Irrigation Scheduling by Tensiometers

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Contents

1. Irrigation scheduling

The practice of irrigation is aimed to supplement the incident precipitation so that both precipitation and applied water ensure a favourable moisture regime in the soil conducive to high yield. However, it is a costly venture and calls for appropriate water management skills on the part of farmers, because injudicious use of irrigation water significantly reduces crop yield per unit of applied water. The goal of an efficient irrigation programme is to "***provide knowledge on correct time and optimum quantity of water application to optimize crop yields with maximum water use efficiency and at the same time ensure minimum damage to the soil"***. Thus,

- Irrigation scheduling is the decision of when and how much water to apply to a cropped field.
- Its purpose is to maximize irrigation efficiencies by applying the exact amount of water needed to replenish the soil moisture to the desired level.
- Make efficient use of water and energy.

2. 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 irrigation 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. In addition irrigation scheduling with tensiometers offers several advantages:

1. It enables the farmer to schedule water rotation among the various fields to minimize crop water stress and maximize yields.
2. It reduces the farmer's cost of water and labor through fewer irrigations, thereby making maximum use of soil moisture storage.
3. It lowers fertilizer costs by holding surface runoff and deep percolation (leaching) to a minimum.
4. It increases net returns by increasing crop yields and crop quality.
5. It minimizes water-logging problems by reducing the drainage requirements.
6. It assists in controlling root zone salinity problems through controlled leaching. It results in additional returns by using the "saved" water to irrigate non-cash Crops that otherwise would not be irrigated during water-short periods.

3. Introduction to Tensiometer

Tensiometer is a soil water measuring device that is sensitive to soil water change and useful for irrigation scheduling (Fig. 1). Plant roots undergo tension as they pull the water out of a soil matrix. Tensiometer is a device that measures the soil water tension by acting like a mechanical root. This mechanical root is equipped with a gauge that continuously registers how hard the root must work to extract water from soil. Tensiometer is particularly accurate at low tensions, which is the wettest part of the soil water range. Tensiometers work best in course textured soils or in fine soils, such as clay, when a relatively high soil moisture content is maintained. They are popular with growers of high-value crops, such as vegetables and fruits on sandy soils.

Fig.1. Installed tensiometer in sweet orange

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. The basic components are a reservoir and cap, body tube, vacuum dial gauge, and a ceramic tip (Fig. 2).

3.1 ***Reservoir and cap*** – The reservoir acts as a water supply for the body tube. The cap on the reservoir must provide an airtight seal for the tensiometer otherwise the device will not work.

3.2 ***Body tube*** – The body tube provides support and a liquid connection between the porous tip and the vacuum gauge. Tensiometers come in various lengths. Standard lengths are 6, 12, 18, 24, 48, and 60 inches.

3.3 ***Ceramic tip*** – The ceramic tip is a porous cup, but the openings are so small that when saturated with water, the surface tension of water at air – water interface seals the pores and only water can pass through the pore within the range of soil tensions (0 – 85 centibars) to be measured.

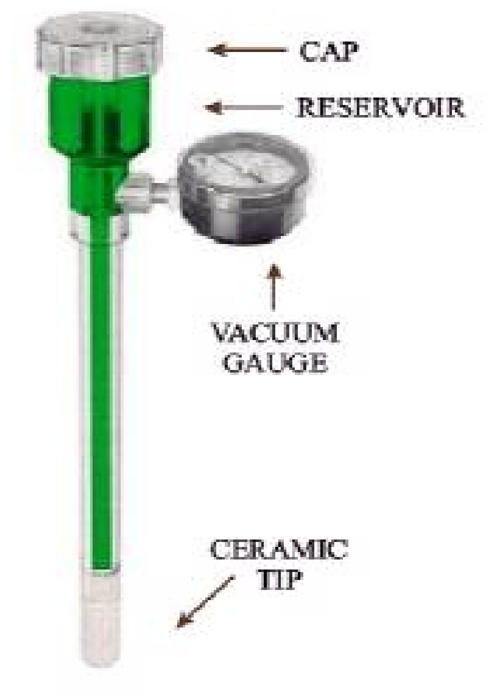


Fig. 2. A Tensiometer

3.4 *Vacuum gauge* – The vacuum gauge (Fig. 3) registers soil moisture tension. Water moving out through the porous cup causes the vacuum dial gauge reading to change indicating the suction or tension, at which the water is being pulled by the surrounding soil. It is calibrated in centibar or hundredths of one "bar."

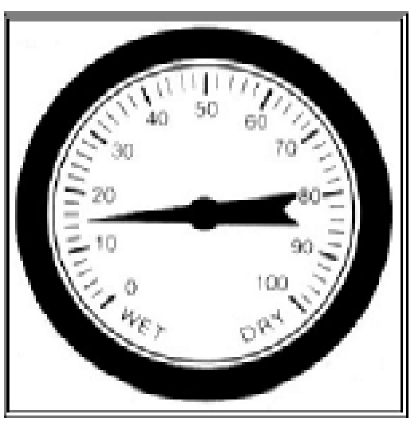


Fig.3. Vacuum gauge

A bar is the unit of pressure, either positive or negative, that has been adopted for the expression of soil suction. The bar is an international unit of pressure in the metric system and is equivalent to 14.5 psi (pounds per square inch) or 0.987 atmospheres. One centibar is also equal to 1 KPa (kilopascal). The soil suction reading on the vacuum gauge dial is an indication of soil water availability for plant use and does not require calibration for salinity or temperature. The readings have different meaning in terms of use for irrigation scheduling depending on soil type. Table 1 suggests interpretation of tensiometer readings in relation to soil texture. A tension higher than 85 will cause the water column inside the tube to break rendering it non-functional. This also is the functional upper limit for tensiometer readings. A depth label is usually placed on the vacuum gauge or on the side of the tube to indicate the depth at which the ceramic tip will be set when installed. This is important for identification purposes.

