Water-Retention Properties of Seventeen Oklahoma Soils

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The quantity of water which a soil can hold in forms available for plant use may be ascertained from the water-retention properties of the soil. Field capacity describes the total amount of water a soil can hold against the force of gravity and permanent wilting point describes the total amount of water which a soil can hold in forms unavailable to plants. The difference between field capacity and wilting point is termed "available water" and is a measure of the amount of water the soil can hold in forms useable by plants. This publication reports approximations of field capacity, permanent wilting point and available water capacity for 17 major soil types in Oklahoma.

Description of Soils

Moisture retention data were collected on seventeen soil types in Oklahoma from the locations listed in Table 1. Detailed profile descriptions of the various soil types may be found in Soil Survey reports of the various counties involved. The soils sampled are within the ranges of the characteristics prescribed in the official descriptions of the Soil Survey of the U. S. Department of Agriculture.

All soils sampled had been under cultivation for a number of years. All had been cropped to wheat or other small grains prior to sampling and had been predominantly in wheat during the time under cultivation.

Measurements and Methods

Samples of soil were taken at three sites at each location by 6-inch increments in the surface foot of soil (0-6 inches and 6-12 inches) and by 12-inch increments at depths below 1 foot. Samples from the three sites were composited by depths. The soil was mixed well and crushed by hand to pass through a U. S. standard 20-mesh sieve.

Moisture equivalent and 15-atmosphere percentage determinations were made on each composite sample of soil. Moisture equivalent was determined by the centrifuge method (1). Moisture equivalent has

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been shown to give a fairly reliable measure of the field capacity of medium textured soils (6) and it is used as an approximation of field capacity in this study. Values for coarse textured soils usually are slightly too low and for fine textured soils are slightly too high.

The 15-atmosphere percentage was determined by the pressure membrane method (4). Fifteen atmosphere percentage has been shown to approximate permanent wilting point (5) and is used for that purpose in this study.

Bulk densities of the various depths of the soils were determined by weighing dried samples of a fixed volume taken with a Veihmeyer sampling tube. In this determination samples taken in routine moisture sampling of another study, were used. The number of samples per site varied with the number of moisture samples taken. Each bulk density value, however, is based on weights of twelve or more replicates per site.

Results and Interpretations

The bulk density, moisture equivalent, 15-atmosphere percentage, and available water capacity data are presented for each soil type in Tables 2-18. For those soil types for which more than one location was sampled, the data in the tables are averages of the locations sampled. In cases where only one location per type was sampled, the data are values for that location. Available water capacity expressed in percent was calculated by subtracting the moisture percentage a 15-atmospheres from the moisture percentage at moisture equivalent. Available water capacity in inches per section was calculated by the following formula:

$$\frac{\text{Bulk density x depth increment (in.) x available moisture percentage}}{100} =$$

Available water capacity (inches of water)

The available water found ranged from 16.44 inches in the Tabler silt loam to only 9 inches in the Minco loam.

It is assumed here that moisture equivalent represents field capacity and 15-atmosphere percentage represents permanent wilting percentage. Actually, the values obtained by these laboratory approximations are probably different from the true field capacity and permanent wilting percentage values. It has been shown that the relationship between moisture equivalent and field capacity is influenced by the depth to which the soil is wetted (3) and by discontinuities in soil texture and structure such as stratification, pans and cleavage planes (2, 6). It is realized that the relationship is affected by these facors in this study. Though available water capacities determine from moisture equivalent

data are not exact, it is believed that the data presented here are sufficiently accurate to be used in the manner subsequently suggested.

The bulk density samples were taken with a Veihmeyer tube. The available water capacities as reported here may be biased. The number of determinations averaged, 12 or more, for each value reported should compensate for random errors within the method. However, a consistant five percent error, high or low, in bulk density throughout a 6 foot soil profile, of 1.5 bulk density and 12 percent available water, would result in an error of only .65 inches of available water in the entire 6 foot profile. Though some bulk density determinations for individual depths may well deviate as much as five percent from true bulk density, it is not likely that the average error for a single profile would exceed five percent.

