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Estimating soil moisture for irrigation

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Quick Facts

- Soil moisture levels should determine timing of irrigation.
- Soil moisture can be estimated by feel and appearance of the soil.
- Tensiometers or resistance blocks also may be used to estimate soil moisture.
- Moisture should be checked in at least one location for each area of the field that differs in soil texture and slope from other areas.

Irrigation water must be applied at the right time and in the right amount for consistently high yields. Excessive water application reduces yields by carrying nitrates below depths of root penetration, and by displacing soil air for too long, causing a lack of oxygen to the roots. Water shortage also will reduce yields. The time to irrigate and the amount of water to apply can be determined by checking soil moisture.

Soil Moisture Determination

Feel and appearance of the soil indicates soil moisture status. A soil tube, soil auger or tile spade can be used to sample soils to determine moisture content. Soil samples should be taken at intervals throughout the depth of the active root zone. An estimate of soil moisture status can be made by squeezing a handful of soil firmly and comparing results with Table 1.

To determine the amount of water required to refill the root zone, the percent soil moisture deficiency is converted by use of Table 2. For example, it may be estimated from Table 2 that a silty clay loam soil holds 2.0 inches (5 centimeters) of available moisture per foot (30 cm) of depth. If the feel test indicates that the moisture is 60% depleted in the upper foot, it would require 60% of 2.0 inches (5 cm) or 1.2 inches (3 cm) to refill the top foot. Estimates for each foot of the root zone would be added to determine the total amount of water needed to refill the root zone.

Table 1: Soil moisture interpretation chart.

Soil moisture deficiency	Moderately coarse texture	Medium texture	Fine and very fine texture
0% (field capacity)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.		
0-25%	forms weak ball, breaks easily when bounced in hand.*	forms ball, very pliable, sticks readily.*	easily ribbons out between thumb and forefinger.*
25-50%	will form ball, but falls apart when bounced in hand.*	forms ball, sticks under pressure.*	forms ball, will ribbon out between thumb and forefinger.*
50-75%	appears dry, will not form ball with pressure.*	crumbly, holds together from pressure.*	somewhat pliable, will ball under pressure.*
75-100%	dry, loose, flows through fingers.	powdery, crumbles easily.	hard, difficult to break into powder.

**Squeeze a handful of soil firmly to make ball test.*

Table 2: Useable soil moisture capacities.

Texture	Available moisture in/ft	Available moisture cm/cm
Fine and very fine (clay, silty clay, sandy clay, silty clay loam, clay loam)	1.6 - 2.5	0.13 - 0.21
Medium (silt loam, sandy clay loam, loam, very fine sandy loam)	1.4 - 2.4	0.12 - 0.20
Moderately coarse (fine sandy loam, sandy loam)	1.0 - 1.6	0.08 - 0.13

A tensiometer is a sealed, water-filled tube equipped with a vacuum gauge on the upper end and a porous ceramic tip on the lower end.

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As roots remove water from the soil, soil moisture tension increases. Water moves out through the ceramic tip, creating a partial vacuum which registers on the vacuum gauge. The ability of the soil to withdraw water from the tensiometer increases continuously as a soil dries. Irrigation reverses this action. Vacuum in the tensiometer draws water from the soil into the instrument.

Electrical resistance block systems use small gypsum blocks and a portable resistance meter to measure soil moisture content. When the blocks are placed in contact with the soil, the moisture content of the gypsum block tends to equal the moisture content of the soil. Measurement of electrical resistance by a meter is a good indication of the soil moisture content. The drier the soil, the greater the electrical resistance.

Either tensiometers or resistance blocks should be installed in pairs with the location of the ceramic tips or blocks dependent on the crop root zone. For gravity irrigation, one pair of these moisture sensors should be located near the upper end of the field and another pair should be near the lower end. There also should be measurement locations for each area of the field that differs in soil texture and slope from other moisture sensor locations. Sensors should be placed at the depths shown in Table 3.

Table 3: Recommended depths for tensiometers and electrical resistance blocks.

Crop	Shallow sensor	Deep sensor
Alfalfa Corn Sorghum Sugar beets Tomatoes	18″ (45.7 cm)	36″ (91.4 cm)
Field beans Potatoes Small grain	12″ (30.5 cm)	24″ (60.9 cm)
Pasture	12″ (30.5 cm)	18″ (45.7 cm)

Tensiometer tips and resistance blocks should be soaked in water and then dipped in a mud slurry before installation. A soil tube or probe can be used to make a hole slightly deeper than the tensiometer or resistance block is to be installed. A handful of pulverized soil should be placed in the hole and followed with about one-third cup (80 milliliters) of water. The tensiometer or block is removed from the slurry and pressed down to the desired level in the hole. The hole is then filled with soil, making a slight mound so that surface water will not enter.

Use of Moisture Sensors

Readings should be taken frequently enough so that the change from one reading to the next is not greater than 0.1 atmospheres. Irrigations are timed by the reading on the shallow tensiometers or blocks and are started at some predetermined reading. (See Table 4.)

Full benefit from use of moisture sensors is obtained only by recording and, preferably, by plotting readings on a chart. This information enables the irrigator to see mistakes in previous irrigations and to predict future irrigation needs from trends.

Early in the growing season irrigation should be stopped when reading for the shallow sensor indicates the soil is at field capacity. Later in the season, if the deep sensor readings indicate that the roots have extracted considerable moisture and irrigation is needed, fields may be irrigated until the deep sensor meter readings approach field capacity.

Table 4: Interpretation of readings of tensiometers and electrical resistance blocks.

Soil moisture tension (atm.)*	Soil texture**	Moisture status	
0 - 0.05 0 - 0.10 0 - 0.20	coarse moderate fine	nearly saturated	May occur for a day or two following irrigation in moderate and fine textured soils. Danger of poor soil aeration if reading persists.
0.10 0.20 0.30 - 0.40	coarse moderate fine	field capacity	Discontinue irrigations when upper block or tensiometer reaches this range to prevent deep percolation except when moisture measurements have indicated that the previous irrigation has failed to refill the root zone.
0.30-0.50 0.40-0.80 0.50-1.50	coarse moderate fine	irrigation range	Usual range for starting irrigations. Starting irrigations in this range assures soil aeration and insures maintaining readily available soil moisture at all times.

**For tensiometers, atmospheres of tension are multiplied by 100 to obtain corresponding tensiometer readings. For resistance blocks, atmospheres of tension are converted to meter readings by referring to a calibration chart for the models of blocks and meter being used. Resistance blocks are less accurate than tensiometers for tensions of less than 0.5 atmospheres. Tensiometers should not be used where tensions of more than 0.7 atmospheres are expected. Ranges are due to variations in soils and in crop response.*

***Resistance blocks should not be used for sandy soils. Tensiometers are not desirable for fine-textured soils unless the crops require maintenance of low moisture tensions.*