Water Conservation

FACTSHEET

BRITISH COLUMBIA | Ministry of Agriculture

Order No. 577.100-2
Revised: June 2015

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 as well as provides savings 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 is not being properly managed.

One of the benefits of scheduling with tensiometers is the ease of use and the immediate results. With tensiometers, users only need to look at the gauge to determine the soil moisture level with no other meters or instruments necessary (Figure 1). The soil water tension is measured in centibars (cbars) which is related to the amount of water in the soil available to plants.

Tensiometers work best in course textured soils or in fine soils, such as, clay, when a relatively high level of soil moisture content is maintained. Note that when fine soil like clay is dry, the tension often exceeds the maximum reading in a tensiometer gauge. Watermarks are therefore commonly used for fine soils. 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. For details on Watermarks refer to Factsheet 577.100-1 *Irrigation Scheduling Techniques* available online.

Figure 1 Tensiometer in the soil after installation

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.

For most soil types, readings under 10 cbars indicate a wet soil, and above 50 cbars indicate a dry soil.

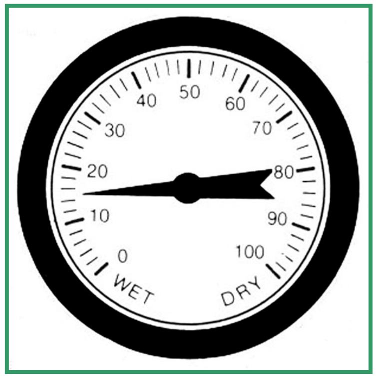

Figure 2 Tensiometer Gauge

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 level. Tensiometers should be placed 12 to 18 inches 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 mid-point 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 placed in field with varying soil types and irrigation systems. Deep rooted plants, such as, fruit trees, should have two tensiometers per site – one at 12 inches and the other at 24 inches.

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 readings from the tensiometers in the centre of a lateral to determine if pressure changes in the line are affecting the amount of water reaching the crop.

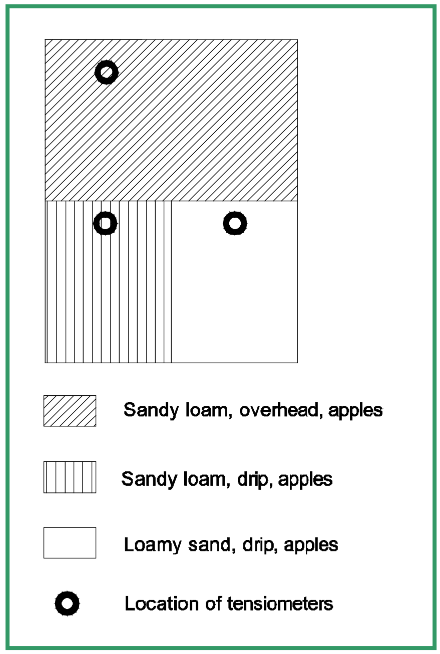

Figure 3 Locations of Tensiometers

Installation of Tensiometers

Prior to installation, the ceramic tip of a tensiometer must be soaked for 24 hours in a container of water, preferably an algaecide to prevent algae growth from clouding the water in the tensiometer column. It is important for the tensiometers to be installed properly and that the ceramic tip has good contact with the surrounding soil. Figure 4 illustrates step-by-step procedures for installing a tensiometer. The tensiometer should be filled with good quality water or distilled water. Adding a few drops of food colouring will make the water level in the tensiometer easier to see.