Use of the Information

Water-retention properties of soils are useful in both irrigated and dryland agriculture. These properties indicate the amount of water required to wet a given soil, the amount of water which may be stored in the soil and the amount of the stored water which may be used by plants.

Knowledge of water-retention properties is useful in irrigation farming for determining when to apply water and the amount of water which should be applied. In dryland farming, this information can be used in determining the amount of soil water available at planting time.

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Table 1.—Soil types studied and locations where sampled.

Soil Type	County	Legal Description			
		Quarter	Section	Township	Range
Bethany silt loam	Kay	S.E.	33	29N	2E
	Kay	N.W.	4	25N	1E
	Garfield	S.W.	15	24N	5W
	Kingfisher	S.W.	13	15N	9W
Tabler silt loam	Grant	S.W.	6	28N	3W
Kirkland silt loam	Kay	N.E.	21	29N	1E
	Noble	N.W.	34	24N	1W
	Payne	S.E.	16	19N	2E
Renfrow silty clay loam	Kingfisher	N.W.	19	16N	5W
Grant silt loam	Garfield	S.W.	17	22N	8W
	Alfalfa	N.E.	16	26N	11W
	Woods	S.E.	26	27N	14W
	Blaine	S.W.	9	19N	10W
Pond Creek silt loam	Garfield	N.E.	16	22N	7W
	Garfield	S.E.	21	23N	8W
	Woods	N.E.	35	27N	14W
	Alfalfa	S.E.	29	26N	12W
Carey silt loam	Harper	S.E.	9	27N	22W
	Harper	N.E.	13	27N	23W
	Custer	N.W.	23	15N	17W
Saint Paul silt loam	Harper	S.E.	9	27N	22W
Tillman silt loam	Washita	S.E.	35	10N	17W
	Tillman	S.W.	19	2S	17W
	Kiowa	N.E.	16	6N	18W
	Cotton	N.W.	13	3S	10W
Foard silt loam	Jackson	N.E.	19	2N	18W
Foard silty clay loam	Tillman	N.E.	2	4S	14W
Dennis silt loam	Rogers	N.E.	35	20N	17E
Parsons silt loam	Rogers	N.W.	2	19N	17E
Vanoss fine sandy loam	Payne	S.W.	36	18N	2E
Lawton silt loam	Kiowa	N.E.	2	3N	17W
Minco loam	Caddo	S.W.	3	12N	12W
Pratt loamy fine sand	Tillman	N.W.	18	4S	16W

Table 2.—Bethany silt loam, average data for four locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.37	1.40	1.46	1.65	1.60	1.66	1.71	
	Percent							
Moisture equivalent	19.89	24.58	29.05	28.47	27.61	27.63	27.15	
15 atmosphere percentage	7.60	11.79	16.82	15.47	15.21	15.14	14.14	
Available water	12.29	12.79	12.23	13.00	12.40	12.49	13.02	
	Inches of water per section of soil depth							
Available water	1.01	1.07	2.14	2.57	2.38	2.49	2.67	14.33

Table 3.—Tabler silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.44	1.35	1.49	1.62	1.61	1.62	1.63	
	Percent							
Moisture equivalent	20.23	24.38	30.96	30.66	29.78	28.01	30.80	
15 atmosphere percentage	7.21	11.11	16.23	15.75	14.85	13.45	15.40	
Available water	13.02	13.27	14.73	14.91	14.93	14.56	15.40	
	Inches of water per section of soil depth							
Available water	1.12	1.07	2.63	2.90	2.88	2.83	3.01	16.44

Table 4.—Kirkland silt loam, average data for three locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.35	1.45	1.52	1.65	1.62	1.71	1.71	
	Percent							
Moisture equivalent	18.67	24.05	29.29	28.00	29.13	29.13	27.39	
15 atmosphere percentage	7.58	12.36	16.13	15.87	16.85	16.79	15.71	
Available water	11.09	11.69	13.16	12.13	13.28	12.34	11.68	
	Inches of water per section of soil depth							
Available water	.90	1.02	2.40	2.40	2.58	2.53	2.40	14.23

