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Morphological characteristics, physiographic features and soil fertility in suitability of cassava in Paramathy Velur block, Namakkal district, Tamil Nadu

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Abstract
The experiment was carried out in Cassava growing tract of Paramathy velur block, Namakkal district, Tamil Nadu to evaluate the suitability of soil for cassava production. Detailed soil survey was carried out using cadastral map as base map of 1: 50,000 to identify the morphological, physical, chemical and exchangeable properties of soils and climatic parameters like moisture and temperature regimes. The classification was done up to subgroup level by following the guidelines of USDA soil taxonomy (soil survey staff, 2006). The study area falls under ustic moisture, isohyperthermic temperature regime. Pedons P1, P4 and P5 were classified as Typic Calciusterts, P3 called as Typic Duriustepts, P2 as Typic Haplustalfs whereas P6 named as Typic Plinthustalfs. Based on the analytical data, the evaluation was carried out with baseline of NBSS & LUP suitability criteria guideline for cassava, reported that P1 and P2 were considered to be highly suitable (S1) soils for cassava production, P3 and P4 falls under moderately suitable (S2) category, P5 is not suitable (N1) for tapioca cultivation whereas P6 is Marginally suitable (S3) for cassava production.

Keywords: soil survey, soil suitability evaluation, soil taxonomy.

Introduction
Soil suitability evaluation involves characterizing the soils in a given area for specific land utilization. The data collected from soil survey helps in development of land-use plans, evaluates and predicts the effect of the land use on environment. The suitability of a given parcel of land in its natural ability is evaluated to enhance it for specific purpose. According to FAO, land qualities such as erosion resistance, water availability and flood hazards are immeasurable, whereas land characteristics such as slope length and angle, rainfall and soil texture which are measurable, it is advantageous to use these latter values to study the suitability. Thus the land characteristic parameters were used to work out soil/land suitability for irrigation, crop growth and forestry.

Soil suitability evaluation for crop production needs crop requirements. Also those requirements had been understood that within the context of limitations imposed by landform and other features which do not form a part of the soil but may have a significant influence on use that can be made of the soil. From the basic crop requirements, a number of soil characteristics are directly related to crop yield.

In case of uncorrectable limitations, the crop cannot give satisfied yield unless management measures were taken, this is the prerequisite for yield maximization. Soil suitability classifications are based on knowledge of crop requirements, of prevailing soil conditions and climatic requirements and of applied soil management. In other sense, soil suitability classifications quantify in broad terms to what extent soil conditions match crop requirements under defined input and management circumstances.

Optimal crop growth and productivity is based on other factors on soil conditions such as climate and agricultural practices. However, it was realized that the following soil parameters, cation exchange capacity, soil organic matter content expressed by organic carbon percentage, soil depth and stoniness are amongst the main factors that influence crop suitability to given land area. The need for sustainable increase in cassava production per unit area in Paramathy block of Namakkal has resulted to more soil being opened up for pedological investigation in large scale cassava production tract because of its major contribution on global marketing. However, it has been observed that continuous cassava production on a particular soil leads decline in soil fertility, which on the other hand may be to nutrient loss/imbalance in soil erosion resistance at the time of tuber removal (Howeler, 2002) [1]. The initial point towards sustainable management is sufficiency information on the land resources. One of the strategies for food security as well as sustainable environment remains studying the soil resources to details through the process of soil characterization and land evaluation for various land utilization types. Land evaluation provides passage for sustainable land use since land will be used accordingly to its capacity. This therefore makes it mandatory to carryout land suitability in order to ensure that the selected site is suitable for long term production of cassava.

Materials and Methods

The study area Paramathy block covered 19149 hectares and its situated in Namakkal district of Tamil Nadu, India. It falls within latitude 11.1121°N and 78.0044°E longitude approximately. The mean annual rainfall distribution (mm) of Paramathy block is 658.8 mm with average elevation of 170 meters.

Average temperature in study area were 24-32°C. The study area is underlined with Quartz, Charnockite, Gneiss, Feldspar and Anorthite. Prevelant type of land use in Paramathy block is majorly arable crop cultivation with Sorghum, Maize, Minor Millets, Pulses, Groundnut, Vegetables, Cassava, Fruit crops and Coconut.