Table 1. Interpretation of Tensiometer readings

Reading (centibars)	Status	Explanation/action
0	***Saturated***	Soil is saturated regardless of soil type. If readings persist, there is possible danger of waterlogging, a high water table, poor drainage and soil aeration, or the continuity of the water column in the tube may have broken.
5 – 10	***Surplus water***	Indicates a surplus of water for plant growth. Drainage continues and persistent reading indicates poor drainage.
10 – 20	***Field capacity***	Field capacity for all types of soils. Additional water will drain as deep percolation, carrying nutrients without opportunity for plant use. Sandy soils, however, have very little storage capacity and suction values increase rapidly as water is removed to plants past 15 to 20. For sensitive crops, the vegetables, corn, potato

		etc, rapid irrigation may be required before damaging stress can develop.
20 – 40	***Irrigation range***	Available water and aeration good for plant growth in fine and medium textured soils. Irrigation is not required for these soils at this range. Coarse textured soils may require irrigation in the 20 to 30 range and finer sandy soils at 30 to 40 centibar ranges.
40 – 60	***Irrigation range***	Usual range for starting irrigation, at 40 to 50 centibar, irrigation may need to be started for loamy soils. On clay soils (silty clay loams, silty clays, etc) irrigation usually starts from 50 to 60. Heavy clay soils still have some available water. Irrigation, however, ensures maintaining readily available soil water. The stage of growth and type of crop will influence the decision.
70	***Dry***	Stress range. However, crop is not necessarily damaged. Some soil water is available in clay soils but may be low for maximum production.
85	***Dry***	Top range of tensiometer accuracy, higher readings are possible, but tension within the water column inside tensiometer will break between 80 to 85 centibar.

4. Tensiometer – Working principle

Soil water exists primarily as thin films around and between soil particles and is bound to soil particles by strong molecular forces (Fig. 4). As the soil dries, the water films become thinner and more tightly bound to soil matrixes. This increase in tension within the films now in contact with the tensiometer causes water to be drawn from the ceramic tip. The withdrawal of water from the ceramic tip creates a partial vacuum in the tensiometer. Water continues to be drawn until the vacuum created inside the tensiometer equals the tension of the water films outside. At this point equilibrium is reached and water ceases to flow. This vacuum gauge reading indicates the amount of suction or tension. As water is added to the soil from rainfall or irrigation, the soil suction is reduced. The higher vacuum in the tensiometer causes soil water to be drawn into the tensiometer, and the vacuum will be reduced until a balance in tension is reached. The tensiometer continuously responds and maintains a balance with the soil water suction or tension and the vacuum gauge indicates the amount of tension, hence the name tensiometer.

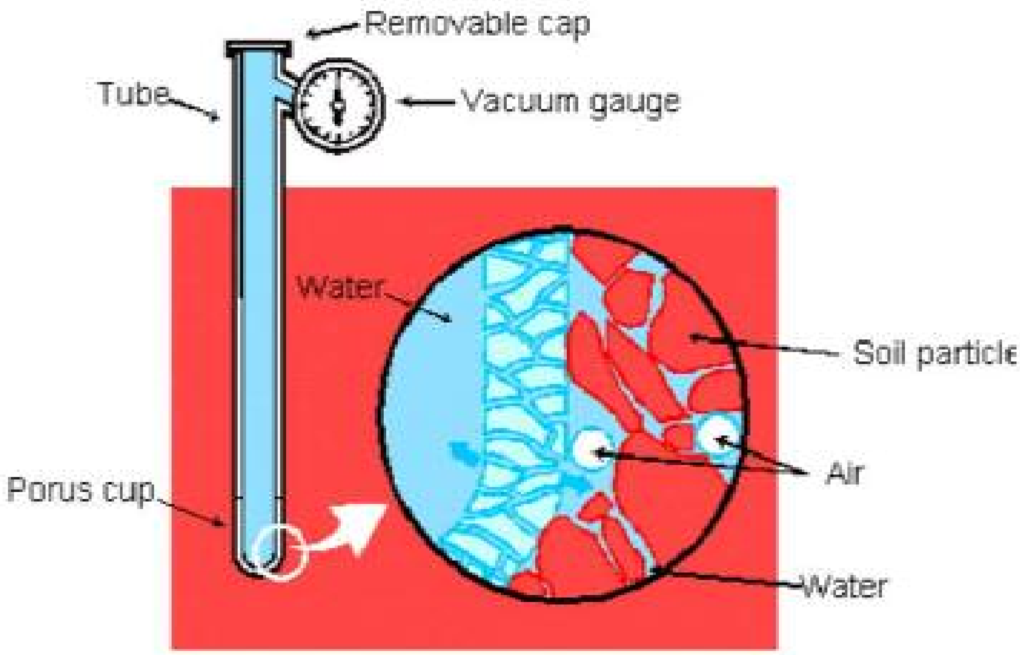


Fig. 4. Tensiometer with magnified cross-section of porous cup

5. Placement of tensiometer

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

b) When operating a trickle system the soil should be maintained at a constant soil moisture. Tensiometers should be placed 30 to 45cm from the emitter in an area that is representative of where the plants are taking up water. Few installation examples are shown in Fig. 5.