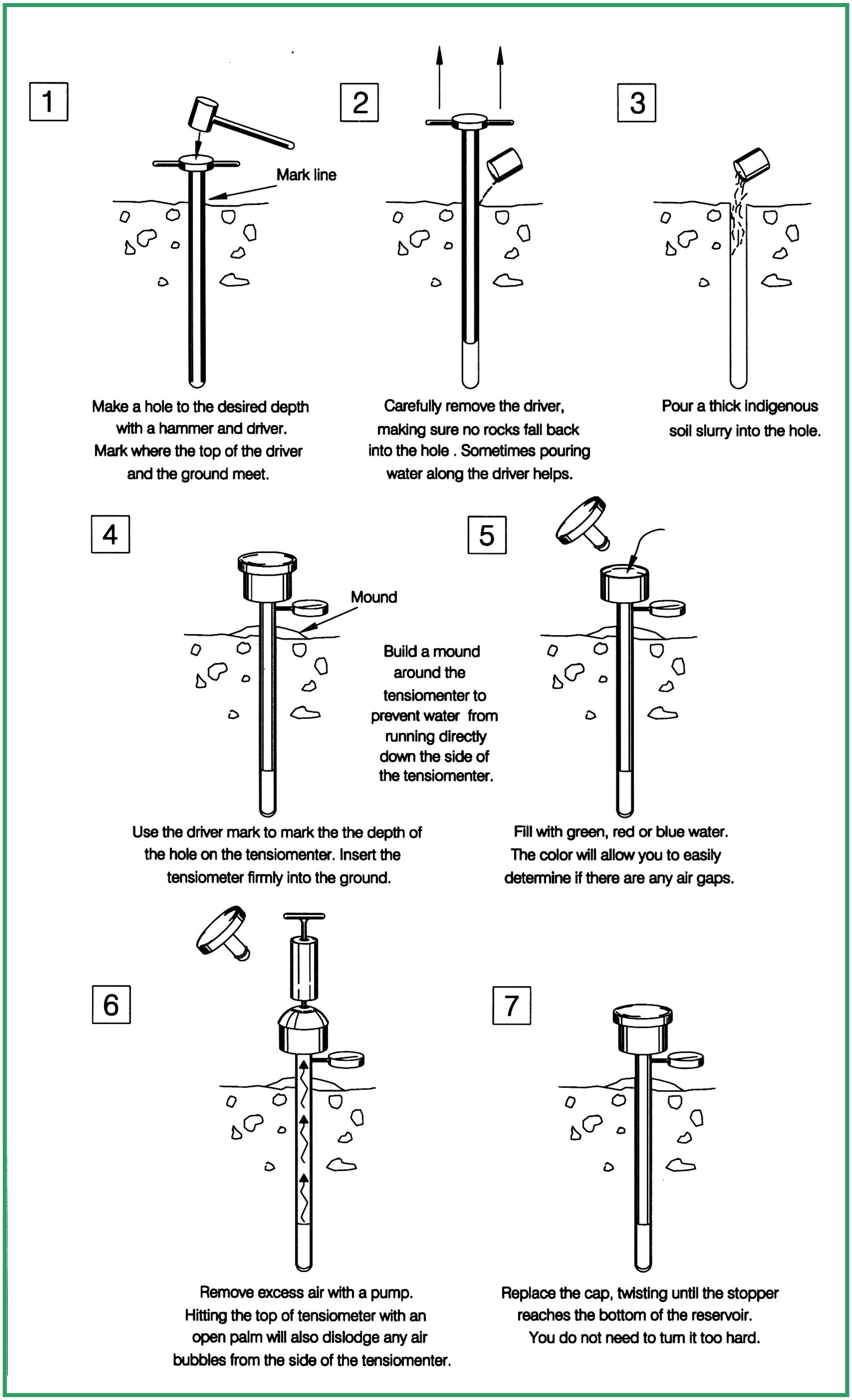

Figure 4 Tensiometer Installation Procedures

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 coloured 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 stand firm in the soil. 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, and Figure 5 shows a plot of the readings for a sprinkler system over an entire irrigation season. Irrigation began when the tensiometers read between 20 and 30 cbars. The drop in tension corresponds to the increase in soil moisture after irrigation. A graphing worksheet (Figure 7) is provided at the end of this factsheet 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.

Table 1. Tensiometer Readings

Date	Time	Tensiometer Reading [cbar]		Weather/ Notes
		12 inches	24 inches	
May 11	11:20 am	15	16	Sunny last week
May 15	09:30 am	22	15	Cloudy
…….	…….	…….	…….	…….
Aug 2	09:00 am	7	7	Begin irrigation
…….	…….	…….	…….	…….

