SOIL MOISTURE RELATIONSHIPS OF SOME NATAL SUGAR BELT SOILS

By R. R. MAUD

Summary

The soil moisture characteristics of the various major soil groups occurring in the Natal Sugar-Belt are presented with particular reference to the amount of available moisture of each soil group. This is correlated with the silt and clay contents of these soils.

Introduction

In addition to an adequate chemical fertility status of the soil, optimum plant growth is dependent on satisfactory soil physical conditions. Whilst extensive data have been accumulated regarding the nutrient status of Natal Sugar-Belt soils, relatively little work has been undertaken in the investigation of the physical properties of these soils. In view of the increasing use being made of supplementary irrigation in the production of sugarcane crops in certain parts of Natal, together with the development of extensive irrigation schemes in the northern regions of the industry in low rainfall areas, more information, particularly regarding the moisture relationships of the soils is now urgently required. The moisture retention properties at different tensions of the more important surface soils of the Natal Sugar-Belt have now been determined and are detailed below.

Methods

Disturbed soil samples were used in the determinations that included the use of both the porous plate apparatus for the tension range 0—1 atmospheres[2], and the pressure membrane apparatus for the tension range 1—15 atmospheres.

Soils

For this investigation between five and ten typical samples of the surface soil of each of the major soil types of the Natal Sugar-Belt were used. It cannot be stressed too strongly that the data here presented are 'mean' results for the different soil types. Single determinations can and do vary considerably from these results, but nevertheless the general trend for each soil type is indicated. In addition as only surface samples were investigated, in any application of this data to field practice consideration must be given to such factors as depth of soil and variations in the soil profile.

The soils investigated were derived from:

(1) Amphibolite—a black clay loam.
(2) Tugela schist—a red-brown loam to clay loam.
(3) Granite—a grey-brown gritty loam.
(4) Table Mountain sandstone (ordinary)—a grey coarse sandy loam.
(5) Table Mountain sandstone (mist belt)—a red-brown loam to clay loam.
(6) Dwyka tillite—a grey fine sandy loam.
(7) Lower Ecca shale—a dark grey-brown loam to clay loam.
(8) Middle Ecca sediments—a grey-brown sandy loam.
(9) Beaufort sediments—a grey-brown loamy fine sand.
(10) Karroo dolerite and basalt—a red clay loam.
(11) Karroo dolerite and basalt—a black clay loam.
(12) Cretaceous sediments—a black clay loam.
(13) Recent Sands—a red-brown coarse sand.
(14) Recent Sands—a grey coarse sand.
(15) Alluvium—a red-brown sandy loam.
(16) Alluvium—a grey-brown clay.

