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Available Water-holding Capacities of Soils in Southern Idaho

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To manage moisture on agricultural cropland, you must know how much water the soil profile can hold and store for plant use. This is called the available water-holding capacity of the soil and is usually expressed as inches of water per foot of soil depth. The available water-holding capacity of any soil can be calculated if you know (1) the thickness of the horizons that make up the soil profile and (2) the moisture characteristics of these horizons.

You can determine the first of these — the kind, arrangement and thickness of soil horizons—by examining the soil profile. You can also obtain this information from soil survey reports available at local Soil Conservation Service offices for many southern Idaho counties. These reports, prepared by trained soil scientists, identify and describe soil series — that is, groupings of soils having similar arrangement and characteristics of horizons making up the soil profile.

The second factor, the moisture characteristics of these horizons, can be determined by laboratory analyses. This publication reports on laboratory studies that determined water-holding capacities of specific soils (soil series) and soil texture classes in southern Idaho.

When you know the profile characteristics of a particular soil, you can use the information in this publication to estimate the water-holding capacity of that soil.

This publication is designed for use by farmers, irrigation technicians, soil scientists, engineers, farm planners and others who need to estimate water-holding capacities of soils.

Samples for this study were collected from agricultural areas across southern Idaho. Sample sites were selected to represent important soil series or "bench mark" soils. The samples were taken from the surface 8 to 12 inches at each site. In all, more than 150 samples were taken, representing 11 soil textural classes and 53 soil series.

Each of the samples was analyzed in laboratory pressure chambers to determine water-holding capacity values. A method called ceramic plate extraction was used to establish a desorption curve for each sample. These curves were the basis for determining permanent wilting point and field capacity. These values, in turn, were used to calculate available water-holding capacity for each soil.

Desorption curves for some typical southern Idaho soils are shown in Fig. 2. The steeply sloped curve of a typical loamy sand soil (Feltham series) indicates a narrow range in moisture between field capacity and permanent wilting point — or low water-holding capacity. Contrast this with the flatter curve of the silt loam soils. These have a much wider range in soil moisture between permanent wilting point and field capacity — or higher water-holding capacity.

Table 2 lists the available water-holding capacity (AWHC), field capacity (FC) and permanent wilting point (PWP) for each of the soil types included in this study. Note that the number of samples varies from 1, in many soil series, to as many as 11. Table 3 shows data obtained for each of the textural classes included in the study. The values for textural classes with numerous sample sites are more reliable than those for classes with only 1 or 2 sample sites.

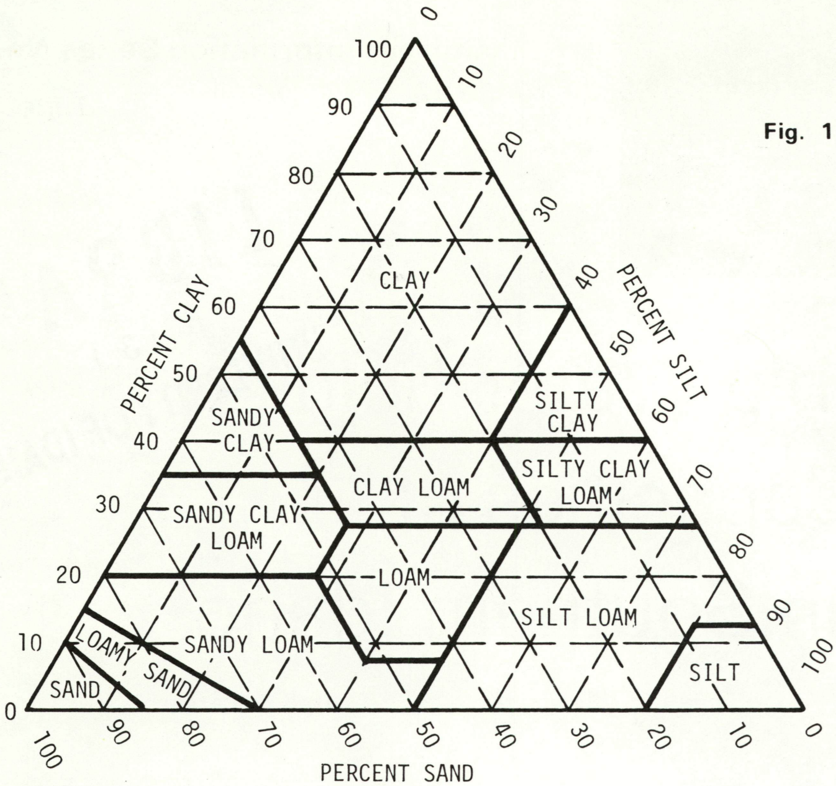


Fig. 1. Chart of textural classes showing percentages of sand, silt, and clay comprising each class.

