Madras Agric. J. 90 (7-9) : 450-455 July-September 2003

Evaluation of physical conditions in major soil series in rice growing tract of Thanjavur district

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Abstract: Survey of Thanjavur district was carried out to identify the soil physical constraints associated in the major soil series. Profile studies conducted at twenty-three locations, covering eight major soil series, representing four soil orders. Physical measurements like infiltration rate, hydraulic conductivity, particle size distribution and bulk density were made. Soil constraints were evaluated by combined interpretationo on the measured soil physical parameters, by relating to critical limits, which characterize each constraint. Out of total area, the extend of area prone for each constraint was projected. Results showed that surface crusting was predominant in Madukkur (20.7%) and Pattukottai soil series (5.7%). In Kalathur soil series 11.5% fluffiness is commonly associated. A problem of high permeability in subsoil was identified in Padugai soil series (5.4%).

Key words : Fluffy soil, Crusting and Permeability.

Introduction

Accomplishment of self-sufficiency in food production is becoming a possibility in India by agricultual technologies that exploit yield potential of crops. This is being achieved by way of crop improvement and nutrient management. Yet, considerable scope is left to produce more food if physical conditions of soil could be improved to suit crops. Recently, the impact of soil physical environment affecting crop performances has been felt in many agricultural lands. Identification of soil physical constraint is therefore necessary for alleviating such limitations. For this purpose, more often information is drawn from morphological featues observed from profile studies. These informations are sometimes insufficient for extending to larger area, as they are mostly qualitative and partly quantitative. In contrast, if a constraint is assessed using any highly associated single quantitative laboratory/field parameter, even then sometimes confirmation could not be arrived. This is because, many physical constraints associate with more than one soil conditions. While a constraint is known by one abnormal physical property, other associating properties within normal limits may mutually exclude that constraint. Under these circumstances, a combined interpretation is necessary for confirming a constraint. In these lines, the present study was attempted to discriminate the soils of Thanjavur district and to determine the constraint associated in each soil series.

Materials and Methods

Thanjavur district consists of plains of two distinct topographical variations *viz.* almost flat cauvery alluviam of Northern part (old delta) and undulating flat plains of laterite soils (new delta). For the study, during 1997 eight soil series covering both old and new delta (87 per cent of total area) were selected. These eight soil series were evaluated by profile studies conducted at twenty three locations (Table 1).

At each location, undisturbed core samples were collected from each horizon of the profile. Important physical properties *viz.* texture, bulk density and hydraulic conductivity (constant head) were estimated by using standard procedures (Gupta and Dakshinamoorthii, 1981; Klute, 1986). At the site study, in-situ infiltration rate was measured using double ring infiltrometer (Landon, 1991).

Based on the estimated soil physical properties, the constraint associated at each location was explored. For this purpose, a multiproperty discrimination table was formulated. The limits

Table 1. Distribution of soils and locations of study area in Thanjavur district

Order	Sub group	Series	Area distributed (ha)			Locations of study area	
			Old delta*	New delta**	% distri-bution	No. of profile	Name of the village
Vertisol	Udothentic Pellustert	Kalathur	61661	-	17.14	3	Ammankudi, Govindapuram, Thittai
	Entic Chromustert	Alangudi	16034	-	4.46	3	Alangudi, Amaravathi, Perungudi
Alfisol	Ultic Haplustalf	Pattukottai	12542	28571	11.43	4	Kattuthottam, Neyvasal, Senniavidithi, Senbagapuram
	Udic Haplustalf	Madukkur	12641	98502	30.89	3	Karamabayam, Nadium, Pulavankadu
Entisol	Typic Ustifluent	Padugai	38572	-	10.72	2	Kadiramangalam, Kalyanapuram
	Aquic Udifluent	Melkadu	-	5044	1.40	2	Parakalakottai, Ravuthanvayal
Inceptisol	Typic Ustropept	Peravurani	-	6673	1.85	4	Koratturukkadai, Marakkavalasai, Valuthalaivattam, Villnivayal
	Vertic Ustropept	Adanur	32096	-	8.96	2	Adanur Keelakurukkai
-	-	Other series (not studied)	29779	13166	11.90	-	-
	Reserve Forest		-	4533	1.25	-	-

* Old delta - Taluks - Thanjavur, Thiruvaiyaru, Papanasam, Thiruvidaimaruthur, Valangaiman and Kumbakonam

** New delta - Taluks - Orathanadu, Pattukottai and Peravurani

Source : Soil Survey (1990)

of discriminations were derived from various sources already reported (Gupta and Dakshinamoorthi, 1981; Ghildayal and Gupta, 1991; Landon, 1991).

A soil prone for a constraint is confirmed, if more than 4 estimated parameters were according to the critical limits. If constraint is a surface phenomenon, then the critical limits are related to properties of surface horizon. Likewise, for sub soil constraint subsurface horizon was related. Under modified USSR land suitability class specifications upto 80 cm depth soil texture was taken into account (top soil texture 30 cm, subsoil texture 50 cm) for the evaluation of soil physical conditions.