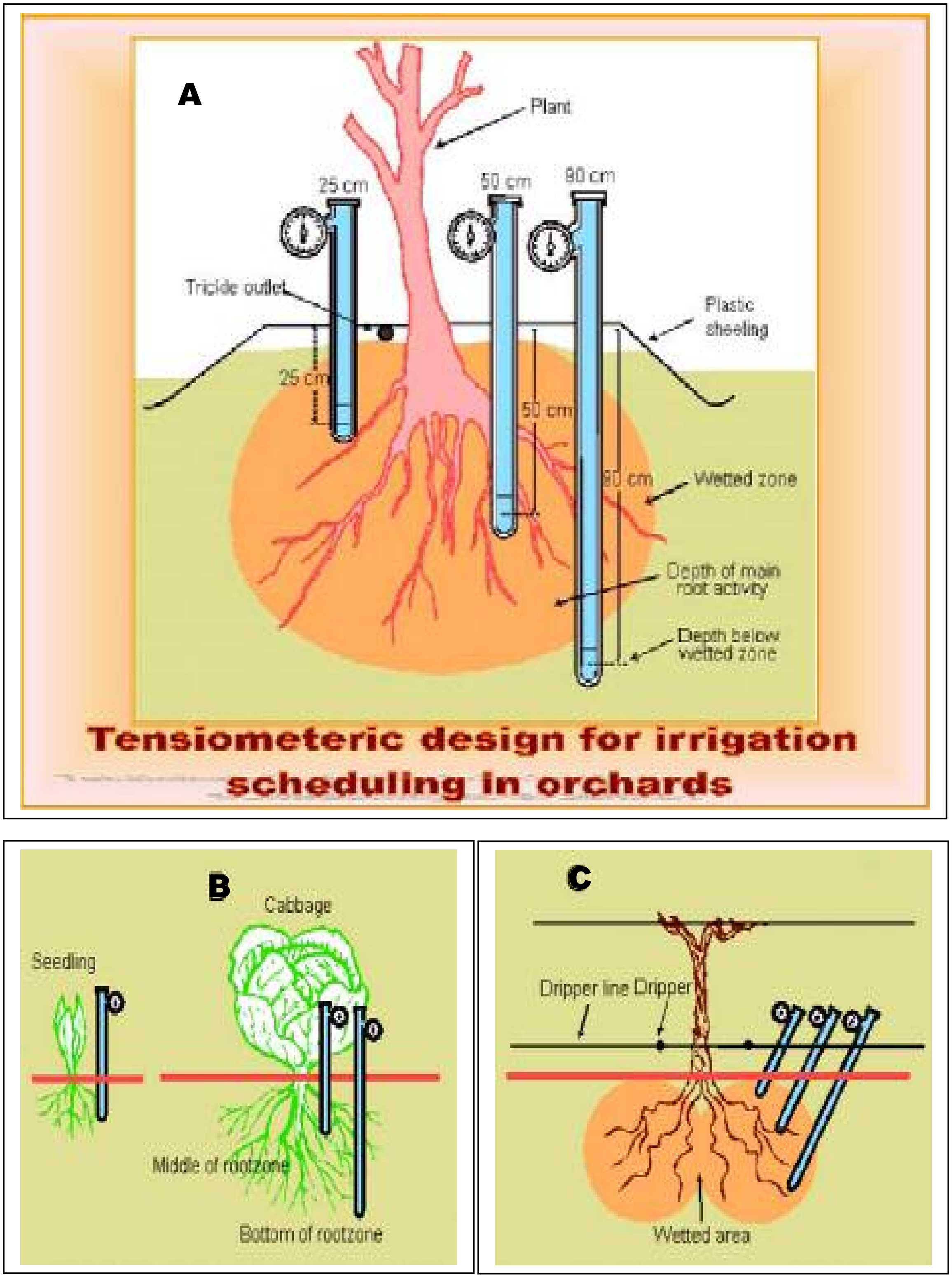


Fig. 5. Tensiometer installation in various crops

c) 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.
d) For any system a second monitoring site should be installed where a significant change in either the crop, soil or irrigation system is evident. Deep-rooted plants, such as fruit trees, should have two to three tensiometers per site one at 25cm, 50cmm and one at 90cm.
e) 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.
f) 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.

6. Tensiometer Installation

It is important for the tensiometers to be installed properly and that the ceramic tip has good contact with the surrounding soil. The tensiometer should be filled with 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. When the crop is young, one shallow tensiometer is adequate, as the plant grows, place a deeper tensiometer at the bottom of the root zone. Ensure that the positions selected receive an average water application. Do not place tensiometers in localized hallows or excess water may build up around them. Install the tensiometer when the soil is moist, preferably 2 or 3 days after irrigation.

6.1 Materials required

1. Sets of tensiometers to give measurements at the top, middle and bottom of the root zone
2. Distilled water
3. Cloth for wrapping the ceramic cup
4. A hand auger made by welding a 13mm coring but in to a piece of steel rod
5. A coring tool made from a one metre length of 13mm water pipe
6. A white painted flag post to mark the position of the tensiometer station, so that tractor operators or labour can see it

6.2 Installation

1. See Fig. 6 for installation procedure.
2. Installation depth – Guidelines for tensiometer installation depth in various crops varying in rooting patterns are given in Table 2.
3. Attach the depth label on the tensiometer to identify the root zone being monitored as either deep or shallow
4. Install the white marker flag post near the tensiometers so that the site is clearly visible
5. Observe the soil water tension reading in the vacuum gauge
6. Record the soil water tension readings at the same time each day, in the early morning. The frequency at which readings are taken depends on soil type i.e., it is determined by the magnitude of change in the tension from day to day. If only small changes occur the readings may be spaced several days apart otherwise reading should be taken daily.

