



# Soil Quality Indicators

## Available Water Capacity

Available water capacity is the maximum amount of plant available water a soil can provide. It is an indicator of a soil's ability to retain water and make it sufficiently available for plant use.

Available water capacity is the water held in soil between its *field capacity* and *permanent wilting point*. *Field capacity* is the water remaining in a soil after it has been thoroughly saturated and allowed to drain freely, usually for one to two days. *Permanent wilting point* is the moisture content of a soil at which plants wilt and fail to recover when supplied with sufficient moisture. Water capacity is usually expressed as a volume fraction or percentage, or as a depth (in or cm).

### Factors Affecting

**Inherent** - Available water capacity is affected by soil texture, presence and abundance of rock fragments, and soil depth and layers.

Available water capacity increases with increasingly fine textured soil, from sands to loams and silt loams. Coarse textured soils have lower field capacity since they are high in large pores subject to free drainage. Fine textured soils have a greater occurrence of small pores that hold water against free drainage, resulting in a comparatively higher field capacity. However, in comparison to well-aggregated loam and silt loam soils, the available water capacity of predominantly clay soils tends to be lower since these soils have an increased permanent wilting point (see Figure 1).

Rock fragments reduce available water capacity of soil proportionate to their volume, unless the rocks are porous. Soil depth and root restricting layers affect total available water capacity since they can limit the volume of soil available for root growth. (Restrictive layers may be naturally occurring or a result of management activities.) Plant rooting characteristics must be considered for a practical understanding of the effects of soil depth and restrictive layers on water available for plant growth. A restrictive layer at 20 inches might have little consequence on the water requirements of a shallow-rooted crop. However, this layer might severely limit the volume of soil a deep-rooted crop can explore for moisture.

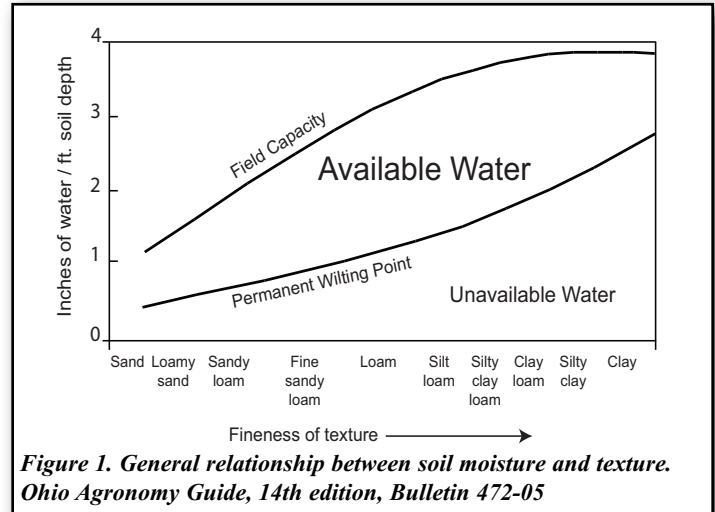


Figure 1. General relationship between soil moisture and texture. Ohio Agronomy Guide, 14th edition, Bulletin 472-05

**Dynamic** - Available water capacity is affected by organic matter, compaction, and salt concentration of the soil.

Organic matter increases a soil's ability to hold water, both directly and indirectly. When a soil is at field capacity, organic matter has a higher water holding capacity than a similar volume of mineral soil. While the water held by organic matter at the permanent wilting point is also higher, overall, an increase in organic matter increases a soil's ability to store water available for plant use. Indirectly, organic matter improves soil structure and aggregate stability, resulting in increased pore size and volume. These soil quality improvements result in increased infiltration, movement of water through the soil, and available water capacity (see Figure 2).

Compaction reduces available water capacity through its adverse effects on both field capacity and permanent wilting point. Compaction reduces total pore volume, consequently reducing water storage when the soil is at field capacity. Compaction also crushes large soil pores into much smaller micropores. Since micropores hold water more tightly than larger pores, more water is held in soil at its permanent wilting point.

