Water Conservation
FACTSHEET

BRITISH COLUMBIA
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IRRIGATION SCHEDULING WITH TENSIOMETERS

The goal of irrigation scheduling is to make the most efficient use of water and energy by applying the right amount of water to cropland at the right time and in the right place. Proper irrigation scheduling requires a sound basis for making irrigation decisions. Methods of irrigation scheduling are based on soil water measurements, meteorological data or monitoring plant stress. Tensiometers measure the soil water tension that can be related to the soil water content.

This factsheet will give guidelines for using tensiometers, taking into account different types of irrigation systems and soil types. At first it may appear to be difficult to schedule irrigations around farm activities such as spraying and fertilizing. Irrigation scheduling is just as important as these other activities. Scheduling prevents wasting of water, stress to crops, loss of fertilizers to leaching and saves on energy costs.

Benefits of Irrigation Scheduling

"Good irrigation scheduling means applying the right amount of water at the right time---in other words, making sure water is available when the crop needs it. Scheduling maximizes irrigation efficiency by minimizing runoff and percolation losses. This often results in lower energy and water use and optimum crop yields, but can result in increased energy and water use in situations where water was not being properly managed."

One of the benefits of scheduling with tensiometers is the ease of use and the immediate results. With tensiometers no other meters or instruments are needed, just look at the gauge to determine the soil moisture. The soil water tension is measured in centibars (cbars) which is related to the amount of water in the soil that is available to plants.

Tensiometers work best in course textured soils or in fine soils, such as clay, when a relatively high soil moisture content is maintained. Another irrigation scheduling method may be more appropriate for fine soils that go through cycles of wetting and drying. The Watermark, an electrical resistance type sensor, works on the same principles as the tensiometer, but is able to read a high soil moisture tension which may occur in fine soils when using trigger levels to schedule sprinkler systems.

Figure 1 **Installed Tensiometer**

Reading Tensiometers

The tensiometer gauge reads the tension between soil and water particles. Soil moisture tension increases when there is less water in the soil. As a result the tensiometer gauge, Figure 2, reads high for dry soils and low for wet soils.

A wet soil would be indicated by a reading under 10 cbars and a reading above 50 cbars would indicate a dry soil for most soil types.

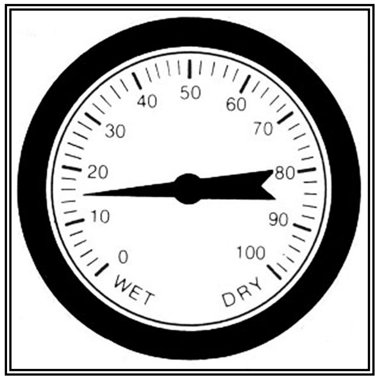

Figure 2 Tensiometer Gauge

Placement of Tensiometers in the Field

For a sprinkler system the tensiometers should be placed in the area irrigated by the first lateral within the root zone of the crop.

When operating a trickle system the soil should be maintained at a constant soil moisture. Tensiometers should be placed 12” to 18” from the emitter in an area that is representative of where the plants are taking up water.

With micro-sprinkler systems tensiometers are placed along the crop row, in the root zone, at the midpoint between two sprinklers. This should be in an area of the field that represents typical soil and crop conditions.

For any system a second monitoring site should be installed where a significant change in either the crop, soil or irrigation system is evident. Figure 3 illustrates possible locations for tensiometers to be places in field with varying soil type and irrigation systems. Deep rooted plants, such as fruit trees, should have two tensiometers per site one at 12” and one at 24”.

Occasionally, due to improper installation or rocks near the ceramic cup, tensiometers may read higher than anticipated. Installing a second set of tensiometers near the first set of tensiometers provides a means of checking the tensiometer readings.

Readings from tensiometers placed at the ends of laterals can be compared to reading from the tensiometers in the center of a lateral to determine if pressure changes in the line are affecting the amount of water reaching the crop.