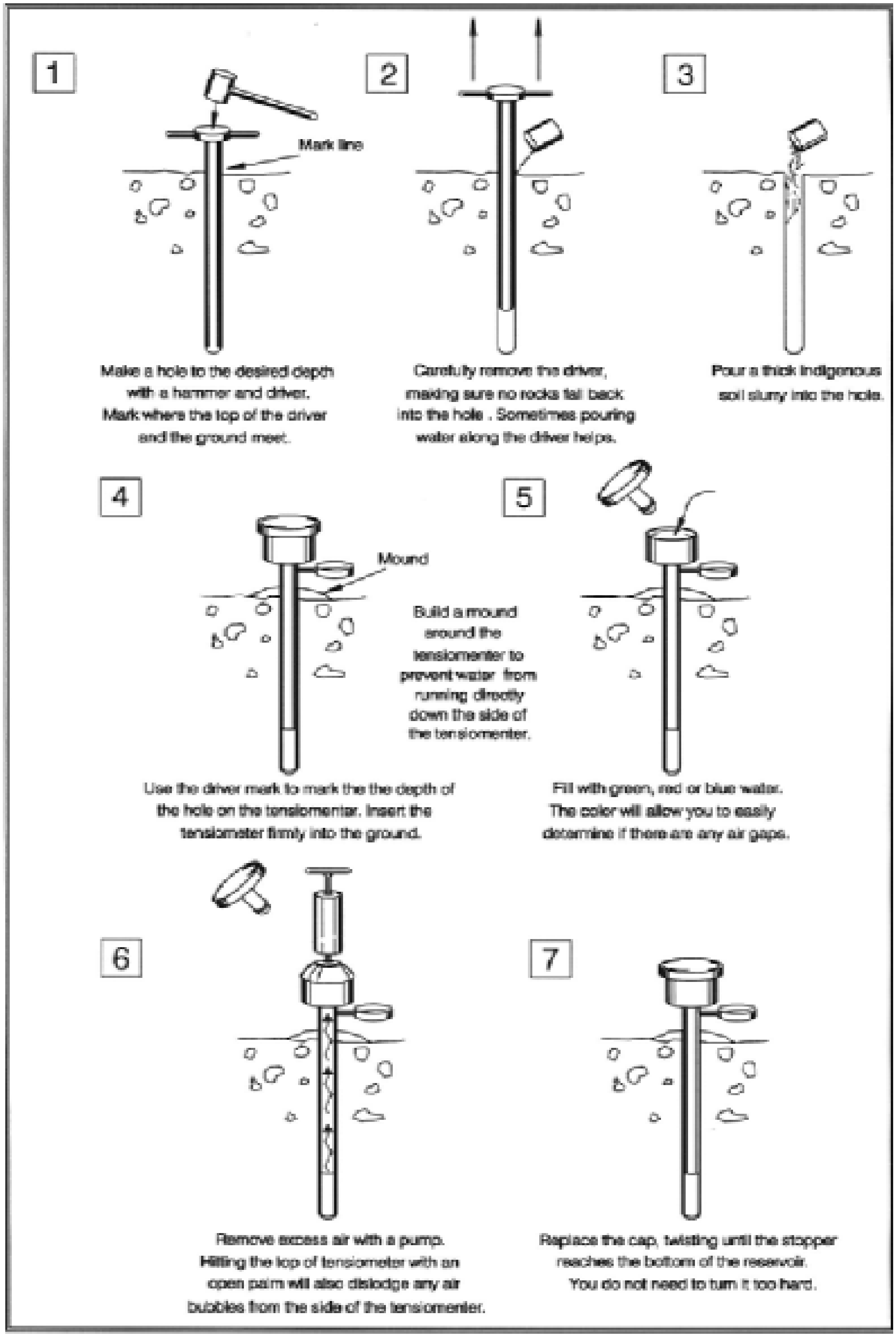


Fig.6. Tensiometer installation

Table 2. Recommended installation depths for tensiometers

Crop	Pair of tensiometers		
	Set shallow instrument at	Set deep instrument at	For extra depth instrument at
Apple	45-60	90-120	150-180
Banana	30	60	
Beans	45	60	
Broccoli	30	50	
Cabbage	30	50	
Carnations	30	45	
Carrots	30	60	
Cauliflower	30	60	
Citrus, orange, lemon	45	60	
Coffee	45-60	90-120	
Grain corn	45	90	
Sweetcorn	30	75	
Cotton	45	90	
Cucumbers	45	90	
Date palm	60	120	
Brinjal	30	60	
Garlic	30	60	
Grapevine	60	120	
Jajaba	45	90	
Lettuce	30		
Melons	45	90	
Mint	30	60	
Okra	45	90	
Onions	30	---	
Papaya	30	60	
Pears	45	90	120
Peas	45	90	
Peppers	38	55	
Pineapple	38	55	
Pomegranates	45	90	
Potatoes	25	45	
Pumpkin	45	90	120
Radish	30	---	
Sugarcane	45	90	
Tea	30	60	
Tobacco	20-38	55	
Tomatoes	45	90	
Watermelon	45	90	

7. 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. Plot the soil suction readings as a function of time on a graph paper for different depths on the same graph and different locations on separate charts (Fig. 7). These curves help the grower to anticipate when an irrigation is needed. Figure 7 shows a plot of tensiometer readings 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. The tensiometers should be monitored more frequently (daily) at high soil moisture tensions. Soil moisture tension can quickly change between 30 to 50 cbars. Thus determine the time of irrigation by monitoring tensiometer suction readings installed in the zone of greater rooting density by following guidelines given in Table 1.

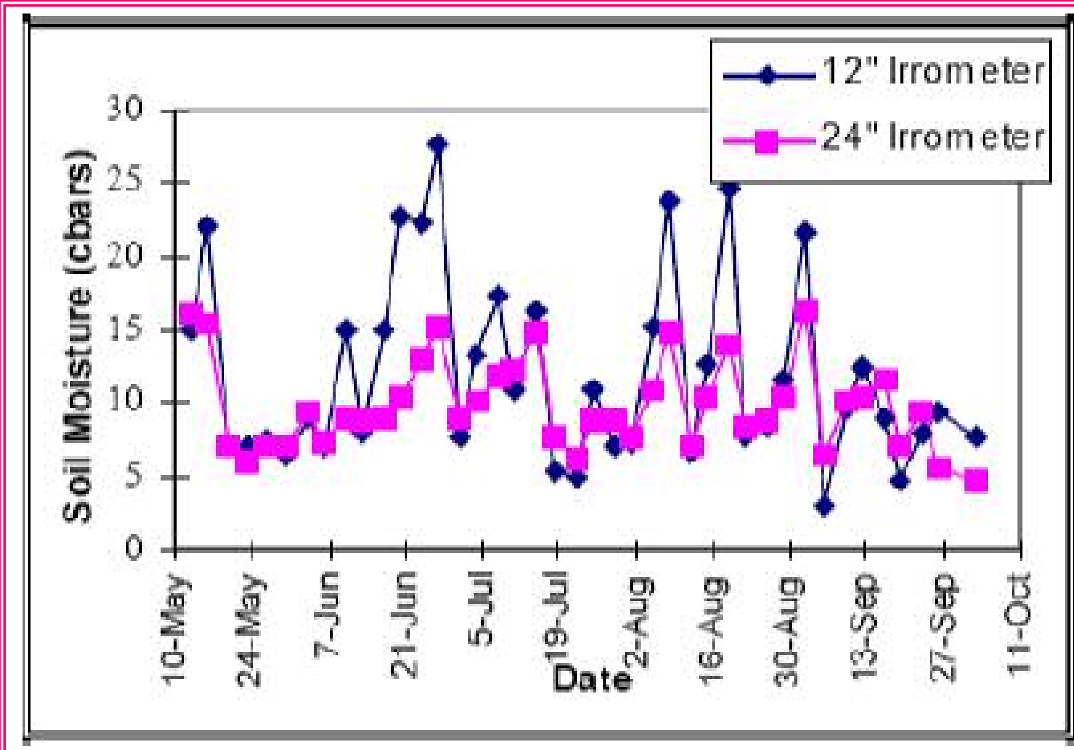


Fig. 7. Graphing tensiometer readings at two depths

7.1 When to take readings

Ideally, take tensiometer readings at the same time each day, in the early morning. The frequency of readings depends on the soil type.

- In heavy soils, read tensiometers just before irrigation and one or two days after the irrigation. In addition, read the tensiometers as necessary between irrigations, to help in deciding the timing of the next irrigation.
- In light soils, take daily readings.

In summer season, crop water use is relatively high, and the soil dries out more quickly. During this season, take tensiometer readings more often. For example, for drip-irrigated tree and vegetable crops in sandy soils, take readings each day. For vines on loamy soils, readings taken two or three times a week are usually enough. During winter season, tensiometer installed in tree crops can be read fortnightly, since water extraction is low to moderate. Consistently low readings could show that there is a water-logging problem and a need for drainage or other remedial action.

