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An Index of Soil Texture and its Relationship to some Physical Properties

by

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Synopsis: A numerical index of soil texture by Whittles (1959) is tested for some Madras soils. The index possessed significant statistical relationship with the mechanical components and other soil physical properties.

Introduction: Single value constants like Field capacity, Moisture equivalent, Hygroscopic moisture etc., have been used from a long time to characterise the physical behaviour of soils. But no suitable single value measurement has been evolved to represent the mechanical composition of the soil so that it may serve as an index of soil texture.

In 1928, Hardy proposed an index of soil texture based on determinations of moisture content at the point of stickiness (P) and of sand content of the soil samples using the formula; Index of texture $= P - \frac{S}{5}$. This value did not get wide popularity due to the reasons that the sticky point is an arbitrary value and much subjected to personal errors.

Whittles (1959) put forward a formula by which a single value measure of soil texture could be calculated from the mechanical analysis data and this value was designated as 'y' value. He classified the soils into different textural classes based on this 'y' value. Roy (1960) tested the validity of this method on a large number of Indian soils of different classes with wide variation of texture and concluded that although the 'y' value overlaps in some cases, on the whole it gives a fair expression of the soil texture.

Durairaj (1961) studied the relationship between different mechanical fractions and proved that the estimation of coarse sand alone would be sufficient to give an approximation of soil texture. The relation of this index to the other soil physical properties was not worked out. With the object of working out this relationship the following study was made.

Experimental: Mechanical composition data of 30 soils was obtained and the 'y' value was calculated as outlined by Whittles (1959). Three physical properties viz., maximum water holding capacity, porespace and volume expansion on swelling were estimated for these soils. The relationship of different mechanical fractions and 'y' value with the physical properties were statistically worked out and correlation coefficients obtained. The results and discussion are presented below.

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Results and Discussion : The range of 'y' values for different textural classes are given in table I. It is seen that the values of one class overlaps the other, yet there is an increase in the value of 'y' as the clay and silt content increases and the 'y' value decreases with increasing content of fine and coarse sand.

TABLE I

Range of 'y' values

Textural class	'y' value	Textural class	'y' value
Clay	1·54 — 1·02	Sandy loam	0·50 — 0·79
Sandy clay	0·96 — 0·67	Sand	—0·08 — 0·35
Sandy clay loam	0·62 — 0·77	...	...

TABLE II

Correlation coefficients and Regression equations for the relationship between mechanical fractions, 'y' value and physical properties

(x) × (y)	Correlation coefficient	Regression coefficient	Regression equation
Clay x Silt	+ ·235	+ ·102	y= 3·48 + ·102 x
Clay x Fine sand	— ·648 ‡	— ·265	y= 27·69 — ·265 x
Clay x Coarse sand	— ·877 ‡	— ·837	y= 68·87 — ·837 x
Clay x 'y' value	+ ·966 ‡	+ ·025	y= ·28 + ·025 x
Clay x WHC@	+ ·697 ‡	+ ·745	y= 26·65 + ·745 x
Clay x Porespace	+ ·936 ‡	+ ·404	y= 40·64 + ·404 x
Clay x Vol. Exp. on Swlg. £	+ ·742 ‡	+ ·530	y= 5·92 + ·530 x
Silt x Fine sand	— ·438 †	— ·422	y= 22·8 — ·422 x
Silt x Coarse sand	— ·522 †	— 1·12	y= 52·06 — 1·12 x
Silt x 'y' value	+ ·468 †	+ ·022	y= ·716 + ·022 x
Silt x WHC@	+ ·447 †	+ 1·10	y= 40·88 + 1·10 x
Silt x Porespace	+ ·299	+ ·297	y= 50·3 + ·297 x
Silt x Vol. Exp. on Swlg. £	+ ·581 ‡	+ ·954	y= 15·0 + ·954 x
Fine sand x Coarse sand	+ ·467 †	+ 1·07	y= 23·49 + 1·07 x
Fine sand x 'y' value	— ·751 ‡	— ·038	y= 1·63 — ·038 x
Fine sand x WHC@	— ·615 ‡	— 1·61	y= 80.2 — 1·61 x
Fine sand x Porespace	— ·647 ‡	— ·683	y= 65·9 — ·685 x
Fine sand x Vol. Exp. on Swlg. £	— ·660 ‡	— 1·15	y= 44·3 — 1·15 x
Coarse sand x 'y' value	— ·924 ‡	— ·021	y= 1·79 — ·021 x
Coarse sand x WHC@	— ·687 ‡	— ·788	y= 83·3 — ·788 x
Coarse sand x Porespace	— ·509 †	— ·264	y= 64·1 — ·264 x
Coarse sand x Vol. Exp. on Swlg. £	— ·807 ‡	— ·618	y= 48·8 — ·618 x
'y' value x WHC@	+ ·757 ‡	+ 38·81	y= 14·5 + 38·81 x
'y' value x Porespace	+ ·697 ‡	+ 14·43	y= 39·8 + 14·43 x
'y' value x Vol. Exp. on Swlg. £	+ ·785 ‡	+ 26·87	y= –2 + 26·87 x
WHC@ x Porespace	+ ·491 †	+ ·328	y= 36·5 + ·328 x
WHC@ x Vol. Exp. on Swlg. £	+ ·899 ‡	+ ·601	y= –7·7 + ·601 x
Porespace x Vol. Exp. on Swlg. £	+ ·852 ‡	+ ·852	y=–52·59 + 1·41 x