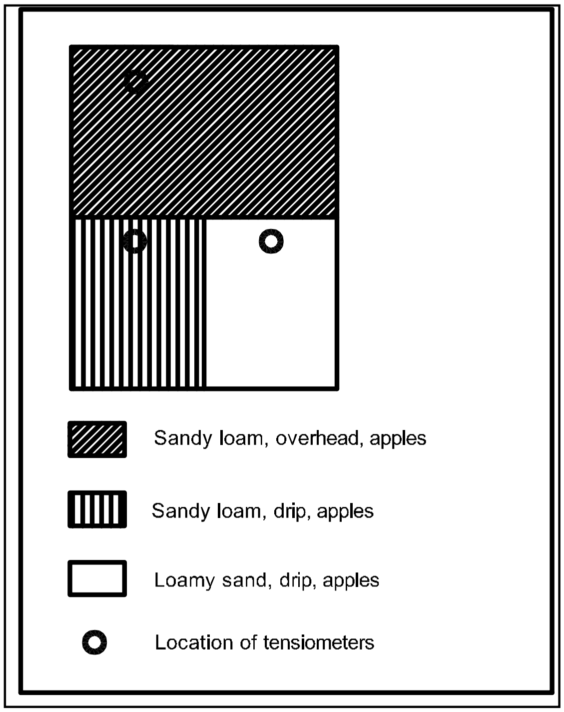

Figure 3 Tensiometer Locations

Installing Tensiometers

It is important for the tensiometers to be installed properly and that the ceramic tip has good contact with the surrounding soil. See Figure 6 attached to the back of this fact sheet for the installation procedure. The tensiometer should be filled good quality water or distilled water. Adding a few drops of food coloring will make the water level in the tensiometer easier to see. The ceramic tip should be soaked in a bucket of water for 24 hours before installation.

Maintenance of Tensiometers

Maintaining the water level in the tensiometer will ensure that suction is not broken. Air in the water column can interfere with accurate readings. Periodically check for air by removing the tensiometer cap and hitting the top of the tensiometer with the palm of the hand. You should be able to see bubbles rising through the colored liquid. If a primer pump is available use it to remove the excess air from the tensiometer.

However, you should never use the primer pump to de-air the tensiometer when the soil is very dry. Air may be drawn up through the ceramic cup. Wait until after an irrigation or rainfall to de-air the tensiometer. Check the contact between the ceramic cup and the soil by gently turning the tensiometer. The tensiometer should not move. Reinstall the tensiometer if it can be easily turned in the soil

Monitoring Tensiometers

The tensiometers should be monitored at least once or twice a week. Plotting a graph of tensiometer readings is a good visual tool to become familiar with the crop's water use. Table 1 gives an example of how to record tensiometer readings.

Table 1 **Record of Tensiometer Readings**

Date	Time	12" (cbars)	24" (cbars)	Weather / notes
May 11	11:20	15	16	sunny last week
May 15	9:30	23	15	cloudy
...				
August 8	9:00	27	16	beginning irrigation
...				

Figure 4 shows a plot of tensiometer readings for a sprinkler system over an entire irrigation season. Irrigation began when the tensiometers read between 20 and 30 centibars. The drop in tension corresponds to the increase in soil moisture after irrigation. A graphing worksheet, Figure 7, is provided at the back of the fact sheet to monitor your tensiometer site.

The tensiometers should be monitored more frequently (daily) at high soil moisture tensions. Soil moisture tension can quickly change between 30 to 50 cbars.

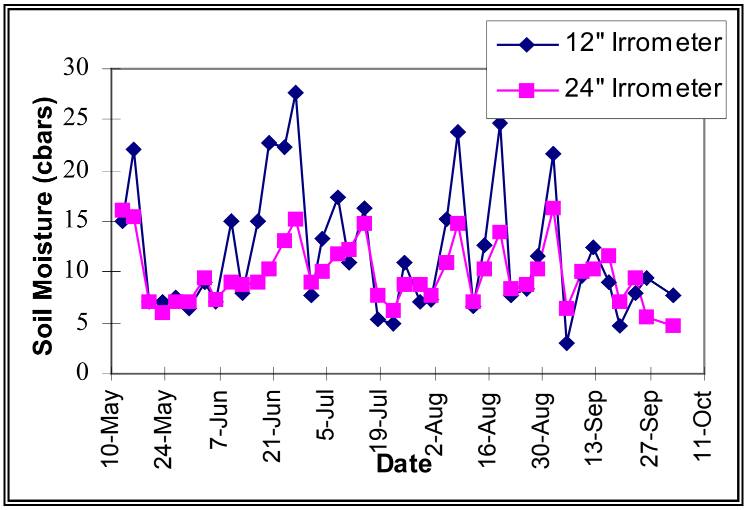

Figure 4 **Graphing Tensiometer Readings**

An irrigation schedule maximizes profit and optimizes water and energy use.