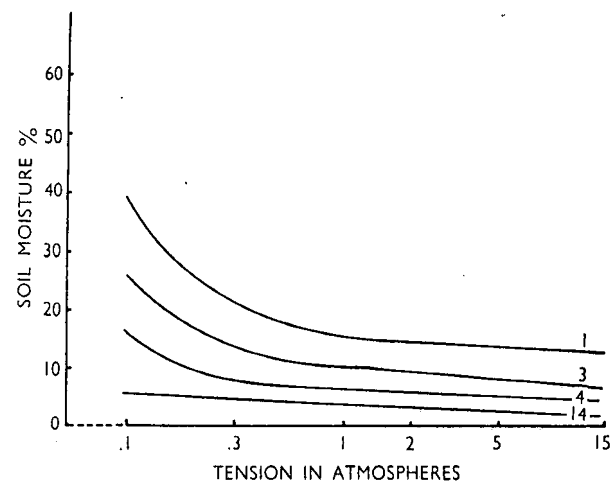

Fig. 1

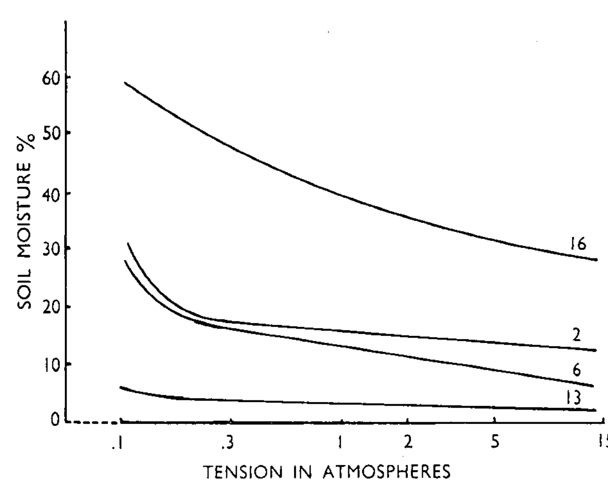

Fig. 2

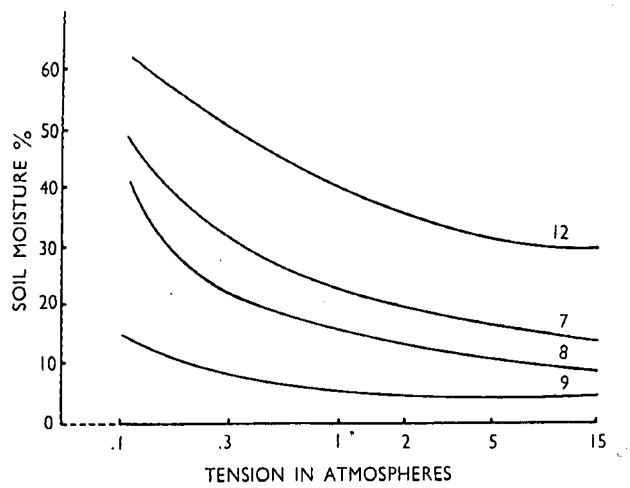

Fig. 3

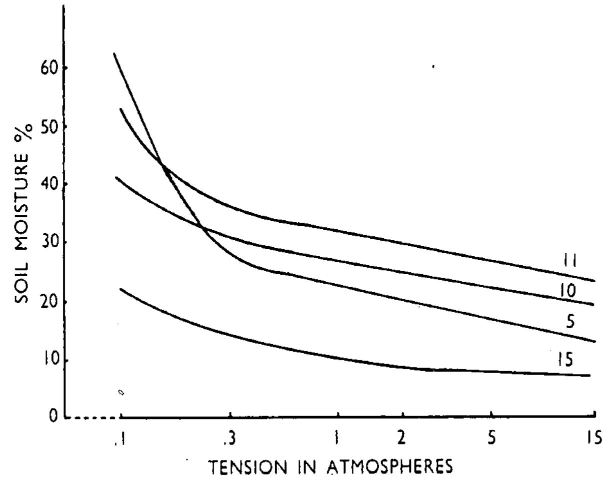

Fig. 4

Whilst the predominant clay minerals occurring in these soils are of the 1:1 lattice type, mostly kaolinite, 2:1 lattice and mixed layer types also occur in some soils. Thus Nos. 1, 2, 3, 6 and 16 probably contain illite in varying amounts, whilst Nos. 11 and 12 contain appreciable amounts of montmorillonite which is also present in limited amount in No. 1.

Results and Discussion

The moisture release curves for these soils are depicted graphically in Figs. 1-4. The numbers refer to that of each soil in the foregoing Table.

These moisture release curves essentially represent the soil moisture suction forces that must be overcome by the plant roots if they are to extract water from the soil at any moisture level.

The two soil moisture constants that are of greatest importance in relation to soil moisture availability are Field Capacity and Wilting Point, for it is between these values that moisture in the soil is available to the plant. The former value has been found by many workers to approximate to that retained by the soil at $\frac{1}{3}$ atmosphere tension, whilst Wilting Point has been found to correlate very closely with the 15 atmosphere moisture percentage of the soil.

In practice the amount of water held in the soil is more usefully expressed on a volume basis and therefore in Table 1 the Field Capacity and Wilting Point of each soil is also expressed in inches of water per foot of soil. The difference between these two values is the number of inches of water per foot of soil that are available to the plant.