Table 5.—Renfrow silty clay loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.36	1.41	1.50	1.65	1.62	1.59	1.69	
	Percent							
Moisture equivalent	23.13	26.48	29.72	31.11	29.91	27.01	27.00	
15 atmosphere percentage	9.86	13.97	14.61	16.87	16.32	15.58	15.12	
Available water	13.27	12.51	15.11	14.24	13.59	11.43	11.88	
	Inches of water per section of soil depth							
Available water	1.08	1.06	2.72	2.82	2.64	2.18	2.41	14.91

Table 6.—Grant silt loam, average data for four* locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.45	1.48	1.41	1.47	1.54	1.52	1.59	
	Percent							
Moisture equivalent	16.93	19.14	20.96	21.70	20.09	21.77	21.15	
15 atmosphere percentage	6.00	7.69	8.96	10.40	9.51	10.78	10.32	
Available water	10.93	11.45	12.00	11.30	10.58	10.99	10.83	
	Inches of water per section of soil depth							
Available water	.95	1.02	2.03	1.99	.96	2.00	2.07	12.02

* All depths except 48-60 and 60-72 are averages of four locations; 48-60 and 60-72 are averages of three locations; shale encountered at 4 ft. at Okeene.

Table 7.—Pond Creek silt loam, average data for four locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.48	1.44	1.46	1.52	1.61	1.56	1.62	
	Percent							
Moisture equivalent	15.78	18.64	22.45	24.23	24.01	23.65	23.41	
15 atmosphere percentage	5.70	7.08	10.38	12.52	11.83	10.07	10.78	
Available water	10.08	11.56	12.07	11.71	13.18	13.58	12.63	
	Inches of water per section of soil depth							
Available water	.90	1.00	2.11	2.14	2.55	2.54	2.46	13.70

Table 8.—Carey silt loam, average data for three* locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.45	1.40	1.41	1.45	1.46	1.43	1.54	
	Percent							
Moisture equivalent	16.58	19.34	22.57	19.68	19.49	17.54	15.84	
15 atmosphere percentage	7.70	9.05	10.79	9.09	8.37	6.80	5.39	
Available water	8.88	10.29	11.78	10.59	11.12	10.74	10.45	
	Inches of water per section of soil depth							
Available water	.77	.86	1.99	1.84	1.95	1.84	1.93	11.18

* All depths except 48-60 and 60-72 are averages of three locations; 48-60 and 60-72 are averages of three locations. Shale encountered at 4 ft. at Custer.

Table 9.—Saint Paul silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.44	1.44	1.40	1.45	1.50	1.53	1.59	
	Percent							
Moisture equivalent	16.98	19.87	24.35	27.78	26.17	26.25	23.80	
15 atmosphere percentage	8.39	7.88	10.26	13.37	13.44	12.72	12.49	
Available water	8.59	11.99	14.09	14.41	12.73	13.53	11.31	
	Inches of water per section of soil depth							
Available water	.74	1.03	2.37	2.51	2.29	2.48	2.16	13.58

Table 10.—Tillman silt loam, average data for four locations.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.28	1.32	1.51	1.66	1.65	1.63	1.59	
	Percent							
Moisture equivalent	19.78	23.70	25.41	25.04	24.85	24.24	23.83	
15 atmosphere percentage	9.54	12.84	15.02	14.92	14.81	15.19	14.47	
Available water	10.24	10.86	10.39	10.12	10.04	9.05	9.36	
	Inches of water per section of soil depth							
Available water	.79	.86	1.88	2.02	1.99	1.77	1.79	11.1(

Table 11.—Foard silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.41	1.41	1.49	1.67	1.56	1.61	1.63	
	Percent							
Moisture equivalent	17.95	21.80	24.03	23.57	22.94	21.17	19.64	
15 atmosphere percentage	8.13	11.51	13.85	14.14	13.31	11.01	9.23	
Available water	9.82	10.29	10.18	9.43	9.63	10.16	10.41	
	Inches of water per section of soil depth							
Available water	.83	.87	1.82	1.89	1.80	1.96	2.04	11.21