Field Survey and Laboratory Analysis:

The project site was surveyed in 2018-2019 using base map of scale 1: 50,000. Using the village map traverse walk around the selected villages were carried out. The villages were classified into three categories as high yielding village (12-15 t/ac), medium yielding village (8-12 t/ac) and low yielding village (<8 t/ac) based on the 10 years of yield data. In each yield category the pedon site was fixed based on mapping unit boundary. Representative profile pits were also dug to examine the soil horizons. Under high yielding category P1 and P2 were dugged out in Sithampoondi and Manikanatham villages (Fig.1&2), under medium yield category P3 and P4 (Fig. 3&4) were excavated in Serukkalai and Kunnamalai revenue villages, whereas in low yield category P5 and P6 (Fig. 5&6) were studied in Sungarampatty and Villipalayam villages respectively. In each location site latitude and longitude was noted using Garmin GPS. The soil samples were collected and analysed using standard procedure. Soil particle size was determined using the International Pipette method (piper, 1966) [4] with sodium hydroxide as dispersing agent. Available N was estimated using Alkaline permanganate method (Subbiah and Asija, 1956) [], Available P by colorimetric method using 0.5 N $NaHCO_3$ of pH 8.5 (olsen, 1954) [3] and Available Na and K by Flame photometer by neutral normal ammonium acetate (Stanford and English, 1949) [5]. Soil organic carbon was determined using Chromic acid wet digestion method (Walkley and Black, 1934) [8]. Exchangeable bases (Ca, Mg, Na and K) such as Ca and Mg was determined using versenate method (Jackson, 1973) [2]. The soil characteristics were compared with critical nutrient requirements parameter of cassava production.

Soil Suitability Evaluation

Land suitability evaluation of the soil was done using the parametric method of Sys *et al*., 1991 [7]. The parameters used for the land quality calculation includes rainfall, length of growing period, mean temperature, slope, wetness, drainage, texture, soil depth, fertility, cation exchange capacity, base saturation and organic carbon. The soil suitability classification consists of assessing and grouping the land types in orders, classes, subclasses and units based on crop requirements.

Results and Discussion

Table 1: Physiographic divisions of pedon

Pedon No.	GPS Location	Land form	Profile position	Micro-features	Soil Slope		Drainage	Flooding	Erosion	Runoff	Gravel %	Rockout crops	
					Gradient (%)	length (m)						Dist. apart (m)	Coverage %
P1	11°12.932 N 077°55.369 E	Inland	Middle part of upland	Ridge and furrow	0-1	0-50	Well	No	Mod.	Med	<15	-	-
P2	11°.08.551 N 77°59.024 E	Inland	Middle part of upland	Ridge and furrow	1-3	50-100	M. Well	No	Slight	Slow	<15	-	-
P3	11°09.426 N 77°59.376 E	Inland	Middle part of upland	Ridge and furrow	0-1	0-50	Well	No	V. Slight	Slow	<15	-	-
P4	11°13.557 N 78°02.570 E	Inland	Middle part of upland	Ridge and furrow	0-1	0-50	Well	No	Mod.	Slow	<15	-	-
P5	11°13.566 N 77°57.572 E	Inland	Footslope	Gilgai, rill, ridges and furrows	1-3	50-100	M. Well	No	Slight	Slow	<15	35-100	<2
P6	11°19.126 N 78°03.958 E	Inland	Middle part of upland	Ridge and furrow	0-1	0-50	M. Well	No	Slight	Slow	<15	-	-

Table 2: Morphological characteristics of pedon

Pedon No.	Survey No.	Depth of pedon	Horizon	Textural class	Colour (Moist)	Structure			Consistence				Bnd		Mottles						Effer (dil. Hcl)	Roots			Cutans
						G	S	T	Dry	Moist	Stk	Pls	d	T	qty	sz	cn	col	sp	loc	-	Qty	sz	shp	-
P1	805/5	0-5	A_p	Sicl	10YR $^{3/1}$	0	f	m	L	vfr	so	Po	c	S	-	-	-	-	-	-	1	C	f	i	-
		5-25	AB	Sicl	10 YR $^{3/1}$	2	m	gr	S	fr	ss	Sp	c	w	-	-	-	-	-	-	1	m	f	i	-
		25^+	C_{ca}	**Quartz felspatic gneiss mixed with lime**																					
P2	146/2C	0-15	A_p	Sicl	2.5YR6/8	0	F	M	L	vfr	ss	Sp	d	S	-	-	-	-	-	-	-	-	-	-	-
		15-40	A	Sicl	2.5YR6/8	1	F	m	L	vfr	ms	Sp	c	S	-	-	-	-	-	-	-	-	-	-	-
		40-70	Bt	Sic	2.5YR5/8	2	vf	sbk	Sh	fi	ms	Mp	c	S	-	-	-	-	-	-	-	-	-	-	
		70^+	R	**Quartz felspatic biotite gneiss**																					
P3	363	0-5	A_p	Ls	5Y R $^{4/3}$	3	F	Pl	Sh	L	Ms	po	d	s	-	-	-	-	-	-	l	f	vf	i	-
		5-31	AB	Scl	5YR $^{4/2}$	3	f	pl	Sh	Fi	Ms	po	c	s	-	-	-	-	-	-	l	-	-	-	-
		31-43	B	Scl	2.5 YR $^{4/4}$	3	c	pl	sh	vfi	ms	po	a	s	-	-	-	-	-	-	l	c	m	t	-
		43^+	Cr	**Granitic gneiss mixed with lime**																					
P4	335/2B	0-20	Ap	Sic	2.5 Y $^{7/2}$	0	F	Sg	L	fr	ss	sp	c	S	-	-	-	-	-	-	3	f	f	I	-
		20-70	B	Scl	2.5 Y $^{7/2}$	1	c	m	sh	fr	ss	sp	c	s	-	-	-	-	-	-	3	-	-	-	clay
		70^+	Cr	**Quartz felspatic biotite gneiss with lime**																					
P5	152/2	0-15	Ap	C	7.5R2.5/1	3	F	Abk	Sh	fi	Ms	Mp	d	S	-	-	-	-	-	-	-	f	f	i	-
		15-43	B	C	7.5R2.5/1	3	F	abk	Sh	fi	ms	Mp	d	S	-	-	-	-	-	-	-	-	-	-	-
		43-85	Bt	Sic	7.5R 3/2	3	F	abk	H	fi	ms	Mp	d	s	-	-	-	-	-	-	1	-	-	-	Clay
		85^+	R	**Felspatic gneiss intermingled with lime**																					
P6	124	0-20	A_p	Sic	5YR5/3	0	M	Gr	L	fr	so	Po	d	W	-	-	-	-	-	-	-	-	-	-	-
		20-65	B_t	Sic	2.5YR5/8	1	F	C	L	Fr	ss	Sp	c	w	-	-	-	-	-	-	-	-	-	-	-
		65^+	R	**Feldspar with granitic gneiss intermingled**																					