@= Maximum water holding capacity
£=Volume expansion on swelling
†=Significant at 0.01 (p) level
*=Significant at 0.05 (p) level
‡=Significant at 0.001 (p) level

The correlation coefficients between the mechanical fractions, the 'y' value and the physical properties are given in table II. Most of the values are highly significant. Correlation between the different mechanical components revealed that clay and coarse sand are highly correlated (r—0·877). Such a relationship was found by Durairaj (1961) also who proposed that the estimation of coarse sand alone is sufficient to define the texture of the soil.

The correlation of 'y' value with the four mechanical fractions showed highly significant positive correlation with clay and negative correlation with coarse sand and fine sand and significant positive correlation with silt. These relationships become more significant in view of the fact that the relationships have been worked out for a group of black and red soils. The correlation co-efficients may increase if the values are calculated for soils from a single group. These high correlation coefficients show that the 'y' value can be taken as a true representative figure for mechanical fractions.

Regarding the relationship of 'y' value with the other physical properties it is interesting to observe that 'y' value is very significantly correlated with moisture holding capacity, porespace and volume expansion on swelling than any one of the mechanical fractions. The different correlation co-efficients are given below for easy comparison.

	Maximum water holding capacity	Proespace	Volume expansion on swelling
Clay	·697	<u>·936</u>	·742
Silt	·447	·299	·581
Fine sand	—·615	—·647	—·660
Coarse sand	—·687	—·509	<u>—·807</u>
'y' value	<u>·757</u>	·697	·785

The highest values are underlined

From the values it could be seen that clay is less correlated with maximum water holding capacity and volume expansion on swelling than 'y' value but the correlation is more in the case of porespace. Similarly the correlation of coarse sand with volume expansion is slightly more than that with 'y' value but less in the case of maximum water holding capacity and porespace. Therefore it is apparent that 'y' value is a better criteria of texture to give an idea of the maximum water holding capacity and volume expansion on swelling of the soils than any one of the mechanical fraction, either clay or coarse sand.

'y' value in soil classification: Soil texture has been recognised as an important property of the soil to be taken into consideration for irrigation and land capability classification. Hitherto only arbitrary values (Metha, 1958) have been given to the various textural classes and incorporated in soil rating. The 'y' value being a numerical index of soil texture, will be very useful in any soil rating system and will give a more true picture of the texture than any other method.

Summary & Conclusion: A statistical treatment of the relationship of 'y' value with the mechanical fractions and the physical properties was made and following conclusions were arrived at.

1. 'y' value is very significantly correlated with silt.

2. The correlation of 'y' value with the three physical properties viz., maximum water holding capacity, porespace and volume expansion on swelling was better than the correlation given by any one of the mechanical fractions with these physical properties.

Mechanical analysis and physical properties data used in this paper.