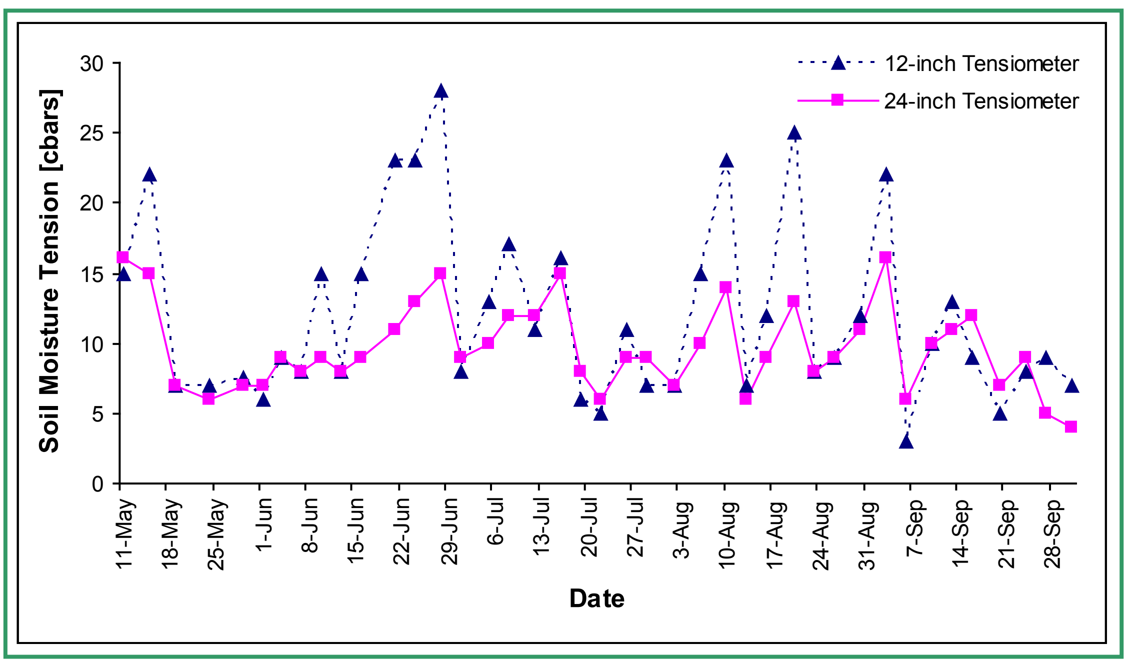

Figure 5 Soil Moisture Profile

Scheduling by Irrigation Systems

To determine the amount of water needed for specific crops, irrigation systems and soil types, refer to the *B.C. Sprinkler Irrigation Manual* and the *B.C. Trickle Irrigation Manual,* both available online. Begin irrigation when the tensiometer indicates irrigation is necessary. For sprinkler systems, this is when a trigger level is reached. For trickle and micro-sprinkler systems, irrigation should commence when the tensiometer readings indicate the soil moisture content is below the optimum level.

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

Drip/Trickle and Micro-jet Systems

For trickle/drip or micro-jet systems, the crop is irrigated frequently (daily) and requires the soil to be maintained at a constant moisture level. This can be done by monitoring tensiometer reading closely and applying frequent but small amounts of water as required. Soil moisture should not be depleted by more than 15%. Table 2 indicates the range the tensiometer should read to keep the soil moisture within the range.

Table 2. Soil Moisture Range for Drip/Trickle and Micro-jet 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 can be maintained by adjusting the set time and the length of time the zone is irrigated. If the soil is always wet or dry, adjust the amount of time the zone is irrigated to bring the soil moisture to the optimal level.

Sprinkler Systems

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 eight to twelve 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 50% of the plant's 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 Level [cbars]
ft	cm		
2	60	Sand	20
		Loamy Sand	25
		Sandy Loam	30
		Loam	35
4	120	Sand	25
		Loamy Sand	30
		Sandy Loam	35
		Loam	40
< 1	< 30	Sand to Loamy Sand	15 – 20
		Sandy Loam to Loam	25 – 35

Tensiometers should be placed 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 (12-inch) and deep (24-inch) tensiometers should be taken into consideration since plants obtain 50% of the moisture from the top one foot of the root zone, and the other 50% from the second foot of the root zone. If the 12-inch tensiometer reads wet while the 24-inch one 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-inch tensiometer reads dry, only add enough water to wet the first 12 inches 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 four days for the soil tension to go from 10 to 15 cbars, but only one 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.

Micro-Sprinklers

A micro-sprinkler system design is similar to a sprinkler system, except that the soil moisture is maintained within a smaller range with low application rates and frequent irrigation. Micro-sprinklers should be operated on at least a two- or three-day cycle. The soil should not remain as wet as the soil that is 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 five cbars above that of the drip system (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 time for the soil to slightly dry out before the next irrigation. If the tensiometer readings are fluctuating greatly, e.g., more than 20 cbars, between irrigations, increase the irrigation frequency to maintain a fairly constant soil moisture level.