The projected area prone for a constraint is worked out as :

$$\text{Area under constraint (ha)} = \frac{CL}{TL} \times TA$$

where,

CL = No. of locations under constraint in a series
TL = Total no. of locations studied in a series
TA = Total area under the soil series (ha)

The critical parameters for discriminating soil physical constraints are given below :

Results and Discussion

The estimated physical properties for twenty three locations covering four soil orders for surface soil and sub surface soil are presented in Tables 2 and 3. At each location, the properties of soil were interpreted for the possibility of having physical constraints like fluffiness, surface hardness, subsoil impedance, subsoil impedance crusting, and slow or high permeability.

Soils of Thanjavur, the rice bowl of Tamil Nadu, have been under continuous rice cultivation and may have the chances of fluffiness. The major causes of occurrence of fluffy soil are due to prolonged submergence, frequent puddling, and higher content of colloidal clay and organic matter. Under these situations the soil may have low bulk density due to addition of crop residues in the surface horizons and high hydraulic conductivity. Among the soils studied, fluffiness was identified particularly in Vertisol, at Perungudi under Alangudi series and Ammankudi and Govindapuram under Kalathur series. These soils had bulk density as low as 1.18 mg m^{-3} and hydraulic conductivity as high as 2.50 cm hr^{-1}. Surface crusting is a problem, mostly in soils which, have sandy clay loam textures. In red soils, the predominance of kaolinitic clay and hydrated sesquioxides predispose soil surface to crusting. Crusted soils with appreciable hardness hence have moderately slow infiltration rate, moderate hydraulic conductivity and high bulk density. In the present study, crusting was diagnosed in many soils. In Alfisol, soils at Karambayam and Pulavankadu under Madukkur series, and at Neyvasal and Sennaiavidithi under Pattukottai series have this problem. Similarly soils at Parakalakottai and Ravuthanvayal under Melkadu series of Entiso as well as Koratturukkadai, Marakkavalasai, Valutha laivattam and Villunivayal under Peravurani serie of Inceptisol were prone for surface crusting In these locations surface soil had bulk density ranging from 1.48 to 1.74 mg m^{-3} and infiltratio rate ranging from 2.26 to 4.90 cm hr^{-1}.

In Pattukottai series (alfisol) remarkabl at Senbagapuram, the texture of surface soi was loam sand with medium bulk density (1.6 mg m^{-3}). The abundance of sand fraction throughou the profile influenced the soil to have ver high hydraulic conductivity (10.79 cm hr^{-1} and infiltration rate (7.66 cm hr^{-1}). These distinc properties demarcate the soil to be liable fo high permeability especially in surface soil Inspite of high bulk density, the soil showe copious permeability, which may possibly du to the presence of more sand and less amoun

Physical constraints	Critical parameters				
	Hydraulic conductivity	Infiltration rate	Sand	Clay	Bulk densit
	Cm hr^{-1}	Cm hr^{-1}	(%)	(%)	Mg m^{-3}
High permeable	> 6.25	> 5.0	> 70	< 15	<1.7
Slow permeable	< 0.5	< 1.25	< 40	> 40	> 1.4
Surface crusting	> 6.25	< 5.0	> 50	> 15	> 1.4
Hardening and impeded drainage	< 0.5	< 0.625	< 40	< 30	> 1.5
Subsoil mechanical impedance	< 0.125	< 0.625	< 40	> 40	> 1.8
Fluffy soils	> 2.0	< 1.25	< 40	> 30	< 1.2

Table 2. Identification of physical constraints in vertisol and alfisol

Location	Critical parameters							Constraint associated
	Tex-ture	Soil layer	I.R Cm/hr^{-1}	H.C. Cm/hr^{-1}	Sand %	Clay %	B.D Mg/m^{-3}	
			Vertisol - Alangudi series					
Alangudi	Scl	Surface	1.88	1.66	49.9	32.5	1.24	Fluffiness
	Scl	Subsoil	-	2.01	52.6	31.4	1.25	
Amaravathi	C	Surface	1.30	1.68	28.3	48.4	1.43	
	C	Subsoil	-	0.92	32.7	49.2	1.47	
Perungudi	C	Surface	1.36	2.03	37.1	40.0	1.18	
	C	Subsoil	-	2.07	38.1	38.7	1.34	
			Vertisol - Kalathur series					
Ammankudi	C	Surface	2.12	2.50	33.7	44.4	1.24	Fluffiness
	C	Subsoil	-	1.67	32.9	50.0	1.25	
Govindapuram	C	Surface	1.40	2.12	33.9	40.2	1.18	
	C	Subsoil	-	1.53	35.5	40.8	1.32	
Thittai	C	Surface	0.80	1.58	31.9	48.4	1.16	
	C	Subsoil	-	1.61	31.1	49.5	1.38	
			Alfisol - Madukkur series					
Karamabayam	Sl	Surface	2.48	2.51	75.4	18.6	1.66	Surface crusting
	Scl	Subsoil	-	1.50	77.4	17.7	2.17	
Nadium	Scl	Surface	5.18	4.76	78.8	11.3	1.74	
	Scl	Subsoil	-	1.20	63.5	30.0	1.85	
Pulavankadu	Scl	Surface	3.00	3.11	68.1	18.0	1.68	
	Scl	Subsoil	-	2.22	66.6	21.4	1.85	
			Alfisol - Pattukottai series					
Kattuthottam	Scl	Surface	5.22	2.69	65.1	23.5	1.31	Surface crusting
	Scl	Susoil	-	1.78	66.9	21.9	1.61	
Neyvasal	Scl	Surface	2.25	3.91	67.9	20.4	1.51	
	Scl	Subsoil	-	3.42	70.6	16.4	1.42	
Senniavidithi	Scl	Surface	3.24	3.71	64.2	20.6	1.62	
	Scl	Subsoil	-	2.85	60.0	26.8	1.58	
Senbagapuram	Ls	Surface	7.66	10.79	80.5	8.6	1.62	Highly permeable
	Sl	Subsoil	-	3.29	70.2	18.6	1.45	Surface soil

