SCHEDULING IRRIGATION

Optimum yields are realized using irrigation when water is supplied in accordance with the need of the crop and the deficiency of moisture in the root zone of the soil. In selecting the water deficit to be permitted prior to irrigation, consideration must be given to the effects of soil factors, plant root characteristics, climatic conditions, cultural or harvest operations and irrigation system capabilities.

Some method of accounting should be used to balance daily crop moisture depletion against the addition of water by rain and irrigation. This can be done by computerized scheduling normally furnished commercially.

A simplified procedure named the "checkbook method" developed by Darnell Lundstrom and Earl Stegman is included in the Irrigation Handbook for North Dakota, Chapter 15, or is available from a county agent's office.

With any scheduling system, frequent checks of the actual soil moisture should be made. The methods that can be used for this purpose are neutron meters, electrical resistance units, tensiometers or the feel and appearance method.

Neutron Meter

The neutron meter is an expensive device that employs a radioactive source and requires a license to operate. They are normally used in research and commercial monitoring. Their advantages include good accuracy, use of semi-permanent access tubes for readings and rapid readings.

Electrical-Resistance Instruments

These instruments (Figure 9.1) use the principle that a change in moisture content produces a change in some electrical property of the soil or of an instrument in the soil. They consist of two electrodes permanently mounted in conductivity units, usually blocks of plaster of paris, nylon, fiberglass, gypsum, or combinations of these materials. Electrodes in the blocks are attached by wires to a resistance or conductance meter that measures changes in electrical resistance in the blocks. When the units are buried in the soil, they become almost a part of the soil and respond to changes in soil-moisture content. Since the amount of moisture in the blocks determines electrical resistance, measurement of any change in resistance is an indirect measure of soil moisture if the block is calibrated for a particular soil.

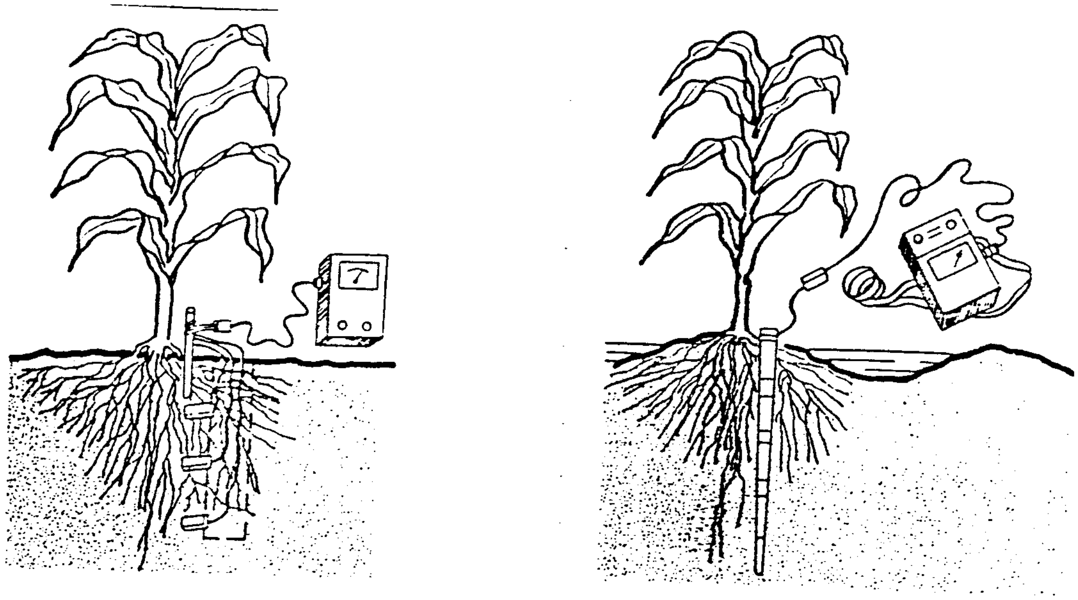

Figure 9.1 - Electrical-resistance soil-moisture meters

Nylon and fiberglass units are more sensitive in the higher ranges of soil moisture than plaster of paris blocks, but often their contact with soil that is alternately wet and dry is not very good. Nylon units are most sensitive at a tension of less than 2 atmospheres. Plaster of paris blocks function most effectively at a tension between 1 and 15 atmospheres, and fiberglass units operate satisfactorily over the entire range of available moisture. A combination of fiberglass and plaster of paris provides sensitivity in both the wet and dry range and provides good contact between the soil and the unit.

