AVAILABLE WATER CAPACITY OF THE SURFACE LAYER OF VARIOUS SOILS FROM THE ARID AND SEMIARID REGION OF PUERTO RICO

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INTRODUCTION

Soil moisture is the most important single factor affecting the yields of crops in southern Puerto Rico. In ordinary years no profitable crop growth can be expected without irrigation. The amount of water that a soil can hold in a state of ready availability for crops varies with the soil type. It is generally accepted that clayey soils usually hold more total water than sandy ones, but it is not so well recognized that some sandy soils may hold as much available water for plants as do heavier types. Of course, the value of soils, particularly in regions where irrigation is necessary, depends not on their total water-holding-capacity, but on how much usable water they can store. If plants cannot avail themselves of the water present, there is no definite advantage in high water-holding-capacity soils. The water that plants find in readily available form is what really matters.

MATERIALS AND METHODS

Samples of 34 soils from the arid and semiarid regions were collected including several from the Lajas Valley in southwestern Puerto Rico (table 1). The maps of the Soil Survey of Puerto Rico were used as a guide (7)[2] in sampling an area. Composite samples were taken from the topmost 8 inches following the technique of Cline (2); then they were air-dried, thoroughly mixed, and passed through a 2-mm. sieve. Special undisturbed samples were taken for bulk-density measurements by using a Bradfield-type cylinder.

All moisture determinations were calculated on the dry-weight basis and later converted to the volume basis by using density values. Field-capacity determinations were made for each soil by packing two soil columns in 2-1. cylinders, wetting them as suggested by Weaver and Clements, and drying duplicate samples from each cylinder in an oven at 105° C. (9). The plant method was used in determining the permanent wilting percentage, using soybeans as indicator plants with four replications for each soil. The 15-atmosphere-moisture percentage was obtained by submitting six samples from each soil in special plates to a pressure of 225 pounds per square inch

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[2] Numerals in parentheses refer to Literature Cited, p. 140.

as proposed by Richards and Weaver (6). The moisture equivalent was determined from duplicate samples according to the method of Briggs and

TABLE 1.—*Approximate location of the soil samples used in this study*

Soil type	Sample No.	Location
Fraternidad clay	9	Km. 229 H. 4, Road No. 2
San Antón clay	10	Km. 1. Variante (near Ponce)
Mercedita clay	14	Near Central Mercedita, East of Ponce
Descalabrado clay	27	Km. 169 H. 9, Road No. 2, between Añasco and Rincón
Ponceña clay	31	Km. 125, road from Juana Díaz to Ponce
Reparada clay	33	Road No. 2, East of Guayanilla
Coamo clay	34	Km. 120 H. 8, Road No. 1
Fe clay	36	Outskirts of Ponce; road to Juana Díaz
Vayas clay	37	Road No. 2, near M. Mercado's residence
Paso Seco clay	49	Hacienda Desengaño, Lajas Valley
Portugués clay	60	Road from Ponce to Juana Díaz, Hacienda Barrancas
Aguirre clay	63	Hacienda Desengaño, Lajas Valley
Ursula clay	96	Pastillo (Ponce-Juana Díaz)
Aguilita clay loam	15	Near M. Mercado's residence, Guayanilla-Ponce
Yauco clay loam	29	Km. 236, Road No. 2
Santa Isabel clay loam	39	Km. 215 H. 5, Road No. 2
Pozo Blanco clay loam	41	Km. 7 H. 8, road to Lajas
Río Cañas clay loam	66	Hacienda Algarrobo, Road Guayama to Patillas
Teresa sandy clay loam	70	Entrance to Central Cortada
Vives sandy clay loam	74	Hacienda Algarrobo, after Central Lafayette, road Arroyo-Guayama
Cintrona silt loam	40	Near Playa de Ponce
Guánica silt loam	42	Near Lake Cartagena, Lajas Valley
Serrano silt loam	68	Pastillo, Km. 185 H. 6, Ponce
Barrancas loam	72	Hacienda Ponceña, near dam
Jácana sandy loam	38	Km. 212 H. 9, Road No. 2
Guayama sandy loam	50	Barrio Guanábana, Lajas Valley
Juana Díaz sandy loam	61	Road No. 1, after Juana Díaz
Amelia sandy loam	64	Near Lake Cartagena, Lajas Valley
Machete sandy loam	71	Central Machete
Altura sandy loam	73	Near Hacienda Altura, Km. 160 H. 2, Road No. 1
San Germán sandy loam	112	Km. 225 H. 4, Sabana Grande-Yauco
Ensenada sandy loam	115	Near lighthouse, Morrillos de Cabo Rojo
Meros sand	69	Between Santa Isabel and Salinas
Jaucas sand	116	Near lighthouse, Morrillos de Cabo Rojo

McLane (1). Bulk-density determinations were made by drying the undisturbed cores of known volume in an oven at 105° C.