Table 12.—Foard silty clay loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.21	1.32	1.44	1.61	1.59	1.62	1.63	
	Percent							
Moisture equivalent	22.31	25.04	26.65	26.23	25.29	23.00	20.85	
15 atmosphere percentage	9.85	12.68	14.24	13.77	13.08	10.81	9.98	
Available water	12.46	12.36	12.41	12.46	12.21	12.19	10.87	
	Inches of water per section of soil depth							
Available water	.90	.93	2.14	2.41	2.33	2.37	2.13	13.21

Table 13.—Dennis silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.44	1.41	1.34	1.35	1.43	1.54	1.58	
	Percent							
Moisture equivalent	20.50	20.91	25.67	28.23	29.32	29.21	28.92	
15 atmosphere percentage	5.79	9.74	14.38	17.86	18.92	18.49	17.28	
Available water	14.71	11.17	11.29	10.37	10.40	10.72	11.64	
	Inches of water per section of soil depth							
Available water	1.27	.95	1.82	1.68	1.78	1.98	2.21	11.69

Table 14.—Parsons silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.40	1.22	1.32	1.48	1.53	1.58	1.72	
	Percent							
Moisture equivalent	20.50	22.75	25.49	29.55	30.94	29.92	27.82	
15 atmosphere percentage	8.02	9.74	13.51	19.79	18.36	18.90	17.61	
Available water	12.48	13.01	11.98	9.76	12.58	11.02	10.21	
	Inches of water per section of soil depth							
Available water	1.05	.95	1.90	1.73	2.31	2.09	2.11	12.14

Table 15.—Vanoss fine sandy loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.53	1.55	1.60	1.66	1.61	1.67	1.62	
	Percent							
Moisture equivalent	11.80	13.90	15.17	17.90	14.68	12.47	10.77	
15 atmosphere percentage	4.42	5.55	6.82	8.74	6.95	4.32	3.84	
Available water	7.38	8.35	8.35	9.16	7.73	8.15	6.93	
	Inches of water per section of soil depth							
Available water	.68	.78	1.60	1.82	1.49	1.63	1.35	9.35

Table 16.—Lawton silt loam.

	Depth (Inches) 0-6	6-12	12-24	24-36	36-48	48-60	60-72	Total
	Grams per cubic centimeter							
Bulk density	1.29	1.50	1.46	1.58	1.53	1.65	1.66	
	Percent							
Moisture equivalent	21.61	27.20	28.94	27.26	25.65	26.22	21.86	
15 atmosphere percentage	9.32	14.51	15.95	14.29	13.24	13.08	10.30	
Available water	12.29	12.69	12.99	12.97	12.41	13.14	11.56	
	Inches of water per section of soil depth							
Available water	.96	1.14	2.28	2.46	2.28	2.60	2.30	14.02

Table 17.—Minco loam.

	Depth (Inches)							
	0-6	**6-12**	**12-24**	**24-36**	**36-48**	**48-60**	**60-72**	**Total**
				Grams per cubic centimeter				
Bulk density	1.24	1.43	1.49	1.42	1.47	1.39	1.49	
				Percent				
Moisture equivalent	13.63	17.04	14.74	17.46	15.44	21.11	22.56	
15 atmosphere percentage	5.73	7.43	8.01	7.65	8.26	11.50	12.96	
Available water	7.90	9.61	6.73	9.81	7.18	9.61	9.60	
				Inches of water per section of soil depth				
Available water	.59	.85	1.20	1.67	1.27	1.70	1.72	9.00

Table 18.—Pratt loamy fine sand.

	Depth (Inches)							
	0-6	**6-12**	**12-24**	**24-36**	**36-48**	**48-60**	**60-72**	**Total**
				Grams per cubic centimeter				
Bulk density	1.46	1.56	1.57	1.44	1.50	1.69	1.75	
				Percent				
Moisture equivalent	13.70	12.70	11.70	14.20	13.50	17.80	23.80	
15 atmosphere percentage	3.26	3.70	4.14	4.52	4.56	6.05	9.91	
Available water	10.44	9.00	7.56	9.68	8.94	11.75	13.89	
				Inches of water per section of soil depth				
Available water	.91	.84	1.42	1.67	1.61	2.38	2.92	11.75