Table 3: Chemical characteristics of pedon

Pedon No.	Depth of pedon	Horizon	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (g/kg)	Avail. N(Kg/ha)	Avail. P (Kg/ha)	Avail. K (Kg/ha)	CEC Cmol(p+)/kg
P1	0-5	A_p	8.1	0.14	0.20	1.2	120	5.5	96	20.7
	5-25	AB	7.8	0.13	0.18	1.8	112	5.1	88	20.1
	25^+	C_{ca}	**Quartz felspatic gneiss mixed with lime**							
P2	0-15	A_p	8.1	0.17	0.17	0	118	5.7	107	19.7
	15-40	A	7.7	0.13	0.14	0	107	4.9	98	18.2
	40-70	Bt	7.8	0.19	0.13	0	98	4.0	86	16.8
	70^+	R	**Quartz felspatic biotite gneiss**							
P3	0-5	A_p	7.8	0.17	0.36	2.1	101	4.8	93	19.32
	5-31	AB	7.4	0.14	0.30	4.3	97	4.1	89	16.85
	31-43	B	7.2	0.19	0.13	2.1	92	3.1	96	16.2
	43^+	Cr	**Granitic gneiss mixed with lime**							
P4	0-20	Ap	8.6	0.28	0.39	5.94	105	4.4	101	19.53
	20-70	B	8.1	0.19	0.29	8.12	100	3.9	95	19.1
	70^+	R	**Quartz felspatic biotite gneiss with lime**							
P5	0-15	Ap	8.0	0.28	0.39	0	103	5.2	97	19.87
	15-43	B	7.7	0.19	0.32	1.1	99	3.2	81	17.6
	43-85	Bt	8.1	0.10	0.20	1.8	82	2.1	88	16.91
	85^+	R	**Felspatic gneiss intermingled with lime**							
P6	0-20	A_p	7.9	0.16	0.24	0	94	5.1	93.8	18.5
	20-65	B_t	7.7	0.14	0.19	0	88	2.3	98.0	19.6
	65^+	**R**	**Feldspar with granitic gneiss intermingled**							

Optimum level of NPK to produce more roots /ha:
N: 50-90 kg/ha
P: 26-33 kg/ha
K: 66-100 kg/ha

Table 4: Soil site suitability criteria of Tapioca

Soil site characteristics			Rating			
Climatic regime	Mean annual temp.	Unit	Highly suitable	Moderately suitable	Marginally suitable	Not Suitable
			S1	S2	S3	N1 N2
		°C	18-30	18-16 >30	16-12	<12
	Total Rainfall	Mm	1400-2400	1000-600 >2400	600-500	<500
Land quality						
Topography	T	Slope (%)	2-4	4-8	8-16	>16
Wetness (W)	Drainage		well drained	Mod. well	imperfectly drained	Poor drained
	Flooding		Fo	-	-	F1
Physical soil characteristics	Texture class	Surface	L,Sicl, Scl	LS,LcS, C>60	C<60, S,cS	Cm, Sim
Nutrient availability	pH	1: 2.5	6.0-7.0	5.2-4.8 7.0-7.6	4.8-4.5 7.6-8.2	<4.5 >8.2
	$CaCO_3$	%	0.5-2	2-5	5-10	>10
Rooting conditions	Effective soil depth	Cm	>125	100-75	75-50	<50
	EC	dS/m	1-2	2-3	3-4	>6
	OC	%	0.8-1.5	<0.8	-	-
	ESP	%	Non-sodic	5-10	>10	-
	CEC	Cmol(p+)/kg soil	16	Any	-	-
	Base Saturation	%	20-35	<20	-	-