7.2 How to record the readings

Enter tensiometer readings in a notebook or diary with the rainfall and irrigation amounts and dates. It is important to identify the location of tensiometer stations or nests, by recording a valve or site number, the depth of tensiometer being read, and the date and time of taking the reading. It is essential to plot tensiometer readings on graph paper (Annexure – I).

8. Water scheduling by irrigation systems

To determine the amount of water needed for specific crops, irrigations systems and soil types begin the irrigation season when the tensiometer indicates irrigation is necessary. For sprinkler systems this is when a trigger level is reached.

For drip 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.

***8.1 Drip 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 3 indicates the range the tensiometer should read to maintain 15% of the available water in the soil is depleted. 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.

Table 3. Soil moisture range for drip systems

Soil type	Soil moisture tension (centibars)	
	Low (wet)	High (Dry)
Sand	10	15
Loamy sand	10	15
Sandy loam	15	20
Loamy	25	30

***8.2 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 centibars above that of the drip system, see Table 3. 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 centibars, between irrigations, increase the irrigation frequency (remember we want to maintain a fairly constant soil moisture).

***8.3 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 4 gives minimum trigger levels for various crop rooting depths and soil types.

Table 4. Tensiometer trigger levels for sprinkler systems

Rooting depth (cm)	Soil texture	Trigger levels (centibars)
< 30	Sand to Loamy sand	15 – 20
	Sandy loam to Loam	25 – 35
60	Sand	20
	Loamy sand	25
	Sandy loam	30
	Loam	35
120	Sand	25
	Loamy sand	30
	Sandy loam	35
	Loam	40

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 30cm tensiometer reads wet while the 60cm 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 60cm, even though the 30cm tensiometer reads dry only add enough water to wet the first 30cm 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 based on tensiometer readings for various irrigation systems are summarized in Table 5.

Table 5. Water scheduling by irrigation system

Irrigation system	*Scheduling method*	*Notes*
Drip	Set time	Daily irrigation, change the set time to maintain a constant soil moisture
Micro jet	Set time	Same as drip
Micro sprinkler	Set time	Same as drip, 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	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

9. 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 loamy soil. Figure 8 gives the general relationship between available soil moisture and soil moisture tension.

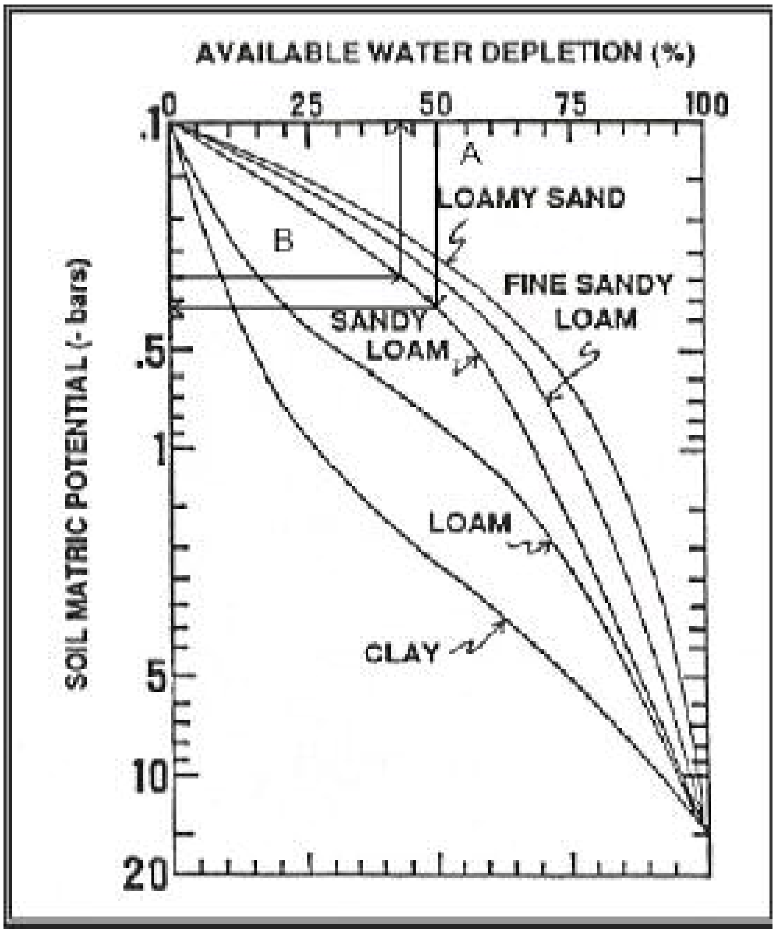


Fig.8. Influence of available soil moisture on soil moisture tension

The tension on Figure 8 is read in bars. This means 0.1 bar is equivalent to 10 centibars and 0.5 bars is 50 centibars. The ticks/divisions 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 15 to 50%

available water depletion. The crop type, soil texture, rooting depth and irrigation system type determines the amount of water that should be applied to maintain optimum amount of moisture in the soil. For example a tensiometer in sandy loam soil should not read higher than 35 cbars and a tensiometer in loamy soil should not read higher than 80 cbars, this is near the end of the range that tensiometers can operate at.

9.1 ***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. 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 8. 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.

9.2 ***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). Thirty cbars corresponds to 43% depletion of soil moisture, see Figure 8. 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.

10. Interpreting the tensiometer readings

The graph in Fig. 9 shows typical changes in tensiometer readings as a function of time. A tensiometer station or nest normally consists of three tensiometers, but for easier interpretation, the readings from only two have been plotted in Figure 9. The following interpretations were made on the changes in the readings that lie below the labels such as 'comment 1' on the graph. Look at the graph first, then read the relevant comment in the text below.

Comment 1: Tensiometer readings were increasing right up to when the 10 hour irrigation (in this case, 65 min) started. Note how quickly the tensiometer readings fell when water reached the porous cup of both the deep and the shallow tensiometers. This indicates that the entire root zone was wetted.

Comment 2: A 10 hour irrigation was applied. This was completely unnecessary, since the tensiometer readings were still low, showing that topsoil and subsoil were wet enough for plants to obtain water.

Comment 3: Rainfall at this time slowed the rate of increase in tensiometer readings and delayed the need for irrigation.