The relationship existing between the moisture retained by the soil at Field Capacity and Wilting Point, together with the available moisture per foot of soil with regard to the silt and clay content of the soil is also of interest. 'Mean' mechanical analyses of the different soil types are given in Table 2.

Table 1

Soil	D	FCw	FCv	FCi	WPw	WPv	WPi	Available moisture ins./ft.
1. Amphibolite	1.45	20.36	29.52	3.54	13.43	19.47	2.34	1.20
2. Tugela schist	1.45	17.46	25.32	3.04	12.18	17.66	2.12	0.92
3. Granite	1.60	12.89	20.62	2.47	6.49	10.38	1.25	1.22
4. Table Mountan sandstone (Ordinary) ..	1.70	7.61	12.94	1.55	4.10	6.97	0.84	0.71
5. Table Mountain sandstone (Mist belt) ..	1.10	27.32	30.05	3.61	12.99	14.29	1.71	1.90
6. Dwyka tillite	1.65	16.67	27.51	3.30	6.24	10.30	1.24	2.06
7. Lower Ecca shale ..	1.40	27.62	38.67	4.64	12.53	17.54	2.10	2.54
8. Middle Ecca sediments	1.65	18.91	31.20	3.74	7.85	12.95	1.55	2.19
9. Beaufort sediments ..	1.60	7.15	11.44	1.37	4.33	6.93	0.83	0.54
10. Karroo dolerite (Red)	1.40	30.32	42.45	5.09	18.69	26.17	3.14	1.95
11. Karroo dolerite (Black)	1.40	34.63	48.48	5.82	21.45	30.03	3.60	2.22
12. Cretaceous sediments..	1.35	47.33	63.90	7.67	29.23	39.46	4.74	2.93
13. Recent Sands (Red) ..	1.60	4.72	7.55	0.91	2.43	3.89	0.47	0.44
14. Recent Sands (Grey) ..	1.60	3.48	5.57	0.67	2.03	3.25	0.39	0.28
15. Alluvium (Red) ..	1.55	15.68	24.30	2.92	9.17	14.21	1.71	1.21
16. Alluvium	1.35	47.61	64.27	7.71	28.67	38.70	4.64	3.07

D = Natural Bulk Density of soil
FC_i = Field Capacity in inches/ft.
FC_w = Field Capacity % by weight
WP_w = Wilting Point % by weight
WP_i = Wilting Point in inches/ft.
FC_v = Field Capacity % by volume
WP_v = Wilting Point % by volume

Table 2

Soil	% Coarse Sand	% Fine Sand	% Silt	% Clay
1. Amphibolite	14.8	34.5	15.6	35.1
2. Tugela schist	26.2	26.1	6.0	41.7
3. Granite	48.5	18.5	9.2	23.8
4. Table Mountain sandstone (Ordinary)	52.2	25.9	6.0	15.9
5. Table Mountain sandstone (Mist belt)	24.7	23.3	12.4	39.6
6. Dwyka tillite	23.2	50.1	12.3	14.4
7. Lower Ecca shale	32.1	22.2	16.5	29.2
8. Middle Ecca sediments	10.5	40.9	20.3	28.3
9. Beaufort sediments	24.1	51.2	6.4	18.3
10. Karroo dolerite (Red)	7.6	21.4	16.6	54.4
11. Karroo dolerite (Black)	10.2	16.3	21.0	52.5
12. Cretaceous sediments	11.2	44.7	12.1	32.0
13. Recent Sands (Red)	62.0	24.0	3.5	10.5
14. Recent Sands (Grey)	63.1	29.5	1.7	5.7
15. Alluvium (Red)..	22.8	52.1	6.4	18.7
16. Alluvium	0.28	2.35	25.49	71.88

Correlations have been worked out by Mr. H. Dicks of the Mount Edgecombe Experiment Station as follows:

Table 3

	Coefficient of Correlation(r)	Regression Equation
Field Capacity *vs.* % Clay	0.9015	—
Field Capacity *vs.* % (Silt+Clay) ..	0.9485	y=0.07365x+0.2037
Wilting Point *vs.* % Clay	0.9548	—
Wilting Point *vs.* (Silt+Clay)	0.9622	y=0.04528x — 0.0891
Available Moisture *vs.* % Clay ..	0.7093	—
Available Moisture *vs.* % (Silt+Clay)	0.8027	—

From this it is evident that a very high correlation exists between percentage moisture in the soil at Field Capacity and Wilting Point on the one hand and the clay and silt+clay content of the soils on the other.