Water-holding capacity: *definitions and discussion*

Available water-holding capacity of a soil is the amount of water that a soil profile can store in the root zone for use of growing plants. This is an important soil characteristic in managing or budgeting water for plant growth.

To understand **available water-holding capacity,** we must first understand certain definitions and characteristics of soils and plants. Plants must work to obtain water from soil. Water is attracted to soil particles and held in soil pores with varying force. The strength of this force depends on the size of soil particles, size of pores and thickness of the layer of water surrounding each particle.

When the soil is near saturation, a relatively thick layer of water is held very loosely around the soil particle. Since little attraction exists between soil particles and water surrounding the particles or occupying large pores, excess water quickly drains away because of the pull of gravity. When drainage rate or loss of water to gravity (gravitational water) becomes negligible, the soil is said to be at **field capacity.**

As the layer of water becomes thinner, the energy needed by the plant to extract water from the particle becomes greater. When the energy needed to extract water becomes greater than the energy which the plant can exert, plants cannot obtain water from the soil. When plants can no longer obtain needed water, they wilt and die. This is called the **permanent wilting point (PWP)** and is defined as the moisture content of a soil at 15 bars or atmospheres of suction (negative pressure). Water held by the soil too tightly to be extracted by the plant roots is referred to as unavailable water.

While **permanent wilting point** is fairly constant and measurable in the laboratory by applying 15 atmospheres pressure to soil samples, **field capacity** is not as sharply or easily defined and measured in the laboratory. Field capacity is the moisture content of a soil at approximately 1/3 bar or atmosphere. However, this varies depending upon soil characteristics. Coarse textured soils reach field capacity (or approach negligible drainage rate) at a lower tension than soils consisting of finer particles, as shown by the field capacity curve in Fig. 2. Thus, sandier soils with larger pore spaces have a field capacity value of much lower suction (higher pressure) than silt loam textured soils with smaller pore spaces.

The difference between **permanent wilting point** and **field capacity** is the **available water-holding capacity** of the soil (Fig. 2). This value varies depending upon soil characteristics. Pore size, pore shape and continuity of pores play important roles in water-holding capacity. Geometry and size of pores in soils depend on the size of particles (soil texture) and the arrangement of particles (soil structure) forming the soil.

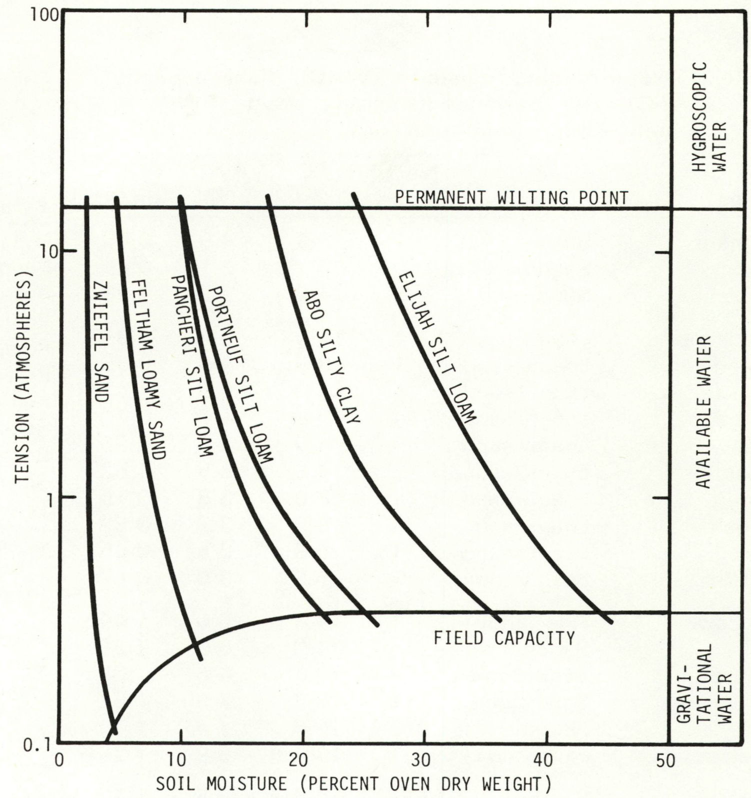
Soil texture classification groups particles into three different size categories (sand, silt, and clay) depending upon particle diameters (Table 1). A soil composed of coarser particles (sands) will form larger pores than a soil composed of finer sized particles (silt and clay). Soils are grouped into 12 textural classes based on the relative proportion of each of the

Table 1. Size limitations of soil fractions (particle diameters) comprising soil textural classes.

