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The Relationship of Soil Water with Soil Moisture Constants

by

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Introduction: Investigation of soil moisture constants, physical properties of soils and their relationships will be of much use for an understanding of the moisture characteristics of the soils. The classification of soil moisture in relation to plant is a realistic approach. The range of soil water from wilting coefficient to field capacity is of greater importance due to its availability for crop growth and production. which has been designated as 'available range'. The range of soil water from 'wilting coefficient' to 'ultimate wilting point' and that from 'ultimate wilting point' to zero have been named as "moisture unavailable to plants" respectively. Soil moisture constants *viz.*, water holding capacity, moisture equivalent, wilting point, ultimate wilting point, their inter-relationships and relationship with soil water are discussed in this paper.

Review of Literature: Water holding capacity of South Indian soils is mainly controlled by clay, organic matter and base exchange capacity (Kandaswamy, 1961). The importance of study of field capacity springs from the fact that the moisture held at field capacity represents the maximum available water, above which the water will be drained away. Veihmeyer and Hendrickson (1931) reported that moisture equivalent is a close measure of the field capacity of the fine textured soils but not always sandy soils. This moisture constant is found to be affected by texture and organic matter. Salter and Haworth (1961 b), Salter and Williams (1963) concluded that the field capacity was significantly affected by the application of farm manure in a sandy loam soil. Furr and Beeve (1945) preferred moisture equivalent in the place of field capacity. Alway and McDole (1917) have shown that field capacity of sands is higher than the moisture equivalent. According to Richards and Weaver (1944) moisture equivalent represents the moisture content at 1/3 atm. on a porous plate. Kandaswamy (1961) reported a positive correlation between water holding capacity and moisture equivalent. Briggs and Shantz (1912 a) found direct relationship between moisture equivalent and wilting coefficient and thereby proposed an indirect method of estimation of wilting coefficient. Wilting coefficient was studied in detail by Veihmeyer and Hendrickon (1946), Bouyoucos (1936 and 1939), Furr and Reeve (1945), Salter and Haworth (1961 a) and Salter and Williams (1963). It has been shown that wilting coefficient is controlled by clay and organic matter. The influence of organic matter was found to be marked in coarse textured soils.

Taylor *et al* (1934) reported the range of wilting of plants from wilting of basal leaves to wilting of all leaves. Furr and Reeve (1945) found that the growth of plant ceased when the basal leaves were completely wilting and the

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top leaves have partially lost their turgidity in sunflower plants. They designated the moisture at this point as "first permanent wilting point". The moisture content at the time of wilting of all the leaves was named as "ultimate wilting point". The range between first permanent wilting point and ultimate wilting point was called "wilting range" which is the potential reserve of soil water available for the existence of the plant and not useful for the growth of the plant. They reported higher value of wilting range in fine textured soils and lower value in coarse texture soils which was by no means consistent.

Furr and Reeve (1945) suggested that the soil moisture could be classified as (1) moisture available for vegetative growth (2) moisture in the wilting range and (3) moisture unavailable to plants. The available range is influenced by the texture of the soil (Briggs and Shantz 1912; MacGillavary and Doneen, 1942; Kramer and Coile, 1940). It was also found to be increased due to the addition of organic matter (Bouyoucos, 1939, Salter and Haworth 1961 b, Salter and Williams 1963). The wilting range and unavailable range also vary according to the clay content of the soils.

Material and Methods: Soils of varying texture and kind were selected for study. Soils taken up for the study were black, red, alluvial, lateritic, laterite and other mixed types. Pure sand, and pot mixture (1: 1: 1 red earth, sand and farmyard manure) were also included. Hence a total of ninteen variants of soil samples were studied. Soils were collected from a depth of 0.9" crushed, sieved and passed through 2 mm. sieve, and taken for the various estimations. Water holding capacity was estimated in duplicate by Keen and Raczkowski method as outlined by Piper (1950). Bouyoucos method as indicated by Piper (1950) was employed for the estimation of moisture equivalent. Wilting coefficient and ultimate wilting point were determined by Furr and Reeve (1945) method; growing sunflower as indicator crop. Organic carbon and mechanical composition were analysed by conventional methods. The values were expressed on oven-dry basis of the soils. The moisture equivalent was taken as the approximate field capacity. The correlation coefficient was worked out among the different properties, soil moisture constants and different classes of soil water to assess the relationships.

Results: (i) *Texture and organic carbon:* The mechanical composition and the organic carbon content of different soils indicated that the textural composition of the soils varied from heavy soils to sand containing 57.03 to 5.23 per cent of clay. The silt content varied from 1.51 to 22.81 per cent. With regard to the sand fractions, coarse sand content was higher than fine sand in almost all soils except one sample. The finer fractions (clay and silt) content was high in black soils and low in red soils. Alluvial soils, laterite soils and mixed soils contained variable amount of finer fractions.