Irrigation scheduling techniques for various irrigation systems are summarized in Table 4.

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 6 gives the general relationship between available soil moisture and soil moisture tension. On the chart, tension is expressed in bars and cbars, meaning 0.1 bar is 10 cbars, and 0.5 bars is 50 cbars. Tensiometer readings should not go beyond 50% of available water depletion for sprinkler systems. For example, a tensiometer in a sandy loam soil should not read higher than 40 cbars; and a tensiometer in a loam soil should not read higher than 80 cbars which is near the end of the range that tensiometers can operate at.

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

Table 4. Summary of Irrigation Scheduling by Irrigation Systems

Irrigation System	Scheduling Method	Notes
Drip/Trickle/Microjet	Set Time	Daily irrigation Change the set time to maintain a constant soil moisture
Sprinkler	Set Time	Monitor deeper soil moisture during irrigation Reduce or stop irrigation if the soil is wet
	Irrigation Cycle	Monitor soil moisture readings daily or every couple of days Begin irrigation once the trigger level is reached
Micro-Sprinklers	Set Time	Adjust the operating time of each zone to reflect soil moisture conditions but keep the irrigation interval the same
	Irrigation Frequency	Maintain the set time and lengthen or shorten the interval to maintain soil moisture at an optimum level

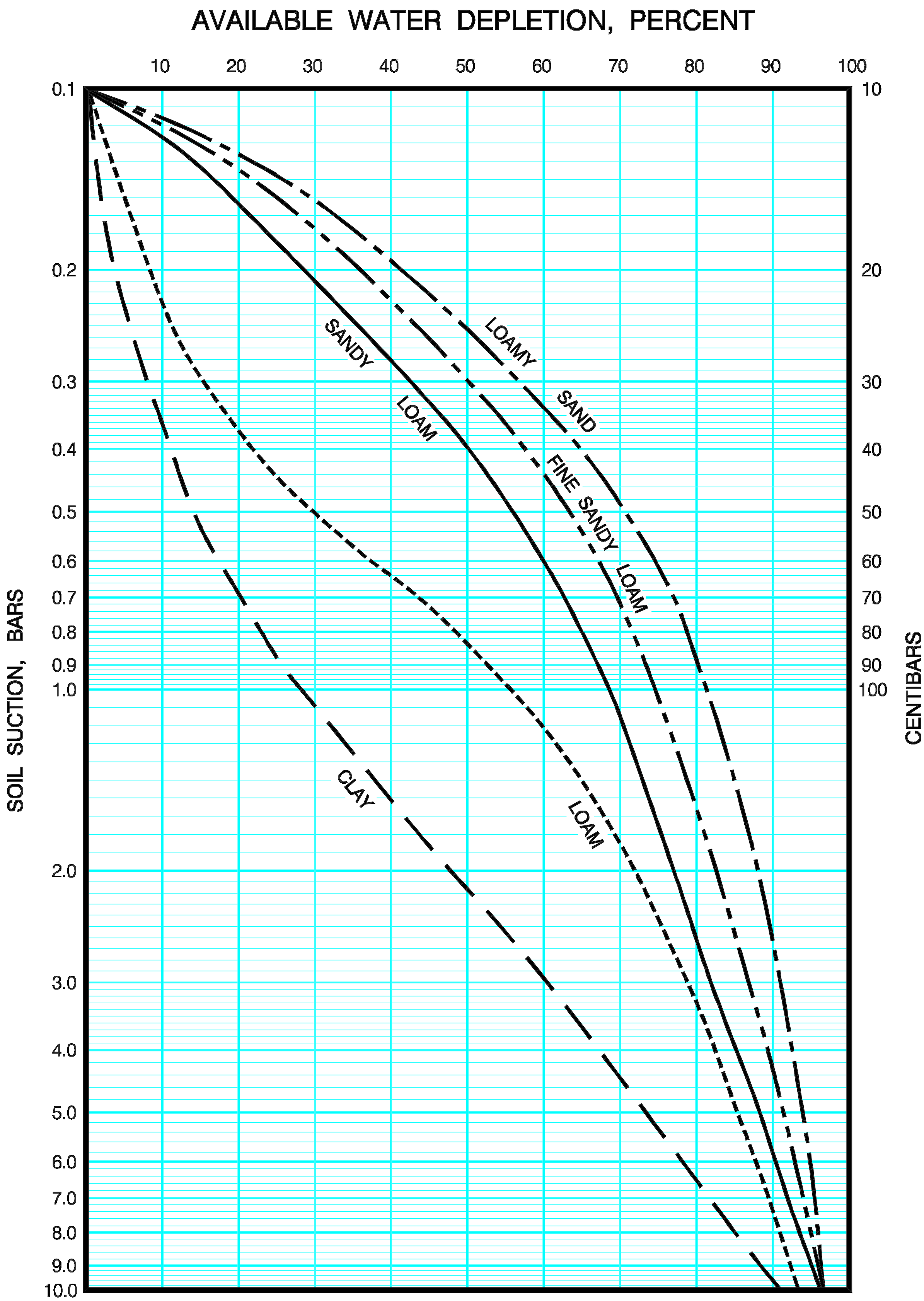

Figure 6 Relationship between Soil Moisture Tension and Available Water Depletion

Example A

Refer to Table 5 for available water storage capacity (AWSC) and application rates (AR) based on soil types.

A crop grown on a sandy loam soil has a rooting depth (RD) of 1 m. At what soil water tension should irrigation begin if the crop is irrigated by a sprinkler system? What is the net amount of water necessary for this irrigation?

Answer:

With a sprinkler system, irrigation should begin when 50% of the available water is depleted. From Figure 6, the tensiometer should read 40 cbars in a sandy loam soil when 50% of the soil water is depleted. In this case, the total available water soil capacity (AWSC) is:

Total AWSC = RD x AWSC
= 1 m x 12.0 cm/m
= 12.0 cm

Then, 50% of AWSC is:

50% of AWSC = Total AWSC x 50%
= 12.0 cm x 50%
= 6.0 cm

