Plant Available Water: How Do I Determine Field Capacity and Permanent Wilting Point?

Plant available water is the water content difference between field capacity and permanent wilting point of your soil at any given depth. Plant available water is easy to calculate, but accurate estimates of both field capacity and permanent wilting point are necessary for the value to be helpful in irrigation scheduling. Understanding the background behind field capacity and permanent wilting point will allow you to use soil moisture sensors to more efficiently irrigate your fields.

What is Field Capacity?

Field capacity is the water content of the soil two to three days after a rain or irrigation event when the remainder of water has been removed by the downward forces of gravity. This value of field capacity assumes that the water removed from the soil profile is only removed by gravity, not through the plants or through evaporation. Because of this, field capacity estimates are generally done before the growing season. In the USA and some other countries, the soil is considered to be at field capacity when the water potential in the soil is at -33 kPa.

Field capacity is not the same as saturation. When the soil is saturated, all the spaces between the soil particles are filled with water. When the soil is at field capacity, the spaces between the soil particles contain both air and water. The structure and texture, of the soil determines how much water can be held in the soil. Sand, for example, does not hold a lot of water because the large grains do not have a lot of surface area . Therefore, its field capacity, or the amount of water in the soil remaining after a large irrigation event, can be as low as 10%. Clay particles, on the other hand, are often shaped like upside-down dinner plates randomly stacked on top of one another with large amounts of surface area. The large surface area and structure of clay soils can have a field capacity above 40%.

What is Permanent Wilting Point?

The permanent wilting occurs when the volumetric water content is too low for the plant to remove water from the soil. About half of the water in the soil at field capacity is held too tightly to be accessible to plants. The soil is considered to be at permanent wilting point when the water potential in the soil is at or below -1.5 MPa, so the permanent wilting point is the water content of the soil at -1.5 MPa water potential.

Soil at permanent wilting point is not dry. When the water content of a soil is below the permanent wilting point, water is still be present in the soil, but plants are unable to access it.

Determining Field Capacity and Permanent Wilting Point

Reasonably accurate estimates of field capacity and permanent wilting point can be obtained simply by knowing the texture of the soils that you are working with. DataTrac 3 uses the estimates published by Saxton and Rawls (2006) as a starting point for helping you estimate plant available water. The table above is used by Datatrac 3 by selecting soil texture when using the growing tool “Plant Available Water”.
field capacity.

Texture	FC (v%)	PWP (v%)
Sand	10	5
Loamy sand	12	5
Sandy loam	18	8
Sandy clay loam	27	17
Loam	28	14
Sandy clay	36	25
Silt loam	31	11
Silt	30	6
Clay loam	36	22
Silty clay loam	38	22
Silty clay	41	27
Clay	42	30

If you don't know how to determine your soil texture, you can watch a quick video that will help you do this on your own.

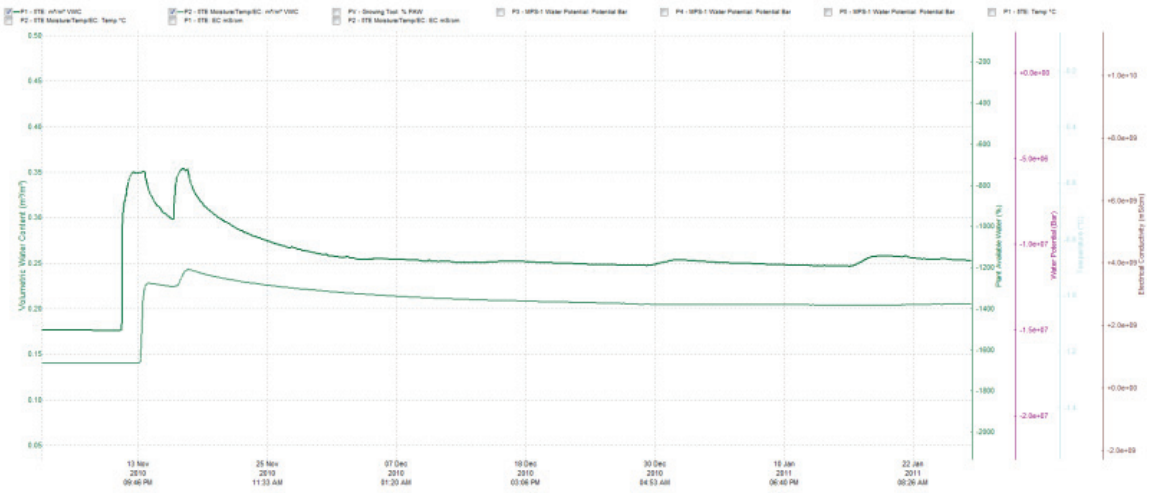
You can also determine your field capacity value in the field using Decagon soil moisture sensors. The methodology below is a rough adaptation from Methods of Soil Analysis, Vol. 4 methodology (Dane and Topp, 2002).