This relationship depends on the dominant clay mineral type present in each soil. For the purposes of correlation those soils having the 1:1 lattice type dominant have been included whilst the two soils containing appreciable amounts of montmorillonite which exhibit swelling have been omitted.

In all cases the inclusion of the silt fraction has increased the degree of correlation and for this reason only the regression equations related to the silt+clay content of the soil have been plotted in Fig. 5.

The difference between the two lines, (the shaded area), reflects the average available moisture in inches per foot of soil of a given silt+clay content. This value would appear to increase with increasing silt+clay content of the soil, the relationship being significantly linear. (cf. r=0.8027).

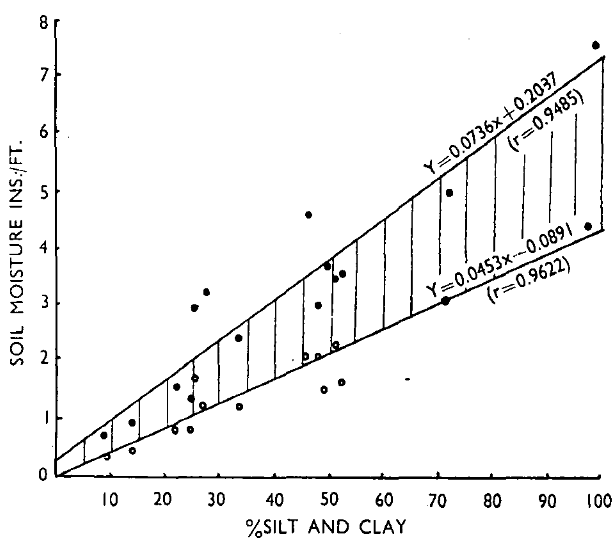

Fig. 5

Considering the relationship between percentage moisture in the soil at Field Capacity and Wilting Point and percentage clay in the soil it is of interest that the correlation coefficient for Field Capacity is r=0.9015 whilst that for Wilting Point is r=0.9548. This would appear to indicate the relative importance of the clay fraction in determining the moisture retention properties of the soil especially at higher tensions.

References

[1] Richards, L. A., 1941—A pressure membrane extraction apparatus for soil solutions. *Soil Science* 51 : 377-386.

[2] Richards, L. A. and Fireman, M., 1943—Pressure-plate apparatus for studying moisture sorption and transmission by soil. *Soil Science* 56 : 395-404.

S.A.S.A. Experiment Station,
MOUNT EDGECOMBE.
12th March, 1962.

Mr. Thompson said it was necessary to know from what depth the plant could draw water and also with what efficiency. He had never been able to get a satisfactory answer to this question. When conducting irrigation schemes it was desirable to know the answer in order to get irrigation frequencies right. Not knowing this answer, the tendency was to work on too shallow a depth and therefore to invest heavily in excessive equipment, and to irrigate the top soil perhaps too frequently.

Dr. Dick, in the chair, asked the author if the tests he had used for moisture retention were such that they could be employed by the ordinary planter.

Mr. Maud said all the grower would require to do was to dry a sample of soil in an oven and determine the loss in weight and hence the moisture content. This could then be related to the data given in the paper.

Mr. Alexander asked how a plant could exert such a high pressure, even amounting to 225 lbs. per sq. in., in drawing water from the soil. He wondered how it was possible for a tree 400 feet high to extract water by its roots and raise it to its top.

Dr. Dick said apparently that there were two factors involved. One was osmotic pressure and the other the suction caused by the continuity of the stream of water going up. The water drawn off the top of this stream by transpiration had to be replaced by water from below.