Coarse fragments (gravels)	over 2.0 mm
Sands	2.0 to 0.05 mm
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002 mm
Clay	less than 0.002 mm

Source: USDA Agricultural Handbook 18, Soil Survey Staff, 1952.

Fig. 2. Typical desorption curves of representative soils from agricultural areas of southern Idaho.



various sized particles (Fig. 1). For example, a model sandy loam is comprised of 70% sand, 20% silt, and 10% clay.

Soil structure is the arrangement of soil particles with respect to each other. Particles of matter tend to have an attraction for each other. These attractive forces, enhanced by the presence of organic materials, cause the soil particles to arrange themselves into aggregates. Aggregates influence size and continuity of pores. These soil characteristics affect water-holding capacity of the soil profile.

Horizons or layers within the soil profile can greatly influence the amount of soil moisture available to the plant also. Hardpans, plowpans, bedrock or other restrictive layers prevent penetration of roots and water, thus limiting the effective depth of rooting zone and profile available to hold water. Clayey or fine textured and compacted horizons usually do not block penetration of roots and water although they do greatly restrict root and water penetration depending on the density of the horizon. A horizon of reduced permeability, such as these clayey horizons underlaying a more permeable material, can result in a "perched" water table. This condition is usually temporary, lasting only until the gravitational water has had time to pass through the restrictive horizon. Thus, duration of a perched water table depends on the amount of water added to the surface and the rate at which the excess water passes through the slowly permeable horizon.

A different problem occurs when the underlying materials or horizons are coarser textured than the horizons above. Although it might seem logical that the coarser material would result in rapid drainage of gravitational or excess water, this is not the case. In fact, the underlying coarser materials act as a barrier to movement of water from the finer surface horizons. This causes the surface horizons to become saturated. Thus, a "perched" water table can be formed in a profile that has neither fine textured nor compacted layers.

For example, a soil having loam textured surface horizons underlain by a sandy subsoil horizon can develop a zone of saturation or near saturation in the surface horizon. This excess water will resist gravity flow and remain until used up by plants or evaporation. Additional water applied to the surface horizons would bring this zone to saturation and allow movement through the interface. As soon as the supply of water to the surface was cut off and the zone dropped below saturation, movement of water across the interface would cease.

An important factor in measuring the available moisture-holding capacity of a soil is the growing plant itself. The amount of water held in a soil controls the length of time that the plant can obtain water from the soil. This is related to the **consumptive use** (CU) rate of the plant. **Consumptive use** of water by the plant depends on climatic conditions (temperature, humidity, etc.) and the plant itself (size, species, leaf area, etc.). Damage to the plant in the form of decreased yield or reduced crop quality generally occurs before soil moisture is depleted to the permanent wilting point. The point at which damage to the plant takes place varies considerably with plant species since some species are much less effective at extracting water from the soil than others. This may be due to depth of rooting in the soil or the plant's capacity to extract moisture from the soil. Some crops can use only a fraction of the total available moisture in the soil profile.

Available water-holding capacity of the soil profile and the water use characteristics of the crop grown are the basis for irrigation scheduling.

Yield potential of non-irrigated cropland is controlled to a large extent by moisture available for producing the crop. This is directly related to water holding capacity of the soil profile and the ability of natural precipitation to supply moisture to fill this capacity.

Table 2. Water-holding capacity (WHC), field capacity (FC), and permanent wilting point (PWP) of south Idaho agricultural soils.