Scheduling by Irrigation System

To determine the amount of water needed for specific crops, irrigations systems and soil types refer to the BC Trickle and Sprinkler Manuals. Begin the irrigation season when the tensiometer indicates irrigation is necessary. For sprinkler systems this is when a trigger level is reached. For trickle and micro-sprinkler systems this is when the tensiometer reading is dry, that is the high reading of the desired range.

The tensiometers are used to fine tune set times and the frequency of irrigations by monitoring the actual moisture within the soil.

Drip or Trickle and Microjets

For trickle, drip or Microjet systems the crop is irrigated frequently (daily) and requires the soil to be maintained at a constant moisture level. Table 2 indicates the range the tensiometer should read to maintain 15% of the available water in the soil is depleted.

Table 2 Soil Moisture Range for Drip Systems

Soil Type	Soil Moisture Tension (cbars)	
	low (wet)	high (dry)
sand	10	15
loamy sand	10	15
sandy loam	15	20
loam	25	30

The moisture level is maintained by adjusting the set time, the length of time the zone is irrigated. If the soil is always wet or dry, reduce or increase the amount of time the zone is irrigated to make up for the soil moisture difference.

Micro-Sprinklers

A micro-sprinkler system is designed like a sprinkler system but because of the low application rates and frequent irrigations the soil moisture is maintained within a smaller range. Micro-sprinklers should be operated on at least a 2 or 3 day cycle. The soil should not remain as wet as soils being irrigated with drip systems and should not reach sprinkler trigger levels for deep rooted crops.

For micro-sprinklers the higher reading of the tensiometer range is about 5 cbars above that of the drip system, see Table 2. The lower level remains the same.

When irrigating on a set irrigation interval, change the set time according to the soil moisture. Use the tensiometers to determine if the soil is wet or dry. If the soil remains too wet between irrigations, reduce the set time. Likewise if the plants are becoming stressed increase the set time.

If the soil is constantly wet between irrigations decrease the irrigation frequency to allow the soil time to dry out a little before the next irrigation. If the tensiometer readings are fluctuating greatly, more than 20 cbars, between irrigations, increase the irrigation frequency (remember we want to maintain a fairly constant soil moisture).

Sprinklers

Scheduling by irrigation start time may be the most practical method for sprinkler irrigation systems that are not automated. It is usually convenient to maintain a set time of 8 or 12 hours and use a tensiometer trigger level to indicate when irrigation should begin. An appropriate set time should be chosen for the site. The trigger level is reached when 40-50% of the plant available water has been removed from the soil. Table 3 gives minimum trigger levels for various crop rooting depths and soil types.

Table 3 Tensiometer Trigger Levels for Sprinkler Systems			
Rooting Depth		Soil Type	Trigger Levels
ft	cm		(cbars)
2	60	S LS SL L	20 25 30 35
4	120	S LS SL L	25 30 35 40
< 1	< 30	S-LS SL_L	15 - 20 25 - 35

S = Sand, LS = Loamy Sand, SL = Sandy Loam, L = Loam

Place the tensiometers in the area irrigated by the first lateral. Irrigation in the first lateral would begin once the tensiometer reaches the trigger level. The remainder of the crop is irrigated as usual. Wait for the tensiometer to reach the trigger level before beginning the next cycle. For deep rooted crops both the shallow and deep tensiometers should be taken into consideration since, plants obtain 40% of the moisture from the top 25% of the root zone. If the 12" tensiometer reads wet while the 24" shows the soil is dry the set time should be increased for the water to reach the deeper roots. Alternately if the soil is wet at 24 inches, even though the 12" tensiometer reads dry only add enough water to wet the first 12" by decreasing the set time.

Another method for scheduling sprinkler systems is to watch the rate of change in tensiometer readings. As the soil dries the rate of change in tensiometer readings will increase. For example, it may take 4 days for the soil tension to go from 10 to 15 cbars, but only 1 day to go from 25 to 30 cbars. A sharp upward curve in the tensiometer graph indicates irrigation should be started soon. Monitor the tensiometers more frequently at high soil moisture tensions. Irrigation scheduling techniques for various irrigation systems are summarized in Table 4.