When the tensiometer reads 40 cbars, the sprinkler system should be run long enough to replenish this 6.0 cm of soil water which is the net amount of water applied. Irrigation system design and efficiency must be taken into consideration to determine the gross amount of water applied. The maximum application rates listed in Table 5 must not be exceeded when irrigating. Adding excess water may result in water loss to runoff or deep percolation.

Example B

Refer to Table 5 for AWSC and AR based on soil types.

A crop with a rooting depth of 1.3 m is irrigated by a sprinkler system on a loamy sand soil. The tensiometer in the soil reads 30 cbars. Should irrigation begin? If so, what is the net amount of water necessary for the irrigation?

Answer:

From Figure 6, 30 cbars of soil water tension on a loamy sand soil means 57% soil moisture has been depleted. The crop is under stress, and needs irrigation immediately.

Total AWSC = RD x AWSC
= 1.3 m x 9.0 cm/m
= 11.7 cm

Net Amount Applied = Total AWSC x 57%
= 11.7 cm x 57%
= 6.7 cm

Therefore, 6.7 cm of water is needed to replenish the soil water. The same rules in Example A apply to the gross amount applied and application rates in this example.

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]
Sand	1.9	0.75	1.0	0.40	8.0	1.0
Loamy Sand	1.7	0.67	0.9	0.35	9.0	1.2
Sandy Loam	1.2	0.47	0.6	0.24	12.0	1.5
Loam	0.9	0.35	0.5	0.20	16.0	2.1

References

Van der Gulik, T., Tam, S., Nyvall, J., and Brown, L. 2005. *B.C. Irrigation Management Guide*. Irrigation Industry Association of British Columbia, Abbotsford, B.C.

Bureau of Reclamation, Irrigation Guide,

Van der Gulik, T. 1999. *B.C. Trickle Irrigation Manual.* Irrigation Industry Association of British Columbia, Abbotsford, B.C.

Van der Gulik, T. 1985. *B.C. Sprinkler Irrigation Manual*. Irrigation Industry Association of British Columbia, Abbotsford, B.C.

Van der Gulik, T. *Irrigation Scheduling Techniques*. Irrigation Factsheet No. 577.100-1. Resource Management Branch, B.C. Ministry of Agriculture and Lands, Abbotsford, B.C.

Ley, T. *Soil Water Monitoring and Measurement*. Pacific Northwest Extension Publications. PNW 475

Kelley, C.C. Spilsbury, R.H. B.C. *Soil Survey of the Okanagan and the Similkameen Valleys*. The B.C. Department of Agriculture in cooperation with Experimental Farms Service, Dominion Department of Agriculture.