Presentation of Data and Discussion

The available water in soils is regarded as the moisture held at tensions between those of field capacity (about pF 2.0 to 3.0) and permanent wilting percentage (pF 4.2). Field capacity as defined by Veihmeyer and Hendrickson (8) indicates "the amount of water held in the soil after the rate of downward movement of water has materially decreased." In well-drained soils this condition may occur ordinarily 2 or 3 days after they have been thoroughly wet. Laboratory procedures for determining this soil constant are inconvenient and not very precise. The possibility of using other soil constants which can be determined more easily and accurately has been suggested by several workers. Attempts to predict field-capacity values of humid-region soils from Puerto Rico on a basis of clay percentages were successful, but failed when dealing with arid- and semiarid-region soils (3).

TABLE 2.—*Relation between moisture equivalent and field capacity in selected soil types from the arid and semiarid regions of Puerto Rico*

Soil type	Moisture equivalent (percent water)	Field capacity (percent water)	Variation
Mercedita clay	42.8	44.6	+1.8
Descalabrado clay	43.7	40.4	−3.3
Paso Seco clay	42.8	42.7	− .1
Aguirre clay	35.6	38.8	+3.2
Ursula clay	40.0	40.7	+ .7
Santa Isabel clay loam	46.7	46.6	− .1
Pozo Blanco clay loam	37.0	39.5	+2.5
Río Cañas clay loam	40.8	42.6	+1.8
Vives sandy clay loam	43.9	40.6	−3.3
Barrancas loam	42.0	41.8	− .2

Other investigators have presented data relating moisture equivalents to field capacities for South Carolina soils (5).

Moisture equivalents can be obtained easily and accurately under controlled laboratory conditions. An attempt to obtain a reliable regression of field capacity on moisture equivalent in order to evolve an equation to predict the former soil constant in terms of the latter was not successful with soils of arid and semiarid Puerto Rico. For certain individual soils, however, moisture equivalents can be used as a measure of field capacities. Table 2 shows the variation between field-capacity and moisture-equivalent values for several soil series. The field capacity ranges from nearly 39 per cent in Aguirre clay to 46.6 per cent in Santa Isabel clay loam and the moisture-equivalent range is from 35.6 to 46.7 in the same soils. The values agree rather closely, the field capacity deviating less than 4 percent above or below the moisture equivalent.

The permanent wilting percentage is regarded as the moisture content below which plants are unable to obtain water readily enough to offset transpiration losses. It can be obtained accurately by determining the water which remains in the soil when wilting occurs. However, this method requires much labor and usually takes 2 or 3 weeks to complete. Attempts to correlate permanent wilting percentages with other soil constants have been made (4). The regression of permanent wilting percentage on 15-atmosphere percentage for Puerto Rican soils has been expressed by the equation, $Y = 2.37 + 0.76\ X$, in which Y is the permanent wilting percentage and X is the 15-atmosphere percentage. A correlation coefficient of 0.90 indicates that the values are very closely associated. Table 3 shows the relation between permanent wilting percentage and 15-atmosphere percentage in 12 soils from the arid and semiarid region. In general, the permanent wilting percentage lies in the range between the 15-atmosphere percentage and 5-percent moisture below it.

TABLE 3.—*Relation between permanent wilting percentage and 15-atmosphere percentage in selected soil types from the arid and semiarid regions of Puerto Rico*

Soil type	Permanent wilting percentage	15-atmosphere moisture percentage	Variation
Descalabrado clay	18.8	21.4	−2.6
Coamo clay	17.7	20.8	−3.5
Paso Seco clay	18.2	22.8	−4.6
Ursula clay	17.4	22.5	−5.1
Río Cañas clay loam	13.6	16.3	−2.7
Guayama sandy clay loam	14.5	16.1	−1.6
Teresa sandy clay loam	18.7	21.3	−2.6
Vives sandy clay loam	16.7	17.7	−1.0
Guánica silt loam	27.3	29.0	−1.7
Jácana sandy loam	13.6	15.0	−1.4
Juana Díaz sandy loam	10.9	13.0	−2.1
Amelia sandy loam	9.8	11.7	−1.9

The available water content for a number of soils in southern and southwestern Puerto Rico is shown in table 4. In clay soils the values range from about 18 to 25 percent. Clay loams fluctuate from 17.6 to 21.6, silt loams from 17.7 to nearly 25, sandy loams and sandy clay loams from 18.6 to 24, and sands from 9 to 16.7. The tendency is for heavier soils to have higher water-holding capacities, but their permanent wilting percentages are correspondingly higher. On the other hand, on lighter soils where field-capacity values are lower, permanent wilting occurs at lower moisture contents. Some sandy soils hold as much as or even more available water than heavier clayey soils. Jácana sandy loam, for example, can store about 22 percent of available water in its surface layer, while Aguirre clay can