Electrical-resistance instruments are sensitive to salts in the soil; fiberglass units are more sensitive than plaster of paris. Their readings are also affected by concentrations of fertilizer. Where fertilizer is spread in bands, the unit should be placed well to one side of the bands. Temperature also affects readings in all units but much less than other sources of variation. In some units calibration drift has caused changes of as much as 1 atmosphere of tension in a single season. The magnitude of a change depends on the number of drying intervals and the number of days between each. Readings also vary with soil type. Since the same reading may indicate different amounts of available moisture for different soil textures, the instrument must be calibrated for the soil in which it is to be used.

If readings are to be representative of an area, the blocks must be properly installed. Individual blocks must be placed in a hole, which disturbs the soil. If the soil is not replaced in the hole at the same density and in the same way as in the rest of the profile, the root development and moisture pattern may not be representative. A good method is to force the block into undisturbed soil along the sides of the hole dug for placement of the blocks (Figure 9.1). In one type, the blocks are cast in a tapered stake. A tapered hole, the same size as the stake, is bored into the ground with a special auger. The stake is saturated with water and then pushed into the hole so that close contact is made between the stake and the soil.

Most of the commercial instruments give good indications of moisture content if they are used according to the manufacturer's instructions. For good results, however, the blocks need to be calibrated in the field for each job. Experience and careful interpretation of instrument readings are needed to get a good estimate of soil-moisture conditions.

Tensiometers

Tensiometers (Figure 9.2) work on the principle that a partial vacuum is created in a closed chamber when water moved out through a porous ceramic tip to the surrounding soil. Tension is measured by a water manometer, a mercury manometer, or a vacuum gage. The scales are generally calibrated in either hundredths of an atmosphere or in centimeters of water. Tensiometers that utilize a mercury manometer are usually preferred as research tools because they afford great precision. Because of their simplicity, tensiometers equipped with Bourdon vacuum gages are better suited to practical use and to irrigation control.

After the cup is placed in the soil at the desired depth, the instrument must be filled with water. Water moves through the porous cup until the water in the cup and the water in the soil reach equilibrium. Any increase in tension that occurs as the soil dries causes the vacuum gage reading, which can be read above ground, to increase. Conversely, an increase in soil-water content reduces tension and lowers the gage reading. The tensiometer continues to record fluctuations in soil-water content unless the tension exceeds 0.85 atmosphere, at which point air enters the system and the instrument ceases to function. After an irrigation or rain, the instrument must again be filled with water before it can operate.

Some experience is required to use a tensiometer. If air enters the unit through any leaks at the rubber connections, measurements are not reliable. Air leaks can result from faulty cups. They may occur also at the contact points of the setscrews used to secure the porous cup to the metal support. Some manufacturers provide a test pump that can be used to test the gage and to remove air from the instrument.

Tensiometer readings reflect soil-moisture tension only; that is, they indicate the relative wetness of the soil surrounding the porous tip. They do not provide direct information on the amount of water held in the soil. Tension measurements are useful in deciding when to irrigate, but they do not indicate how much water should be applied. A special moisture-characteristic curve for the particular soil is needed to convert moisture-tension measurements into available-moisture percentages.

Tensiometers do not satisfactorily measure the entire range of available moisture in all soil types, but they are probably the best field instruments to use to determine moisture conditions in the wet range. They are best suited to use in sandy soils since in these soils a large part of the moisture available to plants is held at a tension of less than 1 atmosphere. Tensiometers are less well suited to use in fine-textured soils in which only a small part of the available moisture is held at a tension of less than 1 atmosphere.