Table 4 Summary: Irrigation Scheduling by Irrigation System

Irrigation System	Scheduling Method	Notes
Drip / Trickle	set time	daily irrigation, change the set time to maintain a constant soil moisture
Microjets	set time	same as drip/trickle.
Micro-sprinklers	set time	same as drip/trickle, although the system has an irrigation interval of a few days
	irrigation frequency	maintain the set time and lengthen or shorten the interval to maintain soil moisture at an optimum level.
Solid Set Sprinklers and Handlines	set time	monitor deeper tensiometer during irrigation, when it indicates the soil is wet stop irrigation
	irrigation start time	monitor tensiometer readings daily or every couple of days, begin irrigation once the trigger level is reached
	rate of change	watch for a sharp upward curve in the tensiometer graph

Available Soil Water

The type of soil determines how much water can be stored within the soil structure and will therefore be available to the plants. In general a sandy soil has a low available water storage capacity (AWSC) and will require more frequent irrigations than a loam soil.

Figure 5 gives the general relationship between available soil moisture and soil moisture tension. The tension on Figure 5 is read in bars. This means 0.1 bar is 10 centibars and 0.5 bars is 50 centibars. The ticks between 0.1 and 0.5 bars are 15 cbars, 20 cbars, 25 cbars, 30 cbars, 35 cbars and 40 cbars. You should not let the tensiometers read higher than values that correspond to 50% available water depletion. For example a tensiometer in sandy loam soil should not read higher than 35 cbars and a tensiometer in loam soil should not read higher than 80 cbars, this is near the end of the range that tensiometers can operate at.

The type of soil and the plants rooting depth determines the amount of water that should be applied to maintain optimum amount of moisture in the soil.

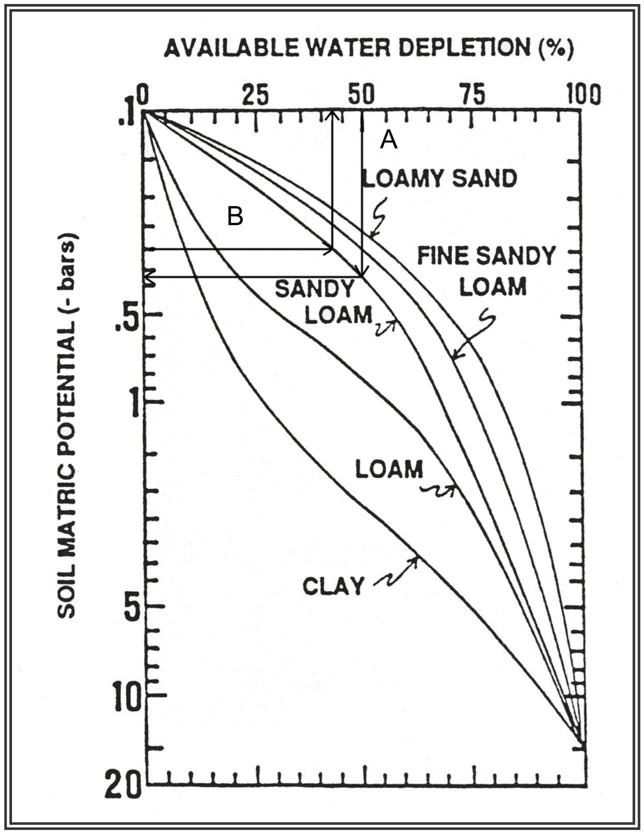

Figure 5 Influence of available soil moisture on soil moisture tension

Example A

A crop with a rooting depth of 1 m in a sandy loam soil will have 12 cm (1m*12cm/m) of water in the root zone available to it. Refer to Table 5 for available water storage capacity and application rates of soils. With a sprinkler system irrigation should begin when 50% of the available water is depleted. For a sandy loam soil this would be approximately 37 cbars, see Figure 5. This means 6.0 cm (12cm*50%) of water has been removed from the soil. Therefore when the tensiometer reads 37 cbars the irrigation system should then be run long enough to replenish the 6.0 cm of water, this is the net application. Irrigation system design and efficiency must be taken into consideration to determine the gross application. Adding excess water may result water lost to runoff or deep percolation.

