Cornell University
School of Integrative Plant Sciences

Soil Health Manual Series — Fact Sheet Number 19-05b

Predicted Available Water Capacity

Available Water Capacity (AWC) is an indicator of the amount of plant available water a soil can store.

Beginning in 2019, the Cornell Soil Health Lab moved to **predict** AWC from a suite of measured sample parameters in the Standard comprehensive assessment of soil health (CASH) package. The laboratory measured AWC will remain available as an optional add-on to the CASH packages.

Modeling AWC

In late 2018, the Cornell Soil Health lab determined that AWC, a valuable, but time-intensive measurement, could be accurately predicted. A CASH database containing 7,951 soil samples was used to develop a Random Forest model to predict AWC from a suite of measured parameters, including % sand, % silt, % clay, Organic Matter, Active Carbon, ACE Protein, Respiration, Wet Aggregate Stability, Potassium, Magnesium, Iron, and Manganese. The Random Forest (RF) model was able to explain more variation in AWC than alternative multiple linear regression models. Specifically, the RF model was able to explain 72.5 % of the variation in AWC with a low average root mean square error (RMSE) value (Fig. 1). RMSE is a measure of how much observed values deviate from the predicted values. The RMSE value was only 3% of actual AWC values, which is equivalent to the sensitivity of the laboratory method. Therefore, our predicted values had no more error than the original raw AWC data.

Random Forest is a robust machine learning algorithm that uses a decision tree approach to model variables. Machine learning algorithms such as RF have become increasingly poplular techniques to model parameters that are difficult or costly to measure. For example, soil properties such as bulk density and hydraulic conductivity are expensive to measure and extremely variable, so environmental scientists have developed models to predict these variables from routinely measured parameters such as % sand, silt, clay, and organic carbon.

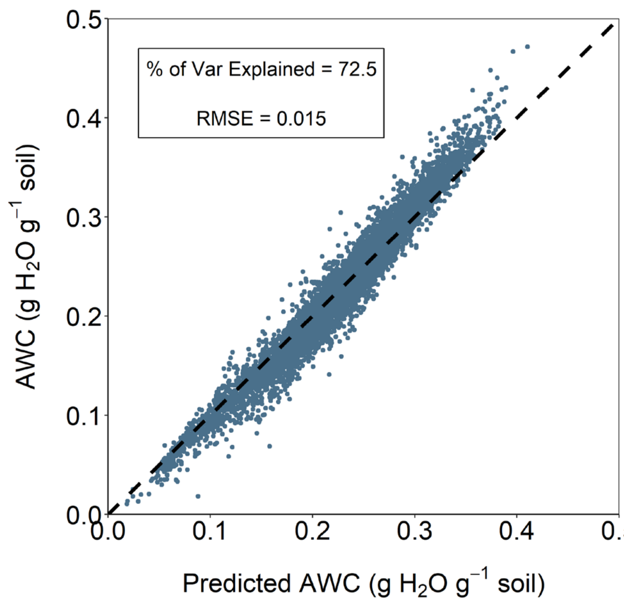

FIGURE 1. Predicted AWC vs. observed AWC for the CASH database (n=7,951).

Managing constraints and maintaining optimal AWC

Short-term strategies:

- Adding stable organic materials, such as composts, that themselves can store larger amounts of water
- Use mulches to prevent water from evaporating from the surface

Long-term strategies:

- Build soil organic matter and aggregation to enhance porosity for water infiltration and storage
- Reduce tillage
- Long-term cover cropping
- Rotate annual crops with perennial species
- Keep actively growing roots in the system to build and maintain soil pores

In coarse textured soils, improving water holding capacity is more challenging than in finer textured soils that inherently store more water. Therefore, managing for increased AWC, and also for decreased evaporation through surface cover, is important in coarse textured soils.

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How AWC relates to soil function

Water is stored in medium and small sized soil pores and in organic matter. AWC provides a measure of how much water will be available to plants in the field, and therefore how crops may fare in extremely dry conditions. In the field, a soil is at the upper end of soil wetness when water that it can't hold up against gravity has drained - this is called *field capacity*. The lower end of the range is called the *permanent wilting point*, when only water unavailable to plants, also called hygroscopic water, is left. The water stored in the soil is plant available until it decreases to the permanent wilting point (Fig. 2).