Comment 4: The readings of the shallow tensiometer began to increase rapidly and a short (five hour) irrigation was applied to re-wet the upper root zone but not the deeper root zone, which was still wet enough. The irrigation did not penetrate deep into the root zone and the water did not reach the deep tensiometer, so its readings continued to rise.

Comment 5: The readings of the shallow and the deep tensiometers have increased, showing that irrigation was needed to wet the entire root zone. A 10 hour irrigation was needed to re-wet the entire root zone. Immediately after the irrigation, both tensiometer readings fell, showing that the irrigation was adequate but not excessive.

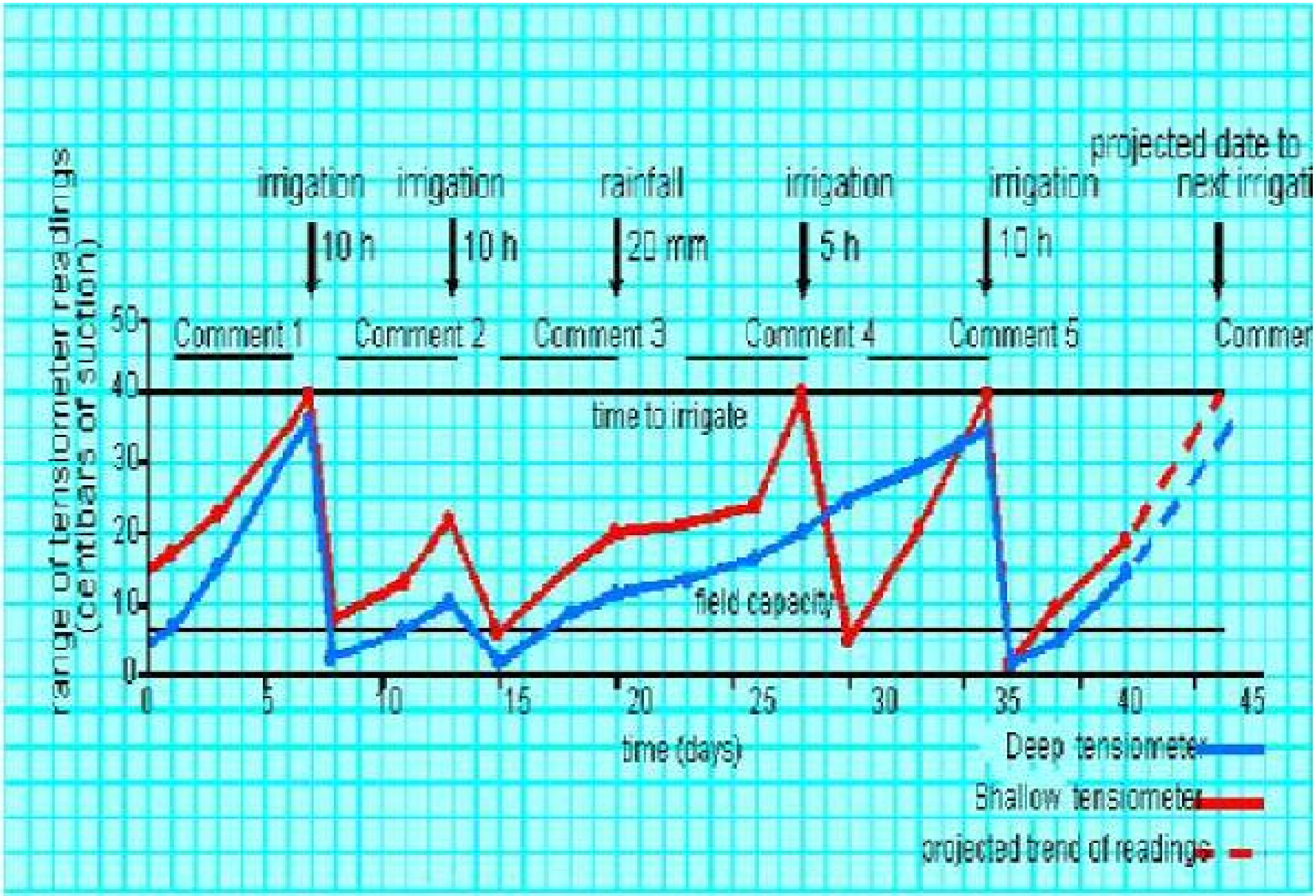


Fig.9. An example for interpretation Tensiometer readings recorded at 2 depths

Comment 6: By observing the slope of the line produced by joining the plotted tensiometer readings, and referring to earlier irrigation cycles, it is quite easy to project ahead the number of days before the next irrigation is needed – see the dotted lines.

Of course, hot weather or a sudden rainfall will alter the projected trend. In these cases, the decision when to irrigate will have to be based on further tensiometer readings.

11. 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.

12. Points to remember

- The tensiometer with the readings that rise the most rapidly (usually the shallow one) determines when the next irrigation is due.
- The deepest tensiometer helps to determine the correct depth of irrigation
- Do not change your irrigation practice drastically. Monitor the readings for a period; dig holes with a shovel or a 100 mm auger, and follow your irrigation

through the soil until you gain confidence in the tensiometer readings. This may take several irrigation cycles.

- It is not possible to set out instructions on when to irrigate for all crops, soils, methods of irrigation and climatic conditions. However, by plotting your tensiometer readings and keeping them within the desirable range (see Fig. 4) you will gain confidence in using these instruments and will be able to decide when to irrigate and how much water to apply.