Morphological Characteristics
The depth of soil varies from moderately deep to shallow in range. The texture varies in each pedon based on parent material. The texture dominant in high yielding soils were silty clay loam and sandy loam, whereas in medium yielding soils had varied textural class from loamy sand to silty clay. In case of low yielding soils silty clay and clay were the dominant textural classes (Table 2). The gradient percentages of soil slope were level to nearly level in range. All of the pedons were well to moderately well in drainage with slight to moderate erosion (Table 1).

Physical and Chemical Properties
The soils are nearly neutral to slightly alkaline in nature (7.2 to 8.6), non saline electrical conductivity (dSm^{-1}). Soils of P1 and P2 are highly fertile when compared to remaining pedons. CEC of P1, P2 and P3, P4 falls under medium and high in fertile (26.2 to 30.7) respectively, whereas in P5 and P6 the CEC recorded low in its status (16.91 to 19.87). Calcium carbonate was rich in pedon 4 when compared to rest of the pedons (Table 3).

Soil Classification
Based on the morphological, physical, chemical and exchangeable properties of soils and climatic parameters like moisture and temperature regimes the classification was done up to subgroup level by following the guidelines of USDA soil taxonomy (soil survey staff, 2006). The study area falls under ustic moisture, isohyperthermic temperature regime. Pedons P1, P4 and P5 possess clay > 30% with noticed cracking in mineral surface eligibles to meet the requirement of vertisol with ustic moisture regime and it has calcic horizon with its boundary within 100 cm of soil surface named the pedons as Typic Calciusterts. Pedon 3 possess ochric epipedon followed by cambic subsurface horizon and hence grouped under Inceptisol. Due to ustic moisture regime these pedons qualify for ustepts suborder. These pedons have duripan horizon and hence called Duriustepts greatgroup. It typifies the central concept of great group, hence the pedon 3 called Typic Duriustepts. Pedons P2 and P6 were classified as ustalfs owing to presence of argillic horizon and >30% Base saturation with ustic moisture regime. P6 do not meet the requirement of all other great group within a suborder, so P6 called as Haplustalfs whereas P2 have Plinthite as its constitute called Plinthustalfs. Whereas both the pedons typify the central concept of great group P2 and P6 had its prefix subgroup as Typic Haplustalfs and Typic Plinthustalfs respectively.

Table 5: Suitability classification for cassava production

Pedon	Order	Class	Sub-class	Unit
Typic Calciusterts (P1)	S	Suitable	S1	H
Typic Haplustalfs (P2)	S	Suitable	S1	
Typic Duriustepts (P3)	S	Suitable	S2	h,f
Typic Calciusterts (P4)	S	Suitable	S2	C
Typic Calciusterts (P5)	N	Not Suitable	N1	T
Typic Plinthustalfs (P6)	S	Suitable	S3	D

*d-drainage, h-depth, f- fertility, c- calcium carbonate, t- texture

Summary and Conclusion
The soils of pedon 2 is considered to be fertile and highly suitable to cassava production, whereas pedon 1 had shallow depth even it has good fertility and well suited physiographic features since cassava, a root crop extend its tuber in horizontal axis need well fertile soil instead more soil depth, so P1 and P2 were considered to be highly suitable (S1) soils for cassava production (Table 5). Based on crop suitability criteria (Table 4) P3 and P4 had its limitation with depth, critical limit in fertility and CaCO3 content, since these factors were correctable P3 and P4 falls under moderately suitable (S2) category (Table 5). Pedon 5 had uncorrectable textural limitation as clayey nature which may not favors the root penetration and tuber growth (Table 4), so the soils under that area were considered to be not suitable (N1) for tapioca cultivation (Table 5). P6 had correctable limitations such as low soil fertility and moderately well in drainage thus the soils were said to be marginally suitable (S3) for cassava production (Table 5). Continuous utilization of K leads to nutrient depletion in soil, so it is in need to increase K level in soil by means of balanced fertilization and also adoption of mixed cropping.

Fig 1: Pedon 1 opened for investigation

Fig 2: Pedon 2 opened for investigation

Fig 3: Pedon 3 opened for investigation

Fig 4: Pedon 4 opened for investigation

Fig 5: Pedon 5 opened for investigation

Fig 6: Pedon 6 opened for investigation

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