Sandy soils, which tend to store less organic matter and have larger pores, tend to lose more water to gravity than clayey and loamy soils (Fig. 2). Therefore, a common constraint of sandy (coarse textured) soils is their ability to store water for crops between rains, which is especially a concern during draughty periods, and in areas where irrigation is costly or not available.

In heavier (fine textured) soils, the available water capacity is generally less constraining, because clays naturally have high water retention ability. Instead, they are typically more limited in their ability to supply air to plant roots during wet periods, and to allow for enough water to infiltrate during intense rainfall events.

Note that total crop water availability is also dependent on rooting depth, which is considered in separate soil health indicators - surface and subsurface hardness.

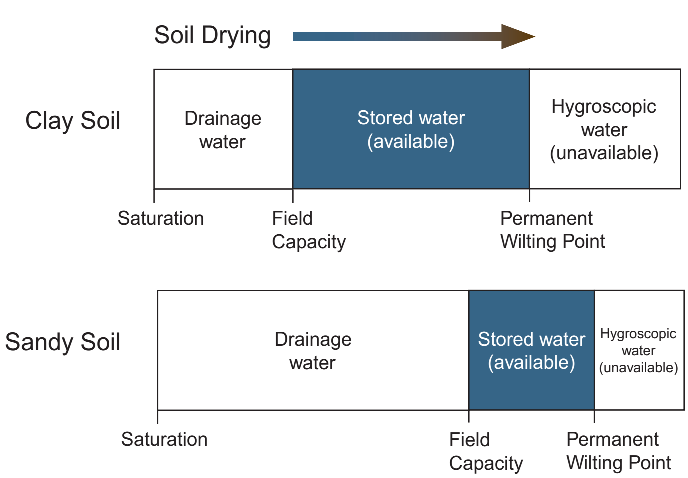

FIGURE 2. Water storage for two soil textural groups. The blue shaded area represents water that is available for plant use.

Scoring function

Figure 3 below depicts the **Predicted** Available Water Capacity scoring functions and upper value limits for coarse, medium, and fine textured soils. Scoring functions were combined for medium and fine classes because no clear differences were observed between these texture groups.

The red, orange, yellow, light green and dark green shading reflects the color coding used for the ratings on the soil health report summary page.

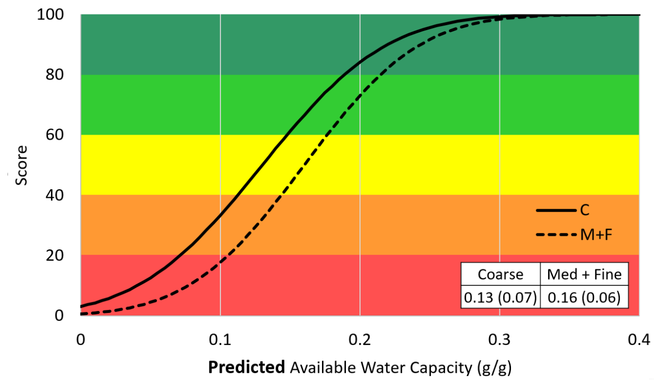

FIGURE 3. Predicted Available Water Capacity (AWC) scoring functions for Coarse (C), Medium (M) and Fine (F) textural classes. Mean and standard deviation (in parenthesis) for each class are provided. In this case more is better. Higher AWC scores indicate a greater capacity of the soil to store plant available water.

Note that the original AWC laboratory methodology is available in Fact Sheet Number 16-05. In addition, the Cornell Soil Health Laboratory AWC Standard Operating Procedures (CSH 05) can be found under the 'Resources' tab on our website.

For a more comprehensive overview of soil health concepts including a guide on conducting in-field qualitative and quantitative soil health assessments, please download the Cornell Soil Health Manual at bit.ly/SoilHealthTrainingManual.

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