I.R. - Infiltration Rate; H.C. - Hydraulic Conductivity; B.D. - Bulk Density

of clay. Similar experience has been reported earlier by Mathan *et al.* (1991). In two locations, a problem of subsoil high permeability was identified. They were Kalyanapuram under Melkadu series of entisol and Keelkurukki under Adanur series of inceptisol. Presence of large amount of sand in subsoil horizon might be major cause of this disorder. Due to this, hydraulic

Table 3. Identification of physical constraints in entisol and inceptisol

Location	Critical parameters							Constraint associated
	Tex-ture	Soil layer	I.R. Cm/hr^{-1}	H.C. Cm/hr^{-1}	Sand %	Clay %	B.D Mg/m^{-3}	
Entisol - Melkadu series								
Parakkalaikottai	Sl	Surface	3.20	6.40	76.6	18.9	1.72	Surface crusting
	Scl	Subsoil	-	3.52	75.8	21.2	1.83	
Ravuthanvayal	Sl	Surface	3.00	6.43	72.2	19.1	1.74	
	Scl	Subsoil	-	2.75	73.5	22.3	1.68	
Entisol - Padugai series								
Kadiramangalam	C	Surface	4.03	3.42	43.5	43.8	1.36	Highly permeable sub soil
	Scl	Subsoil	-	3.04	57.5	27.7	1.47	
Kalyanapuram	Sc	Surface	5.40	1.58	46.3	38.5	1.22	
	Scl	Subsoil	-	2.83	67.1	28.8	1.52	
Inceptisol - Adanur series								
Adanur	Scl	Surface	2.79	2.22	49.1	34.6	1.37	High permeable soil
	Scl	Subsoil	-	2.22	48.5	34.9	1.36	
Keelakurukkai	C	Surface	3.07	1.12	40.6	43.0	1.39	
	Scl	Subsoil	-	2.31	48.8	31.9	1.57	
Inceptisol - Peravurani series								
Koratturukkadi	Scl	Surface	4.80	2.42	74.0	19.0	1.67	Surface crusting
	Scl	Subsoil	-	1.55	66.9	23.4	1.75	
Marakkavalasai	Scl	Surface	3.22	2.23	67.1	20.0	1.48	
	Scl	Subsoil	-	3.11	64.2	24.3	1.66	
Valuthalaivattam	Sl	Surface	4.90	5.47	69.7	18.8	1.69	
	Sl	Subsoil	-	2.18	73.0	16.6	1.77	
Villunivayal	Scl	Surface	2.26	2.66	71.1	19.9	1.64	
	Scl	Subsoil	-	1.92	70.0	19.7	1.76	

I.R. - Infiltration Rate; H.C. - Hydraulic Conductivity; B.D. - Bulk Density

conductivity was moderately rapid. These observations are in line with the reports made earlier by Pagnis *et al.* (1996).

Rarely in few locations, soils were found to be normal as none of the estimated properties showd the occurrence of any physical constraint. They were Alangudi and Amaravathi under Alangudi series, Thittai under Kalathur series, Nadium under Madukkur series, Kattuthottam under Pattukottai series, Kathiramangalam under Padugai series and Adanur under Adanur series.

The area prone for such constraint an per cent distribution out of total area of th district is projected and it was observed tha in Thanjavur, surface crusting and fluffines were most widespread. Much of area in Kalathu series (41313 ha) had the properties of fluffiness In the case of surface crusting, it was predominan in Madukkur series (74466 ha). The constrain of high permeability was evaluated in limite area in the surface soil of Pattukottai serie (2.9%) and in the subsoil of Padugai serie (5.4%).

In summary, for evaluating soils, broad interpretation of single physical data is often difficult, because variability in soil may affect the accuracy of quantification. Instead, interpretation on multiple properties would strengthen the predictions, which has been successfully attempted in the study. The result also indicated considerable scope for such kind of approach in the assessment of physical constraints.

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(Received: August 2002; Revised: April 2003)