TABLE 4.—*Field capacity, permanent wilting percentage, and available water capacity of the surface layer of 34 representative soils from the arid and semiarid regions of Puerto Rico*

Soil type	Sample No.	Field capacity (percent water)	Permanent wilting percentage	Available water capacity (percent water)
Fraternidad clay	9	45.3	22.0	25.3
San Antón clay	10	48.7	27.9	20.8
Mercedita clay	14	42.8	25.3	17.5
Descalabrado clay	27	42.9	25.0	17.9
Ponceña clay	31	59.4	39.2	20.2
Reparada clay	33	46.8	25.0	21.8
Coamo clay	34	42.4	21.4	21.0
Fe clay	36	42.6	21.9	20.7
Vayas clay	37	35.6	20.3	15.3
Paso Seco clay	49	43.6	21.5	22.1
Portugués clay	60	39.7	21.1	18.6
Aguirre clay	63	36.7	18.6	18.1
Ursula clay	96	40.4	17.4	23.0
Aguilita clay loam	15	35.2	17.6	17.6
Yauco clay loam	29	39.6	19.6	20.0
Santa Isabel clay loam	39	45.0	23.4	21.6
Pozo Blanco clay loam	41	42.6	21.7	20.9
Río Cañas clay loam	66	39.1	20.0	19.1
Teresa sandy clay loam	70	42.5	23.9	18.6
Vives sandy clay loam	74	46.9	23.8	23.1
Cintrona silt loam	40	43.1	18.5	24.6
Guánica silt loam	42	44.8	27.1	17.7
Serrano silt loam	68	42.0	17.1	24.9
Barrancas loam	72	39.0	19.5	19.5
Jácana sandy loam	38	37.4	15.6	21.8
Guayama sandy loam	50	40.6	16.7	23.9
Juana Díaz sandy loam	61	40.0	16.0	24.0
Amelia sandy loam	64	31.5	12.4	19.1
Machete sandy loam	71	32.4	13.6	18.8
Altura sandy loam	73	36.0	15.3	20.7
San Germán sandy loam	112	46.0	24.6	21.4
Ensenada sandy loam	115	43.9	20.2	23.7
Meros sand	69	15.0	6.0	9.0
Jaucas sand	116	19.3	2.6	16.7

only store 18.1. Juana Díaz sandy loam and Ensenada sandy loam can store 24 and 23.7 percent, respectively, while Vayas clay and Mercedita clay only store 15.3 and 17.5 percent, respectively (table 4).

From the moisture viewpoint soils must be judged according to their range of available moisture content. In these respect many light-textured soils can be rated as good or better than heavier ones. Most of the soils from the arid and semiarid regions of Puerto Rico have on their surface layer an adequate range of available water. However, the application of irrigation waters must be carefully gaged to conform with their ability to store available water in the root zone. Otherwise heavy losses are likely to occur.

SUMMARY

The available water of soils is considered to be in the moisture range from field capacity to permanent wilting percentage. The customary procedures for determining these two soil constants are quite inconvenient. Although data are presented that show good agreement between moisture equivalents and field-capacity values in selected soils, it was not possible to obtain a reliable regression with soils from the arid and semiarid regions of Puerto Rico. The regression of permanent wilting percentages by the plant method to 15-atmosphere percentages is expressed by the equation, $Y = 2.37 + 0.76 X$, in which Y is the permanent wilting percentage and X is the 15-atmosphere percentage. Data on the available water capacity of the surface layer of soils from the arid and semiarid regions of Puerto Rico are presented. The range of available water is adequate in most soils, fluctuating from about 18 to 25, except in sands where it is lower. It is about the same in heavy soils such as clays and clay loams as in lighter ones such as sandy loam and sandy clay loams.

RESUMEN

El agua aprovechable de los suelos es la que se encuentra retenida entre la capacidad de campo y el punto de marchitez permanente. Las técnicas para determinar estas dos constantes son muy inconvenientes. Aunque se presentan datos que demuestran la relación entre los valores del equivalente de humedad y la capacidad de campo de algunos suelos de las regiones áridas y semiáridas de Puerto Rico, no se pudo obtener una regresión válida. La regresión entre el punto de marchitez permanente y el contenido de humedad en las muestras de suelo sometidas a una presión de 15-atmósferas se puede expresar por medio de la ecuación: $Y = 2.37 + 0.76 X$, donde Y representa el punto de marchitez permanente y X el porciento de humedad restante en las muestras sometidas a una presión de 15-atmósferas. Se presentan aquí datos sobre la capacidad de retención del los agua aprovechable de los suelos de las zonas áridas y semiáridas de Puerto Rico. La mayoría de los suelos tienen una capacidad adecuada que fluctúa entre 18 y 25 porciento, excepto en las arenas donde es menor. Dicha capacidad

es casi idétnica en los suelos pesados, tales como arcillas y arcillas lómicas y en los suelos livianos, tales como los lómico arenosos y las arcillas arenoso lómicas.

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