Organic carbon was highest (3.284%) in the hill soil and lowest (0.057%) in the sand. Pot mixture recorded a medium amount of organic carbon (1.650 %).

(ii) *Moisture constants:* Clay soils recorded higher value of moisture constants than medium and sandy soils and black soils recorded greater value than that of red, laterite and other mixed types.

(iii) *Different classes of soil water:* The values of 'available range', 'wilting range', and 'unavailable range' were recorded. It was found that the clay content and type of the clay are the major factors influencing the values of these three ranges. The available range was high in clay soils and low in sandy soils. The value of wilting range was highly variable. The 'unavailable range' was highest in clay soils and lowest in sandy soils ranging from 15.859 to 2.518 per cent respectively.

(iv) *Relationship among different properties:* The relationship among moisture constants, among soil water classes and between soil water and soil moisture constants are presented in Table 1. No significant correlation was found between organic carbon and other physical properties so also between wilting range and other properties other than water-holding capacity and wilting range and wilting coefficient at 5% and 1% respectively. In other cases high correlation was obtained.

TABLE 1. *Relationship between various properties.*

S. No.	Relationship between X Y	Correlation coefficient γ	Regression equation
1.	Water holding capacity and moisture equivalent	0·957 †	—10·117 + 0·70 X
2.	Water holding capacity and wilting coefficient	0·912 †	—3·853 + 0·29 X
3.	Water holding capacity and ultimate wilting point	0·924 †	—3·899 + 0·26 X
4.	Water holding capacity and available range	0·921 †	—6·270 + 0·41 X
5.	Water holding capacity and wilting range	0·564 *	—0·073 + 0·03 X
6.	Moisture equivalent and wilting coefficient	0·950 †	—0·208 + 0·42 X
7.	Moisture equivalent and ultimate wilting point	0·977 †	—0·109 + 0·37 X
8.	Moisture equivalent and available range	0·965 †	—0·214 + 0·58 X
9.	Wilting coefficient and ultimate wilting point	0·974 †	—0·108 + 0·84 X
10.	Wilting coefficient and available range	0·829 †	—1·853 + 1·14 X
11.	Wilting coefficient and wilting range	0·590 §	—0·017 + 0·15 X
12.	Ultimate wilting point and available range	0·893 †	—1·101 + 1·43 X

N. B: † Significant at 0.1 per cent level
§ Significant at 1.0 per cent level
* Significant at 5.0 per cent level

Discussion: Clay was found to influence the soil moisture constants and other physical properties in the various South Indian soil types studied. The black soil type recorded higher clay content than other soil types. The relationship of textural composition and other properties (including soil moisture constants) was not worked out as it was definitely established by detailed studies in South Indian soils that finer fractions (clay and silt) record positive correlation and coarse fractions negative correlation with moisture constants and moisture characteristics. With regard to organic matter content South Indian soils are generally poor except the lateritic soils of the hills and hilly ranges. The pot mixture containing a moderate amount of organic carbon is considered to be a fertile plant medium. This is probably due to sand content of the mixture which adds heavy weight to the soil. The analysis were carried out only on weight basis. This observation with regard to organic matter content in the present study falls in line with Mahalingam (1962) who observed that hilly soils are rich in organic matter due to optimum climatic conditions for plant growth. No relationship was found to have existed between organic carbon and soil moisture constants and soil water. This is due to the predominant effect of clay on these soil characters. This is in agreement with the findings of Bertramson and Rhodes (1939) that the organic matter had no influence on the moisture holding capacity of heavy soils of Nebraska. Rajagopal and Mariakulandai (1967) found that the added organic matter had no effect on the moisture holding ability of the South Indian soils upto a level of ten tons of farmyard manure per acre.

Moisture constants: The four important soil moisture constants, water holding capacity, moisture equivalent, wilting coefficient and ultimate wilting point are mainly controlled by the amount and type of clay. In the case of lateritic soil lower value of moisture constants were recorded even though the clay content is higher. This is due to the clay type which holds comparatively lesser amount of water than other clays. Further, there were high correlation observed among the moisture constants. The present findings agree with the study of Kandaswamy (1961) who has recorded positive correlation between moisture constants in South Indian soils.

Soil water: Soil water was classified by Furr and Reeve (1945) into moisture available for vegetative growth (available range), moisture in the wilting range (wilting range) and moisture unavailable to plants (unavailable range) based on soil water and plant relationship which are important for growth, existence of the plant and unavailability to plant respectively.