These tests are best done before the growing season as one of the assumptions of this estimate is that water is only being removed from the soil profile through drainage due to gravity

In a representative part of your field, before the growing season begins, install Decagon soil moisture sensors at the soil depths where you are interested in determining plant available water. We recommend at least three depths that cover the early and mid growing root zone as well as below the root zone. Monitor the soil moisture immediately after an irrigation event or a rain event. After three days, in most soils, the water content levels will have stopped changing significantly suggesting that the remaining water content (assuming no evaporation or transpiration) is considered to be field capacity. In some finer textured soils, it may be necessary to wait 4-10 days for the water content to stop changing significantly.

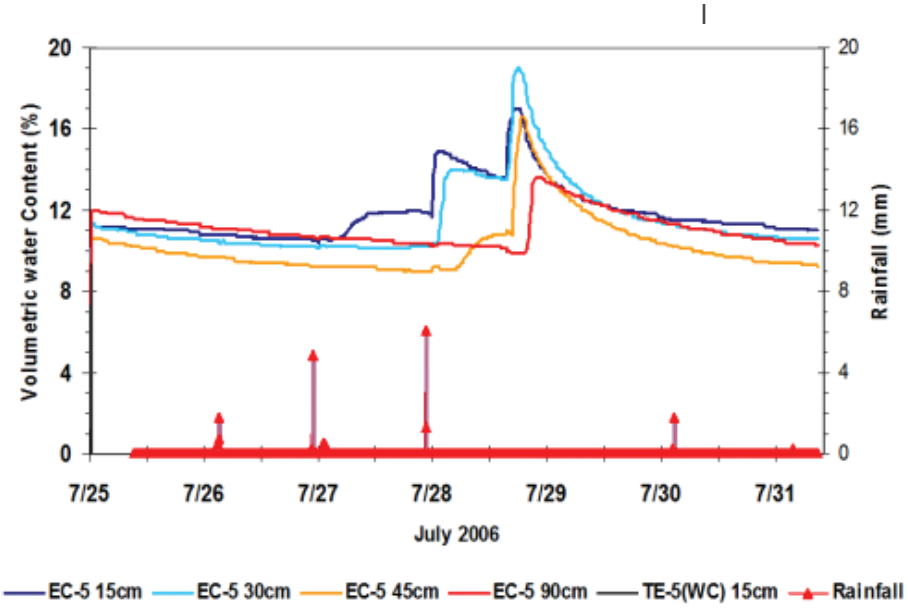
Examples of Estimating Field Capacity using soil moisture data

In the example below, Decagon 5TE water content sensors are installed in silt loam at 0.5 m and 1 m in a vineyard. On 11/13 and 11/17, two significant precipitation events increased the water content at both depths. After the second event on November 17th, you can watch the soil water decrease and then finally flatten out. On about November 25th, the water content levels stop changing quickly suggesting that removal of water from the soil profile due to gravity has slowed down. Since it is winter time at this location, we can assume that evapotranspiration is minimal.



We conclude that the field capacity at 0.5 m is 0.25m3/m3 and the field capacity at 1 m is 0.20 m3/m3

In the next example,Decagon EC-5 water content sensors are installed in sand at 15 cm, 30 cm, 45 cm, and 90 cm depth in an orchard. On 7/28, two large precipitation events increased the water content in the entire soil profile. We will focus on the 45 cm depth sensor, which is in yellow. It took nearly one full day for the water from the storm to reach the 45 cm sensor. So, our peak starts at 7/29 rather than 7/28. You can watch the soil water decrease quickly and then finally



flatten out somewhere between 7/30 and 7/31, or two to three days after the major precipitation event suggesting that removal of water from the soil profile due to gravity has slowed down. July is not the best time to determine field capacity so we cannot make the assumption that evapotranspiration is minimal, but we often forget to do these tests in the spring so this is a realistic example.
sand field capacity

We conclude that the field capacity at 45 cm is 10 % VWC.

Can we determine permanent wilting point in the field?

While field capacity can be easily estimated from the above work, estimating permanent wilting point is somewhat more challenging. Special instrumentation like the WP4C is needed for accurate estimates. For most studies, we recommend either estimating permanent wilting point from soil texture or using a WP4C for determining permanent wilting point. If you do not have access to a WP4C, Decagon's soil moisture release curve construction services can determine the field capacity and permanent wilting points of your soil for you.

When you have these two values, you can plug them into DataTrac 3's growing tool Plant Available Water to accurately determine the amount of water available to your plants based on your soil moisture sensor data.

K. E. Saxton and W. J. Rawls, 2006. "Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions", Published in the Soil Science Society of America Journal. 70:1569-1578

J.H. Dane and G.C. Toppe, eds., 2002. Methods of Soil Analysis Part 4 Physical Methods, Soil Science Society of America, Inc. Madison, Wisconsin, USA.

Printed in USA

06-25-15