Salts in soil water result from fertilizer application or naturally occurring compounds. Salt concentration increases as soil water decreases. For soils high in soluble salts, moisture stress results when plants cannot uptake

water across an unfavorable salt concentration gradient. Soils with high salt concentration tend to have reduced available water capacity because more water is retained at the permanent wilting point than if water was held by physical factors alone. These effects are most pronounced in soils in dry regions where salts accumulate because of irrigation or natural processes.

## Relationship to Soil Function

Soil is a major storage reservoir for water. In areas where rain falls daily and supplies the soil with as much or more water than is removed by plants, available water capacity may be of little importance. However, in areas where plants remove more water than is supplied by precipitation, the amount of water held by the soil may be critical. Water held in the soil may be necessary to sustain plants between rainfall or irrigation events. By holding water for future use, soil buffers the plant – root environment against periods of water deficit.

Available water capacity is used to develop water budgets, predict droughtiness, design and operate irrigation systems, design drainage systems, protect water resources, and predict yields.

## Problems with Poor Function

Lack of available water reduces root and plant growth, and it can lead to plant death if sufficient moisture is not provided before a plant permanently wilts. A soil's ability to function for water storage also influences runoff and nutrient leaching.

Agricultural land management practices that lead to poor available water capacity include those that prevent accumulation of soil organic matter and/or result in soil compaction and reduced pore volume and size:

- Conventional tillage operations,
- Low residue crop rotations, and burning, burying, harvesting, or otherwise removing plant residues,
- Heavy equipment traffic on wet soils, and
- Grazing systems that allow development of livestock loafing areas and livestock trails.

As natural areas are permanently converted to homes, roads, and parking areas, the overall amount of water that can be stored in the soil is reduced. This leads to higher total runoff, increased pressure on storm water drainage systems, a higher likelihood of flooding, and generally poorer water quality in streams and lakes.

## Improving Available Water Capacity

Farmers can grow high residue crops, perennial sod and cover crops, reduce soil disturbing activities, and manage

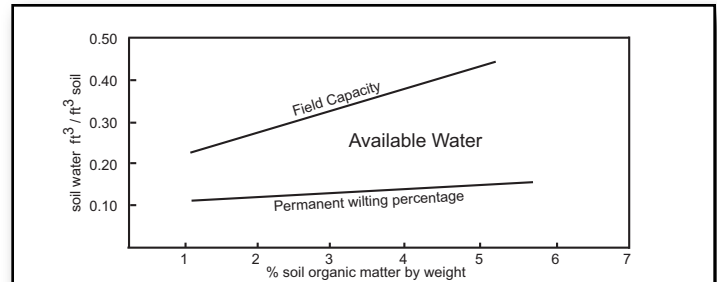


Figure 2. Effect of increasing organic matter on available water capacity of silt loam soils. Adapted from Hudson, SWCS, 1994.

residue to protect and increase soil organic matter to make improvements in a soil's available water capacity. When feasible, tillage, harvest, and other farming operations requiring heavy equipment can be avoided when the soil is wet to minimize compaction; and compacted layers can be ripped to break them and expand the depth of the soil available for root growth.

For soil high in soluble salts, management activities that maintain salts below the root zone can be used. These include irrigation to leach salts below the root zone and practices that promote infiltration, reduce evaporation, minimize disturbance, manage residue, and prevent mixing of salt-laden lower soil layers with surface layers.

Conservation practices resulting in available water capacity favorable to soil function include:

- Conservation Crop Rotation
- Cover Crop
- Prescribed Grazing
- Residue and Tillage Management
- Salinity and Sodic Soil Management

Developers can incorporate the use of permeable parking areas, green roofs, and other practices that minimize the impact of development on soil water storage.

## Measuring Available Water Capacity

Reference: U.S. Department of Agriculture, Natural Resources Conservation Service, 2005. National Soil Survey Handbook, title 430-VI. Soil Properties and Qualities (Part 618), Available Water Capacity (618.05). Online at: <http://soils.usda.gov/technical/handbook/>

## Specialized equipment, shortcuts, tips:

Determination of permanent wilting point moisture content requires a pressure membrane apparatus.

**Time needed:** One to two days is required for free drainage and to allow soil to reach field capacity.