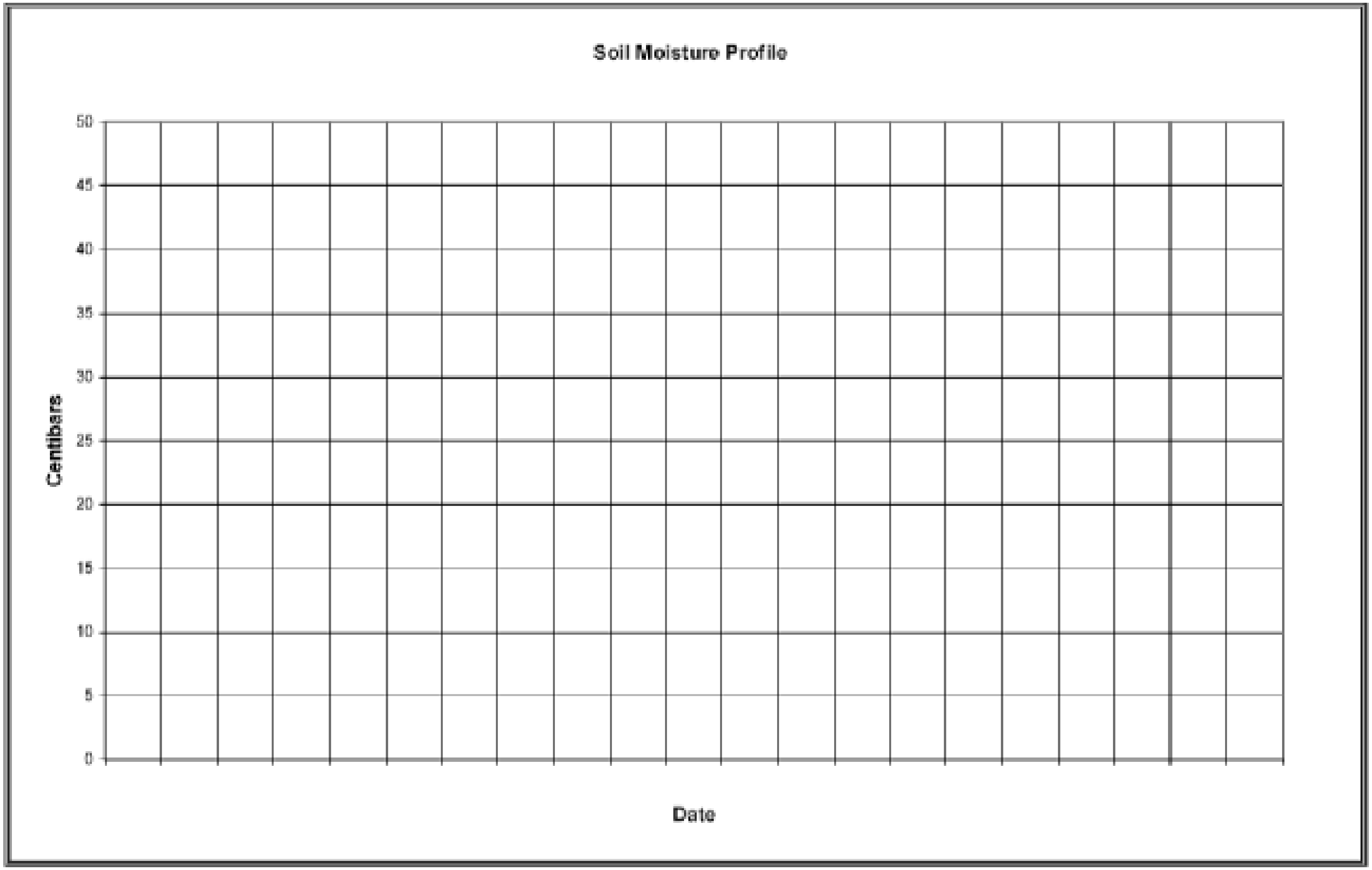
13. Optimum soil moisture tension values

Below given are critical soil moisture tension values for scheduling irrigation's in various crops.

Table 3. Soil moisture tension (SMT) at which irrigation must be applied for maximum yields of important crops under drip irrigation

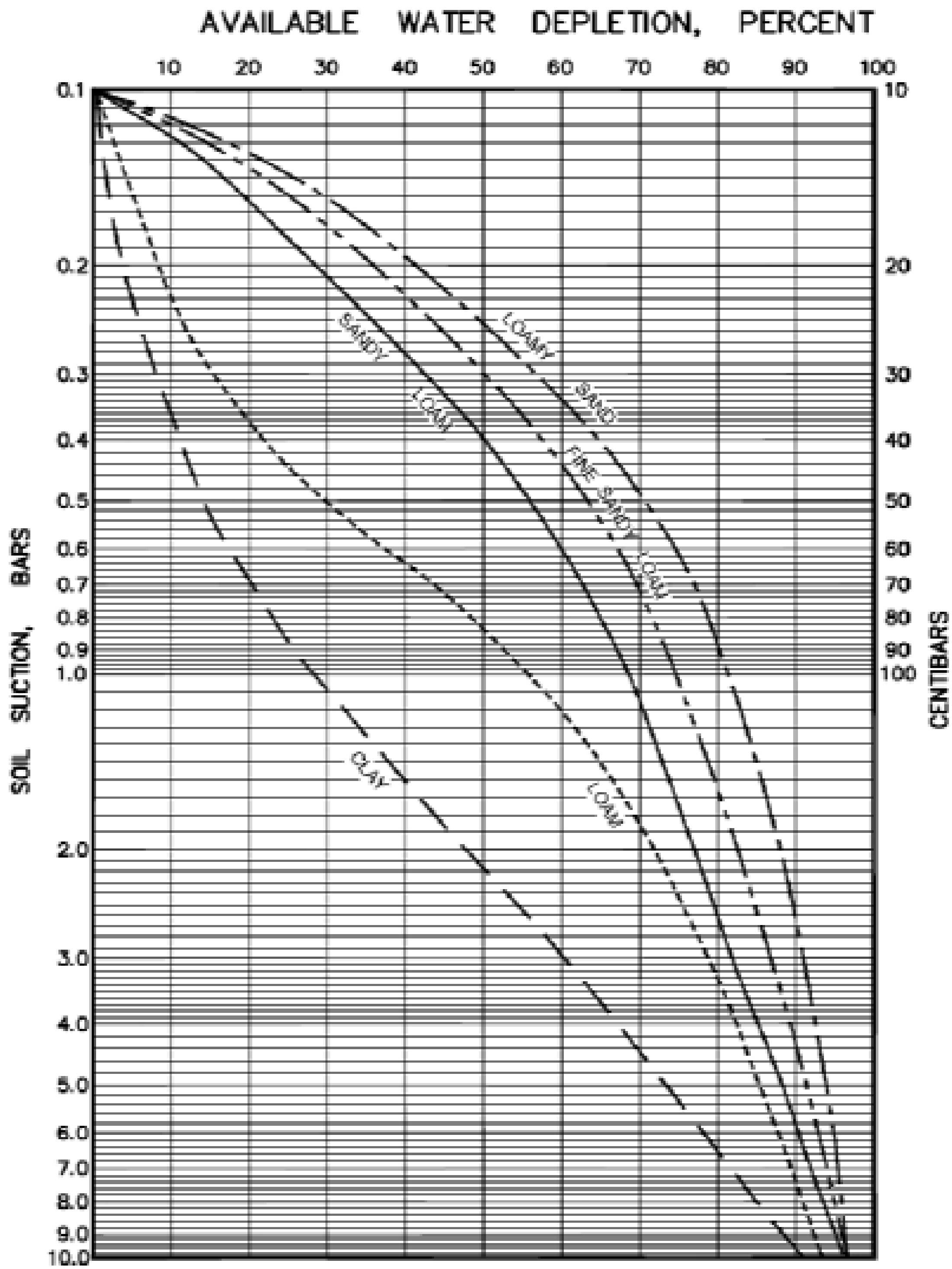
Crop	Critical SMT (Centibars)	Crop	Critical SMT (Centibars)
Sugarcane	40-70	Broccoli	25-30
Grain corn	50-80	Cabbage	34
Sweet corn	45	Cauliflower	34
Babycorn	30-45	Carrot	45
Cotton	70-80	Citrus	50-70
Tobacco	30-40	Cucumber	45
Potato	30-40	Brinjal	45
Tomato	45-70	Grapes	40-60
Brinjal	35-50	Lettuce	40-50
Lady's finger	60-70	Onion	25-35
Banana	35-50	Capsicum	45
Chillies	35-60	Pumpkin	70
Beans	45-50	Radish	25-35

