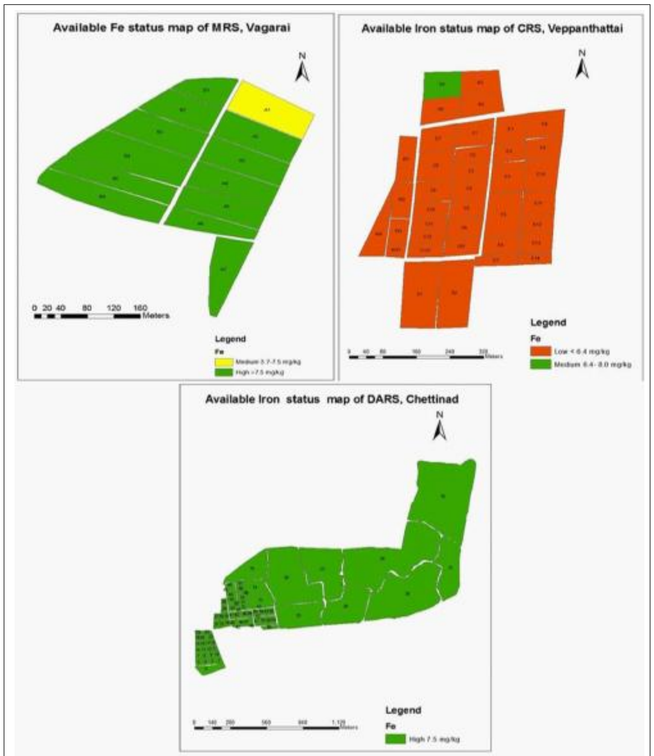

Fig.18: Available iron status map of three Research Stations

pH which is in confirmation with the findings of Adeboye (2011).

Major soil constraints and recommendations for crop production :

Soil constraints were identified using soil test data. The major soil constraints of crop production were identified as texture, erosion, slope, depth, drainage and low organic carbon, low availability N,P and micronutrients. Major constraints for crop production in red soils (MRS, Vagarai) are shallow in depth (40 to 50 cm) with coarse loamy texture, slope, erosion, coarse fragments, low OC, low availability of N and Zn deficiency are the major limiting factors in native red soils. Major constraints for crop production in black soils (CRS, Veppanthattai) are very deep soils, calcareous, clayey and moderate to imperfectly drained with slow permeability and low hydraulic conductivity. The soil constraints for crop production in red laterite soils (DARS, Chettinad) were light surface texture, shallow, moderately deep to deep rooting depth and gravelliness with kaolinite clay mineralogy resulting in poor water holding capacity. Surface crusting is common problem in this soil. The low water holding capacity does not permit post-rainy season cropping without irrigation. Major soil constraints for crop production and recommendations based on limitations for each soil types of study area were discussed in Table 9. Similar observations were made by Reddy *et al*.(1998); Fransis *et al*.(1983) and

Table 9 : Comparative evaluation of productivity of soils in study area along with the management options

Pedon No	Suitability	Major limitations	Management suggested
Agricultural crops			
Red soils at MRS, Vagarai			
1 and 3	Marginally suitable to Moderately suitable	Texture, slope, low OC, low N and Zn	Application of black soils/ tank silt; pre monsoon sowing of green manures; application of farmyard manures, composted coir pith or pressmud at 25 t ha^{-1} per year and crop rotation. Follow site-specific nutrient management.
2	Moderately suitable to highly suitable	Texture, slope, low OC, low N and Zn	Pre monsoon sowing of green manures; application of farmyard manures, composted coir pith or pressmud at 25 t ha^{-1} per year and crop rotation. Follow site-specific nutrient management.
Black soils at CRS, Veppanthattai			
4	Moderately suitable to highly suitable	Drainage, runoff erosion and high $CaCO_3$, high pH, Low N and Fe	Addition of river sand at 100 t ha^{-1}; application of 100 cart loads of red loam soil; summer deep ploughing; broad bed and furrow system manage the surface drainage; raised beds should be 1.2 m wide and 15 cm high and with two furrows of 30 cm width on either side to drain out excess of water; pre monsoon sowing of green manures; application of farmyard manures, composted coir pith or pressmud at 25 t ha^{-1} per year and crop rotation. Follow site-specific nutrient management.
5	Moderately suitable to highly suitable	Drainage, runoff erosion and high $CaCO_3$, high pH, low N, Cu and Fe	
Red laterite soils at DARS, Chettinad			
6, 8 and 9	Marginally suitable to Moderately suitable	Texture, slope, low WHC, Moderately acidic, coarse fragments, OC, low N and P .	Application of black soils/ tank silt; application of Lime (1.0-1.5 t/ha); application of FYM enriched rockphosphate and zinc sulphate; Green manuring; application of organic manures; application of biochar @ 5 -10 t ha^{-1} ; maintenance of surface pH; split application of nitrogen to reduce leaching; use lower rates of less acidifying fertilizers; avoid acidifying fertilizers such as mono ammonium phosphate or sulphate of ammonia; crop rotation with legumes. Follow site-specific nutrient management.
7	Marginally suitable	Texture, slope, low WHC, Moderately acidic, coarse fragments, OC, Low N,P and low Zn	
Horticultural and forest tree crops			
10	Marginally suitable	Depth, slope, erosion, texture, coarse fragments, OC, low N,P and low Zn	Contour bunding, plantation of tree crops such as eucalyptus and subable and other forestry crops. Follow site-specific nutrient management to over come the nutrients deficiencies.
11,12 and 13	Moderately suitable	Depth, slope, erosion, texture, coarse fragments, OC, Low N,P and low Zn	Contour bunding, plantation of tree crops such as eucalyptus and subable, cashewnut, sapota, mango and other commercial forest trees mainly teak. Follow site-specific nutrient management to over come the nutrient deficiencies.

Rajeshwar and Mani (2013).

Conclusion:

The results of this land evaluation can be directly used for alternate land use and also for selecting site specific crops and management options with respect to the limitations prevailing in this area. The major soil constraints of crop production were identified as texture, erosion, slope, depth, imperfect to poor drainage, low available water capacity, low and high pH, low organic carbon, soil calcareousness, low availability of macro nutrients and deficiency of micronutrients. The employment of GIS techniques empowered the generation of thematic maps on soil qualities and developing soil and crop management strategies to increase the agricultural production.

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