Example B

The tensiometer in a loamy sand soil with a crop that has a rooting depth of 1.3 m reads 30 cbars. The available soil water is 11.7 cm (1.3 m * 9 cm/m), see Table 5 for available soil water storage capacity. Thirty cbars corresponds to 43% depletion of soil moisture, see Figure 5. If irrigation were to begin at this time a net application of 4.2 cm, which is 36% of the 11.7 cm of available water, would be necessary to replenish the soil water.

Table 5	Soil Properties					
Soil	Maximum application rates for irrigation set time > 4 hours				AWSC	
	sod		cultivated			
	(cm/hr)	(in/hr)	(cm/hr)	(in/hr)	(cm/m)	(in/ft)
S	1.9	0.75	1.0	0.40	8.0	1.0
LS	1.7	0.67	0.9	0.35	9.0	1.2
SL	1.2	0.47	0.6	0.24	12.0	1.5
L	0.9	0.35	0.5	0.20	16.0	2.1

S = Sand, LS = Loamy Sand, SL = Sandy Loam, L = Loam

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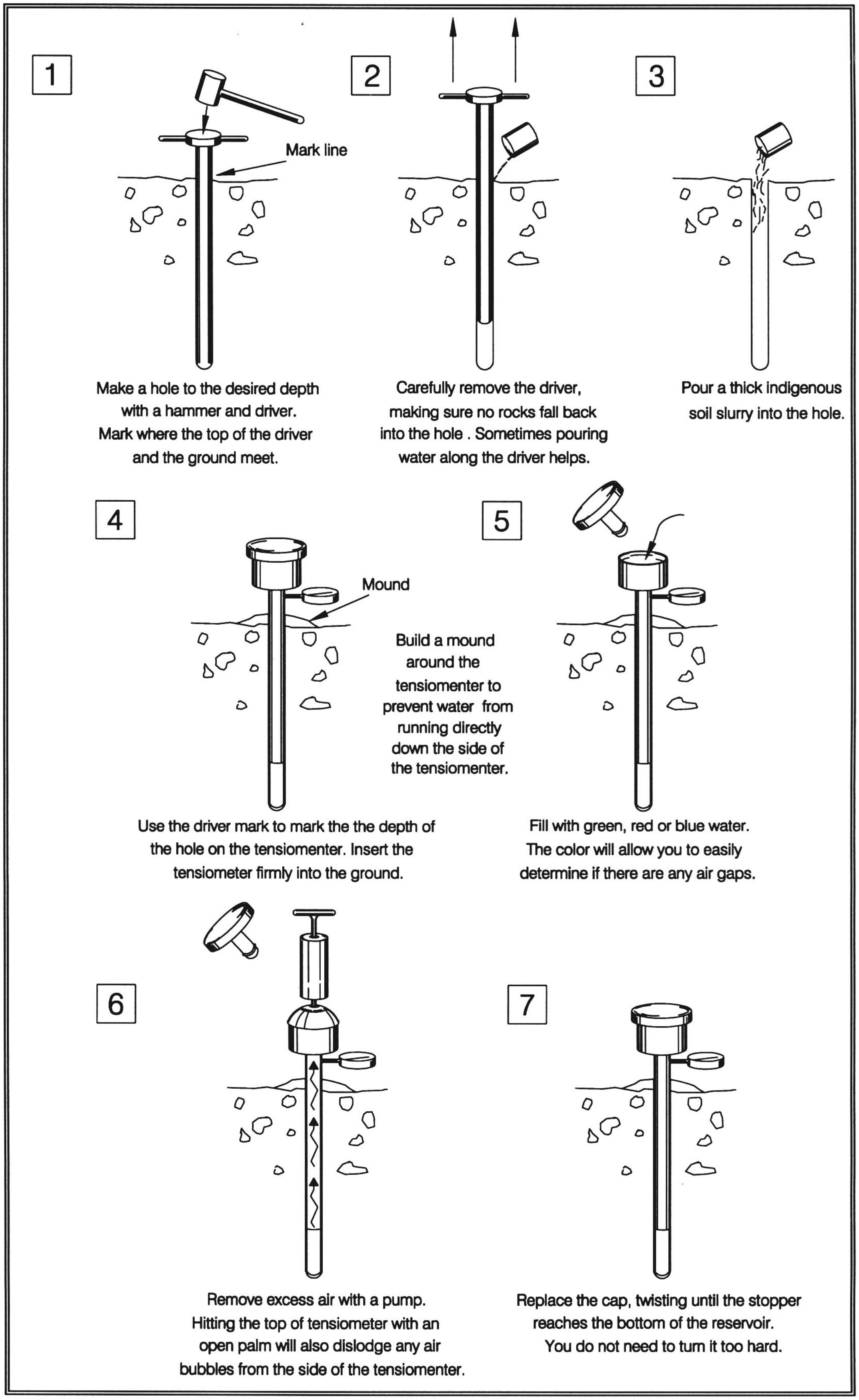