Gough, N.A., Hughes-Games, G.A. and Nikkel, D.C. 1994. *Soil Management Handbook for the Okanagan and Similkameen Valleys*.. Resource Management Branch, B.C. Ministry of Agriculture and Lands, Abbotsford, B.C.

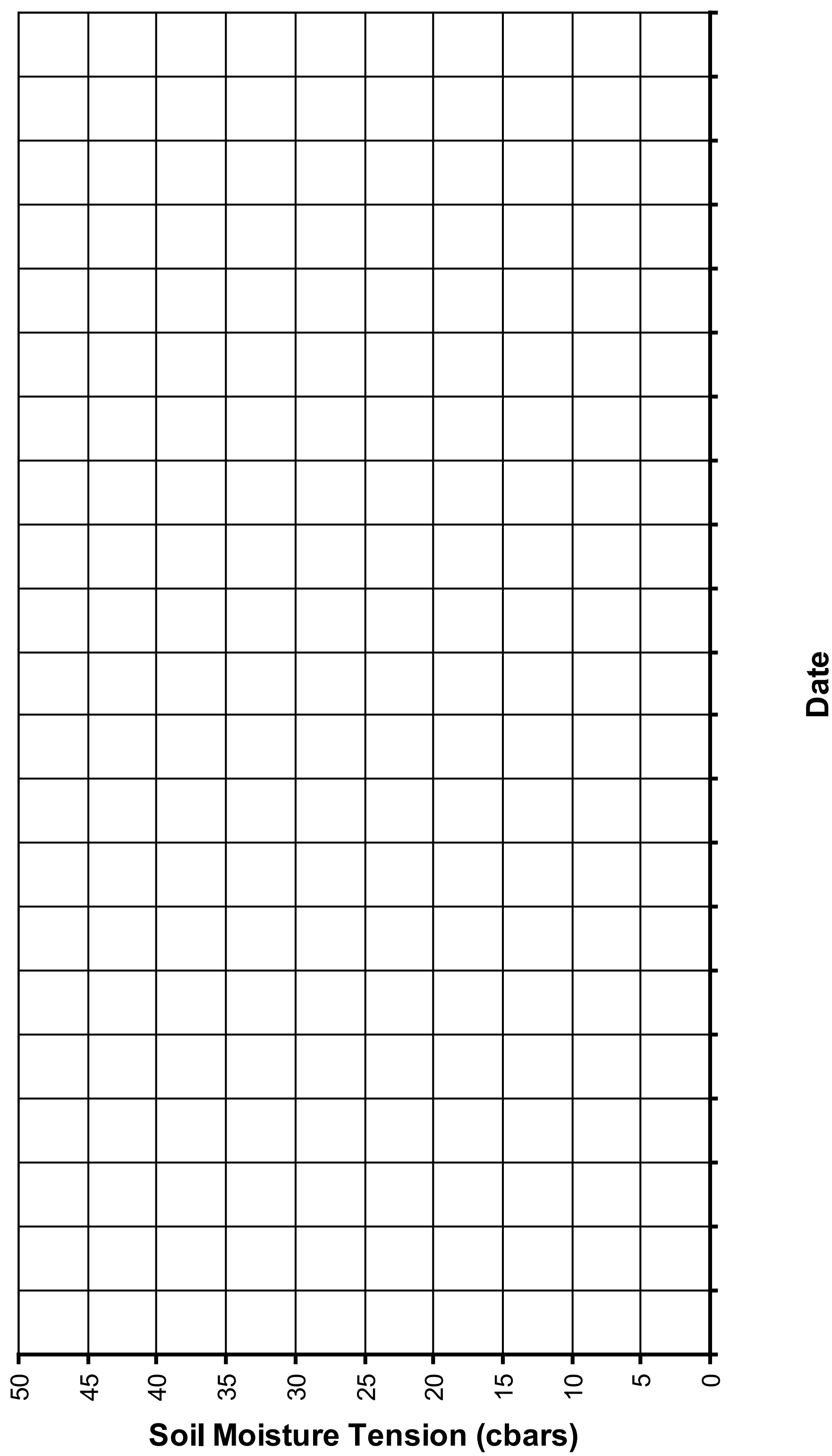

Figure 7 Soil Moisture Profile Using Tensiometer Readings

FOR MORE INFORMATION CONTACT
Phone: 604.556.3001
Toll Free: 1.800.221.7141

MINISTRY OF AGRICULTURE
1767 Angus Campbell Road
Abbotsford, B.C. V3G 2M3