S. No.	Place	Depth in inches	Textural class	Mechanical Analysis				'y' value	Max. water holding capacity	Porespace	Volume expansion on swelling
				Clay	Silt	Fine sand	Coarse sand				
1	2	3	4	5	6	7	8	9	10	11	12
1.	Jakkarpalayam	0—5½	C	73·5	1·3	15·8	9·4	1·45	85·4	63·7	44·6
2.	,,	5½–13	C	68·0	11·6	10·7	9·7	1·54	86·2	73·1	47·2
3.	Sethumadai	15–30	C	49·7	7·7	14·2	28·4	1·24	62·6	58·0	29·4
4.	Muttampalayam	24–36	C	45·0	3·4	13·0	38·6	1·12	53·8	49·5	27·8
5.	Periapodu	0—14	C	41·8	13·4	19·9	24·9	1·26	32·6	43·8	11·0
6.	Sethumadai	9—15	C	40·5	11·0	15·0	33·5	1·18	60·9	55·1	27·1
7.	Periapodu	24–42	C	39·5	5·1	21·7	33·7	1·11	50·0	53·4	23·7
8.	Jakkarpalayam	13–30½	C	38·9	40·4	9·8	10·9	1·41	86·8	61·7	58·2
9.	Muttampalayam	6—12	C	38·8	5·1	14·3	41·8	1·05	54·0	54·2	23·4
10.	Sethumadai	0—9	C	38·5	8·9	15·5	37·1	1·13	66·8	55·8	25·6
11.	Ramanathapuram	6—12	C	37·8	4·6	19·5	38·1	1·02	27·1	53·3	19·0
12.	Anamalai	12–24	C	37·2	5·9	18·5	38·4	1·07	45·3	44·6	17·9
13.	Pulliampatti	6—12	SC	31·5	4·2	18·4	45·9	0·96	56·2	61·4	24·8
14.	Thathamuthanur	6—12	SC	30·2	0·1	20·5	49·2	0·89	47·3	52·0	19·2
15.	Aliyarnagar (6th mile)	12–24	SC	28·6	2·6	16·7	52·1	0·88	44·7	51·2	18·1
16.	Vettaikaranpudur	6—12	SC	25·0	3·3	23·3	48·6	0·87	42·3	51·9	19·4
17.	Puliampatti	0—6	SCL	20·9	3·5	9·7	65·9	0·62	28·1	57·4	19·5
18.	Malayandipatnam	0—10	SCL	20·7	2·2	24·2	52·9	0·77	46·7	40·6	12·9
19.	Ramanathapuram	24–36	SCL	19·2	1·2	19·2	60·4	0·68	45·6	50·3	17·2
20.	Ramanathapuram	0—6	SL	19·0	7·6	18·4	55·0	0·75	40·8	54·2	13·8
21.	Senguttaipalayam	35–52	SL	18·3	12·8	17·9	51·0	0·79	47·4	51·2	19·1
22.	Vettaikaranpudur	0—6	SL	15·4	3·6	29·0	52·0	0·64	30·1	42·8	5·3
23.	Aliyarnagar (3rd mile)	24–36	SL	13·8	1·8	26·3	58·1	0·58	47·3	52·9	14·5
24.	Senguttaipalayam	7—27	SL	13·8	3.7	26·0	56·5	0·59	63·4	57·6	30·7
25.	,,	0—7	SL	13·0	3·6	25·1	58·3	0·57	19·1	46·0	13·0
26.	Anamalai	6—12	L	12·8	13·4	16·8	57·0	0·63	37·3	45·4	13·9
27.	Periapodu	14–24	SL	11·4	5·7	24·6	58·3	0·50	52·6	54·1	22·5
28.	Aliyarnagar (3rd mile)	0–6	S	8·1	1·5	28·3	62·1	0·35	32·3	41·1	4·4
29.	Negamam	0—6	S	5·3	1·3	44·3	49·1	0·14	9·8	39·0	3·7
30.	Vettaikaranpudur	0—6	S	3·2	1·6	26·1	69·0	0·08	33·7	41·2	5·8

C = Clay SC = Sandy clay SCL = Sandy clay loam SL = Sandy loam
S = Sand L = Loam.

3. In land rating for classification purposes 'y' value will be a better index of soil texture than arbitrary values assigned to each textural class.

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