Soil series	Texture	No. of sites	FC (%)	PWP (%)	WHC (in/ft)
Feltham	Sand	1	8.9	4.9	0.65
Quincy	Sand	3	4.7	2.1	0.41
Sqiefel	Sand	3	4.6	2.2	0.38
Chedehap	Loamy sand	1	15.4	5.2	1.65
Diston	Loamy sand	1	8.9	4.9	0.65
Egin Bench	Loamy sand	1	13.0	5.8	1.67
Feltham	Loamy sand	4	9.8	4.6	0.70
Grassy Butte	Loamy sand	1	4.5	2.3	0.36
Heiseton	Loamy sand	2	14.9	5.5	1.52
Rupert	Loamy sand	1	8.5	3.8	0.76
Tindahay	Loamy sand	4	6.6	2.7	0.62
Vining	Loamy sand	1	5.3	2.5	0.45
Zwiefel	Loamy sand	1	5.9	3.0	0.47
Cencove	Fine sandy loam	1	14.9	6.0	1.44
Falk	Sandy loam	5	21.0	6.9	2.28
Matheson	Sandy loam	3	13.1	6.6	1.05
Turbyfill	Sandy loam	1	18.2	7.9	1.67
Turbyfill	Fine sandy loam	3	16.6	7.4	1.49
Unclassified	Fine sandy loam	1	13.4	5.9	1.22
Terreton	Sandy clay loam	1	14.4	7.5	1.12
Bock	Loam	4	20.2	9.0	1.80
Declo	Loam	5	21.5	9.1	2.01
Drax	Loam	1	26.5	11.6	2.41
Garbutt	Loam	1	27.5	12.3	2.46
Heiseton	Loam	1	20.6	7.7	2.09
Hunsaker	Loam	1	23.9	10.1	2.24
Marsing	Loam	1	21.6	8.2	2.17
Paulville	Loam	1	33.1	13.4	3.19
St. Anthony	Loam	1	15.5	6.8	1.41
View	Loam	1	21.1	9.1	1.94
Unclassified	Loam	2	22.0	7.2	2.41
Baldock	Silt loam	1	32.3	11.7	3.34
Bancroft	Silt loam	2	26.0	10.0	2.60
Blackfoot	Silt loam	1	22.9	9.0	2.25
Colthorp	Silt loam	1	31.1	17.3	2.24
Elijah	Silt loam	5	36.7	19.4	2.81
Gooding	Silt loam	3	25.9	12.7	2.13
Greenleaf	Silt loam	2	24.9	11.4	2.18
Hayeston	Silt loam	1	27.8	12.7	2.45
Lanark-Bancroft	Silt loams	1	26.7	10.1	2.69
Lankbush	Silt loam	1	23.1	5.9	2.79
Minidoka	Silt loam	1	23.1	12.0	1.80
Neeley	Silt loam	2	20.9	7.4	2.19
Nyssaton	Silt loam	1	24.4	9.0	2.49
Pancheri	Silt loam	11	23.0	9.7	2.15
Pocatello	Silt loam	1	17.6	6.2	1.85
Power	Silt loam	7	29.7	14.5	2.45
Power-Purdam	Silt loams	3	24.5	9.4	2.44
Portneuf	Silt loam	5	24.5	9.9	2.54
Purdam	Silt loam	6	29.0	11.3	2.87
Rexburg	Silt loam	2	19.6	7.4	1.97
Robana	Silt loam	1	22.3	8.6	2.22
Scism	Silt loam	6	24.3	9.8	2.35
Tetonia	Silt loam	1	22.0	9.1	2.09
Minidoka-Scism	Silts	1	24.3	11.2	2.12
Terreton	Clay loam	2	12.6	5.9	1.08
Annis	Silty clay loam	1	25.5	12.5	2.11
Monteview	Silty clay loam	3	24.0	11.5	2.03
Unclassified	Silty clay loam	1	29.0	14.9	2.28
Abo	Silty clay	1	35.7	17.3	2.98
Goose Creek	Silty clay	1	43.2	25.6	2.85
Terreton	Clay	3	22.3	10.3	1.94

Table 3. Average water-holding capacity of soils representing different textural classes.

Soil textural class	No. of sites	FC %	PWP %	WHC (in/ft)
Sand	7	5.2	2.5	0.43
Loamy sand	17	9.0	4.0	0.84
Sandy loam	14	17.2	6.9	1.67
Sandy clay loam	1	14.4	7.5	1.12
Loam	19	22.2	9.2	2.10
Silt loam	65	24.2	11.2	2.44
Silt	1	24.3	11.2	2.12
Clay loam	2	12.6	5.9	1.08
Silty clay loam	5	25.3	12.4	2.10
Silty clay	2	39.4	21.4	2.91
Clay	3	22.3	10.3	1.94

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