While the available range and unavailable range were influenced by clay no definite relationship was noticed between the texture and wilting range. As the wilting coefficient and moisture equivalent are influenced by clay, these two constants increase simultaneously as the clay increases in a soil. When the upper and lower limits increase, the available range also increases. MacGillavary and Doneen (1942), Kramer and Coile (1940) and Salter and Williams (1963) have also observed increased available range of soil moisture in soils of higher value of field capacity and wilting coefficient. The available range and unavailable range are significantly correlated with each other.

The soil moisture constants *viz.*, water holding capacity, moisture equivalent and wilting coefficient were significantly correlated with available and unavailable range of soil water. Wilting range has correlation with water holding capacity and wilting coefficient only.

Summary and Conclusion: The study on soil moisture constants, texture and organic carbon was conducted in different soils of South India. The soil moisture classification was worked out utilizing the data obtained from soils of varying texture from sand to clay. The study revealed that (1) the amount and type of clay had profound influence on the soil moisture constants and moisture characters; (2) Organic carbon has no bearing on the moisture constants and moisture characters. Hilly soils are rich in organic matter due to conducive conditions for plant growth, which ultimately increase the organic reserve of the soil; (3) High correlation was found among soil moisture constants, water holding capacity, moisture equivalent wilting coefficient and ultimate wilting point; (4) The 'available range' and 'unavailable range' are significantly correlated with other soil moisture constants. 'Wilting range' was found to have correlation with water holding capacity and wilting coefficient only. A high correlation was noticed between available range and unavailable range; and (5) In case of increased values of upper limit (moisture equivalent) and lower limit (wilting coefficient) of available water, the available range also increased.

REFERENCES

Alway, F. J. and G. R. McDole 1917 Relation of the water retaining capacity of a soil to its hygroscopic coefficient. *J. agric. Res.*, **9**: 27-71.

Bertramson, B. R. and H. D. Rhodes 1939 The effect of cropping and manure applications on some physical properties of a heavy soil in Eastern Nebrasha. *Soil Sci. Soc. Amer. Proc.*, **3**: 32-16.

Bouyoucos, G. J. 1936 A rapid indirect method for determining wilting coefficient of soils. *J. Amer. Soc. Agron.*, **28**: 581-6.

——— 1939 Effect of organic matter on the water holding capacity and wilting point of mineral soils *Soil Sci.*, **47**: 377-83.

Briggs, L. J. and H. L. Shantz 1912 The wilting coefficient and its indirect determination. *Bot. Gaz.*, **53**: 20-37.

Furr, J. R. and J. O. Reeve 1945 Range of soil moisture percentages through which plants undergo permanent wilting in some soils from semi arid irrigated areas. *J. agric. Res.*, **71**: 149-70.

Kandaswamy, P. 1961 Soil moisture constants in relation to the physical properties of Madras soils. *M. Sc Thesis Madras Univ.* (unpublished).

Kramer, P. J. and T. S. Coile 1940 An estimate of the volume of water made available by root extension. *Plant Physiol.*, **15**: 743-7.

MacGillavary, J. H. and L. D. Doneen 1942 Soil moisture conditions as related to irrigation of truck crops on mineral soils. *Froz. Amer. Soc Hort. Sci.*, **40**: 485.

Mahalingam, P. K. 1962 A study of the physical and chemical properties of the high level Nilgiri soils. *M. Sc. thesis Madras Univ.* (unpublishsd).

Piper, C. S. 1950 *Soil and Plant ana'ysis. Interscience* publishers. New York.

Rajagopal, A and A. Mariakulandai 1967 Effect of added organic manure on the soil moisture constants in South Indian soils. *Madras agric. J.*, **54**: 83-5.

Richards, L. A. and L. Z. Weaver 1944 Moisture retention by some irrigated soils as related to soil moisture tension. *J. agric. Res.*, **69**: 215-35.

Salter, P. J. and J. B. Haworth 1961 a The available water capacity of a sandy loam soil. I. A critical comparsion of methods of determining the moisture content of soil at field capacity and at the permanent wilting percentage. *J. Soil Sci.*, **12**: 226-34.

——— 1961 b The available water capacity of a sandy loam soil. II. The effects of farmyard manure and different primary cultivations. *J. Soil Sci.*, **12**: 335-42.

——— and J. B. Williams 1963 The effect of farmyard manure on the moisture characteristic of a sandy loam soil. *J. Soil Sci.*, **14**: 73-81.

Veihmeyer, F. J. and A. H. Hendrickson 1931 The moisture equivalent as a measure of the field capacity of soils. *Soil Sci.*, **32**: 181-93.

——— 1946 Soil density as a factor in determining the permanent wilting percentage. *Soil Sci.*, **62**: 451-6.