Figure 6 **Tensiometer Installation**

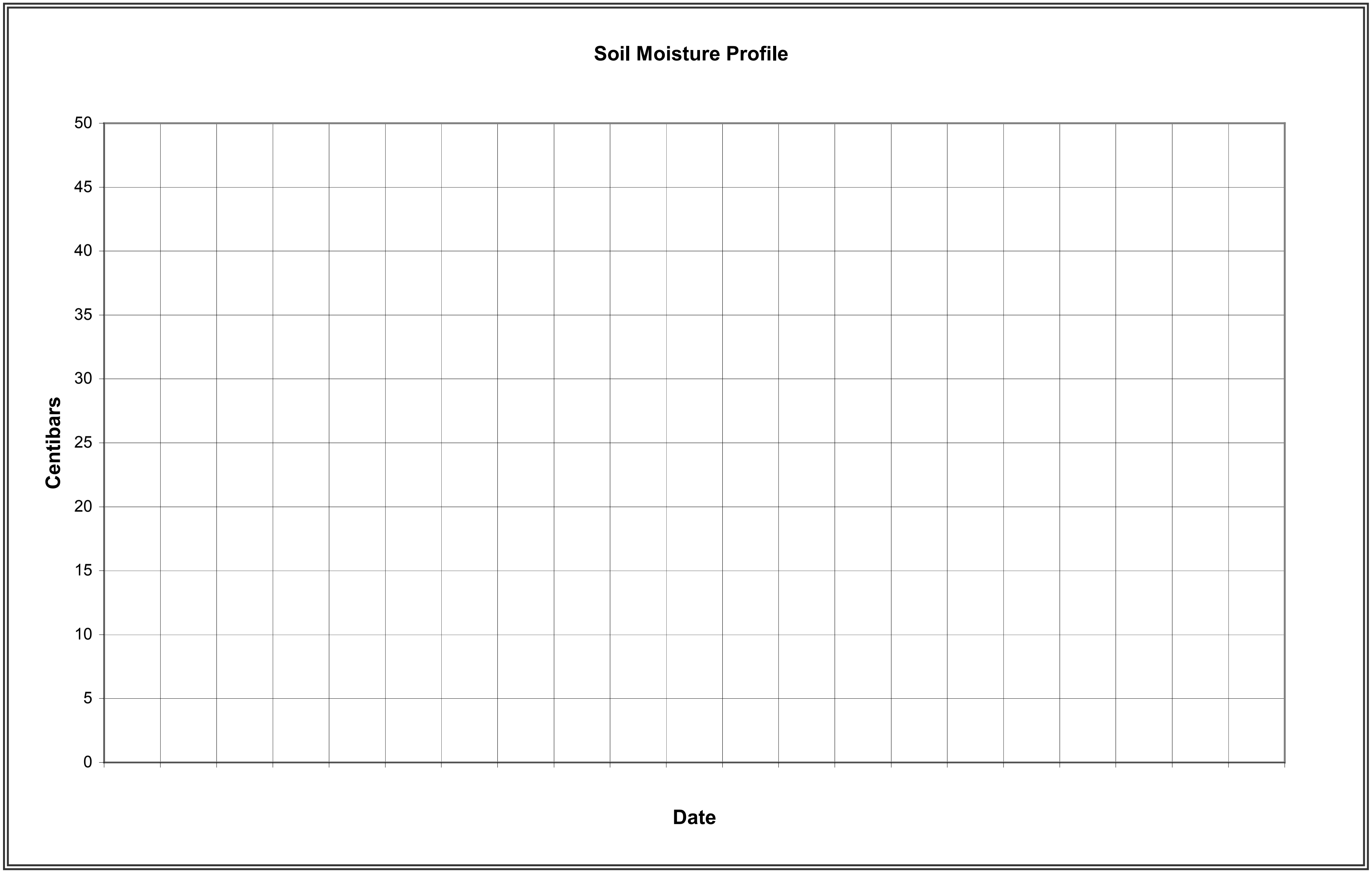
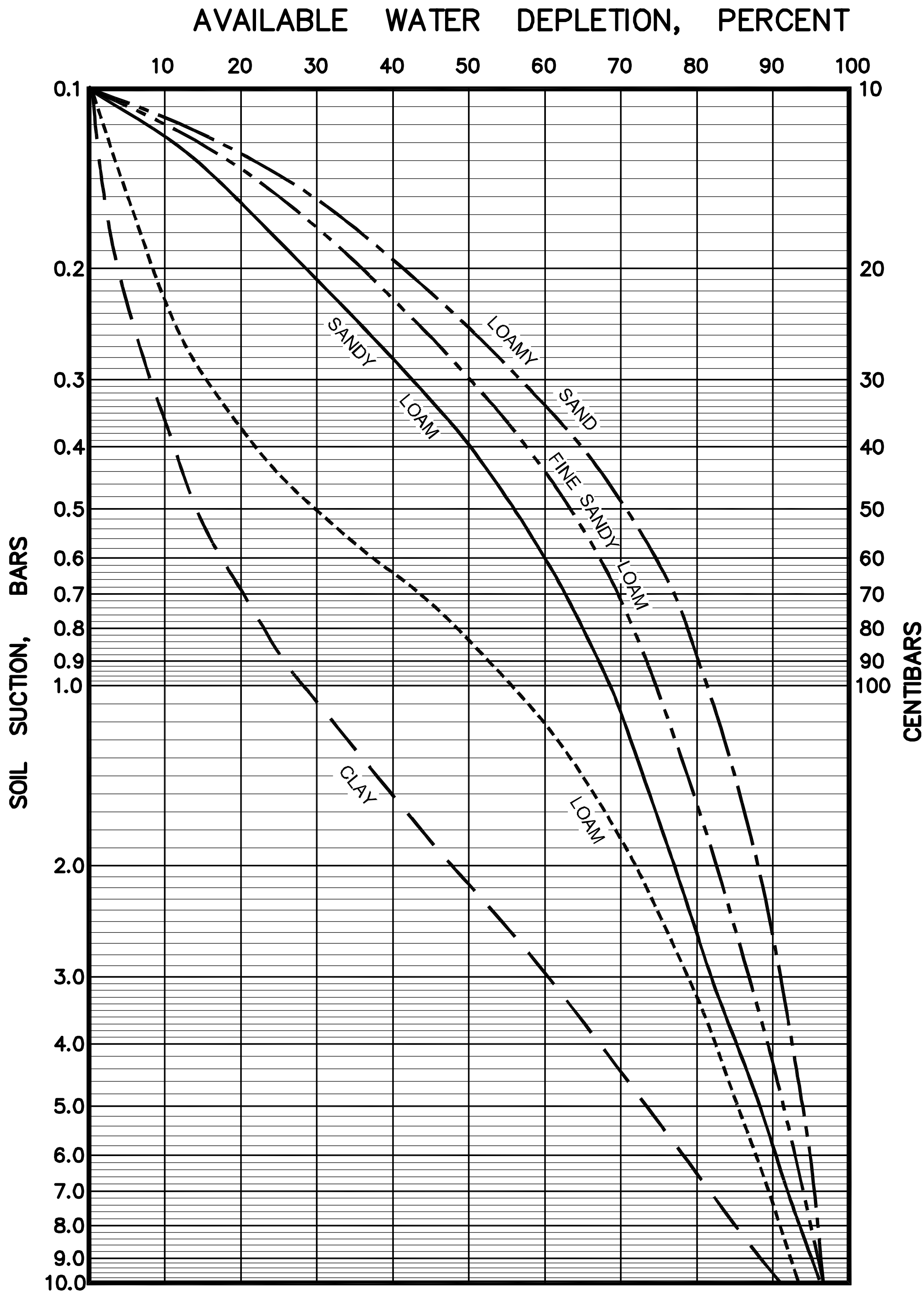


Figure 7 **Record Tensiometer Readings for a Soil Moisture Profile**



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