Annexure – I

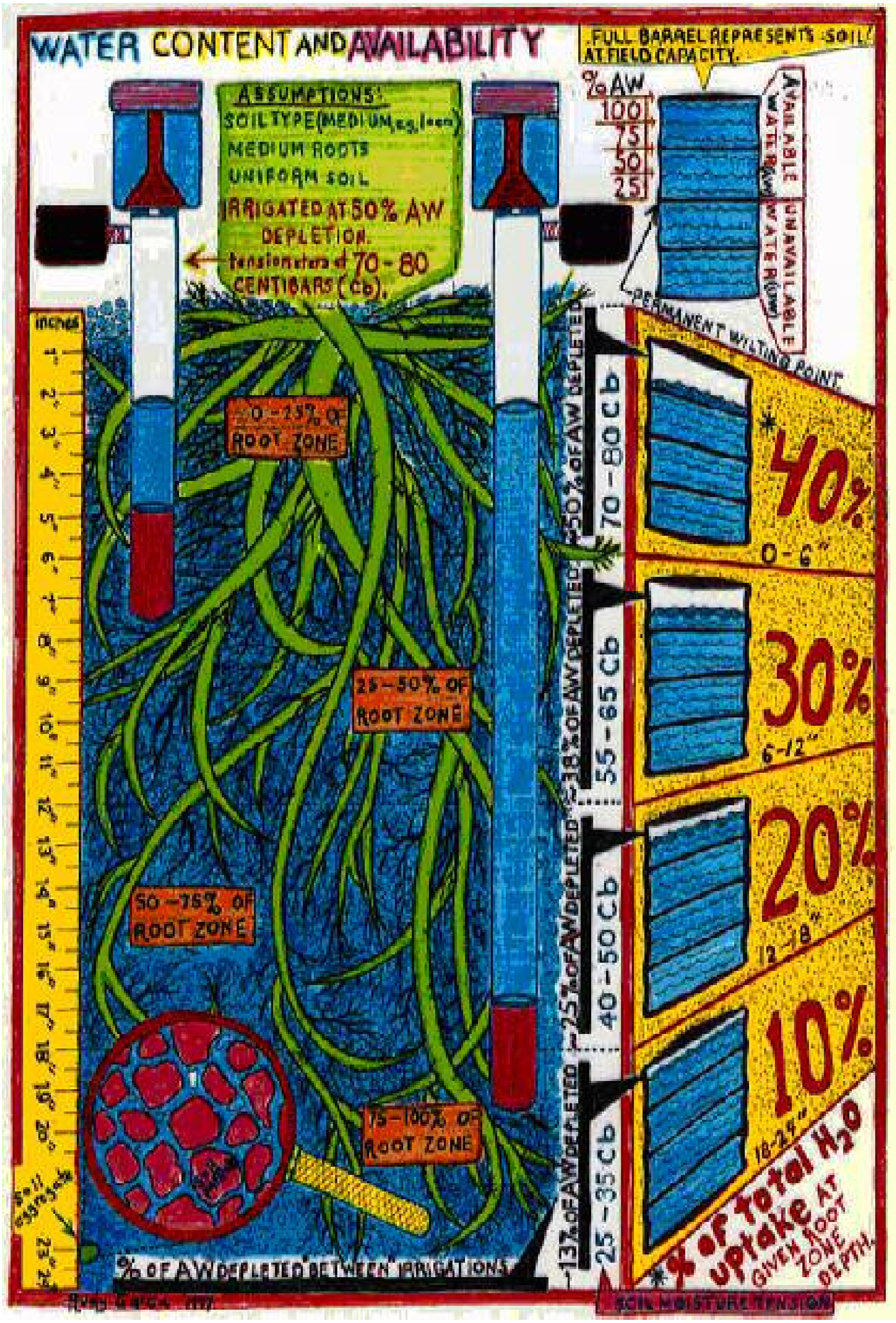


Graph sheet for recording tensiometer readings

Annexure – II



Soil moisture characteristic curves for soils varying in texture


WATER CONTENT AND AVAILABILITY
FULL BARREL REPRESENTS SOIL AT FIELD CAPACITY.
%AW
100
75
50
25
AVAILABLE WATER (AW)
UNAVAILABLE WATER (UW)
PERMANENT WILTING POINT
ASSUMPTIONS:
SOIL TYPE (MEDIUM, e.g. loam)
MEDIUM ROOTS
UNIFORM SOIL
IRRIGATED AT 50% AW DEPLETION.
tensiometers at 70-80 CENTIBARS (Cb).
inches
0-25% OF ROOT ZONE
25-50% OF ROOT ZONE
50-75% OF ROOT ZONE
75-100% OF ROOT ZONE
50% OF AW DEPLETED
70-80 Cb
38% OF AW DEPLETED
55-65 Cb
25% OF AW DEPLETED
40-50 Cb
13% OF AW DEPLETED
25-35 Cb
40%
0-6"
30%
6-12"
20%
12-18"
10%
18-24"
* % of total H_2O uptake at given root zone depth.
% OF AW DEPLETED BETWEEN IRRIGATIONS
SOIL MOISTURE TENSION