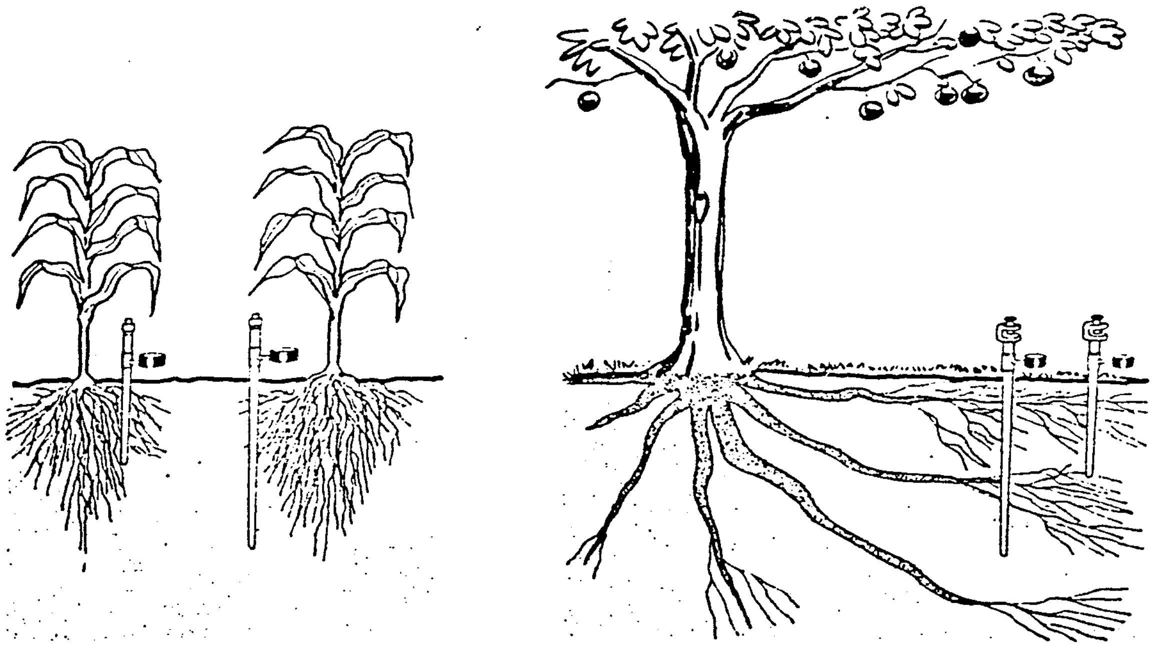

Figure 9.2 - Tensiometers used to measure soil moisture

Feel and Appearance Method of Determining How Much Water to Apply

The best way of determining how much water to apply is to measure the amount of moisture in the soil and the amount that the soil will hold at field capacity. However, this is time consuming and requires special equipment that is not commonly owned by irrigators.

A common method in use is the feel and appearance method where the amount of moisture present is estimated. When the field capacity of the soil is known, the amount of moisture needed is then easy to calculate.

Although gaging moisture conditions by feel and appearance is not the most accurate method, with experience and judgment the irrigator should be able to estimate the moisture level within 10 to 15 percent. The photographs and descriptions of moisture conditions can be used to aid in the determination of moisture present in the soil and amount needed to reach field capacity.

Example:

Assume a silt loam soil is to be irrigated. Samples are taken at the 6-inch, 18-inch and 36-inch depths. Select page showing medium texture soils and assume moisture conditions closely resemble the first photograph for the 6-inch depth, between the 2nd and 3rd for the 18-inch depth and between the 3rd and 4th for the 36-inch depth. Then percent available would be 25, 50 and 75 percent respectively.

From moisture deficiency table, the top foot would need 1.5 inches, the second foot would need 1.0 inch, and the third and fourth foot 0.5 inch per foot, or a total of 3.5 inches for the 4-foot zone.

Obtaining samples:

For row crops, measurements should be made in the row or near the plants. In sprinkler irrigation, the measuring stations should be between the sprinkler heads.

Measurements should be made in that part of the soil from which plant roots extract their moisture and according to the moisture-extraction pattern of the particular crop. One measurement should be made in the upper quarter of the root zone and one or two more measurements at lower levels. If the maximum moisture-extraction depth for a given crop is 48 inches, for example, measurements probably should be made at about 6, 18 and 36 inches. To predict when to irrigate during the early stages of root development, the 6-inch measurement is all that is needed for most crops. As the root system reaches maturity, measurements from all three depths are needed for a clear picture of the moisture level throughout the moisture extraction zone.

Guide for Judging How Much Moisture is Available for Crops

Available Soil Moisture Remaining	Feel or appearance of soil and moisture deficiency in inches per foot			
	Loamy Sand	Sandy Loam	Loam and Silt Loam	Clay Loam or Silty Clay Loam
0 to 25 percent	Dry, loose, single grained, flows through fingers.	Dry, loose, flows through fingers,	Powdery dry, sometimes slightly crusted but easily broken down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface.
Moisture deficiency	.90 to .70 in./ft.	1.3 to 1.0 in./ft.	2.0 to 1.5 in./ft.	2.2 to 1.65 in./ft.
25 to 50 percent	Appears to be dry, will not form a ball with pressure. 1/	Appears to be dry, will not form a ball. 1/	Somewhat crumbly but holds together from pressure.	Somewhat pliable, will ball under pressure. 1/
Moisture deficiency	.70 to .45 in./ft.	1.0 to .65 in./ft.	1.5 to 1.0 in./ft.	1.65 to 1.10 in./ft.
50 to 75 percent	Appears to be dry, will not form a ball with pressure.	Tends to ball under pressure but seldom holds together.	Forms a ball somewhat plastic, will sometimes slick slightly with pressure.	Forms a ball, ribbons out between thumb and forefinger.
Moisture deficiency	.45 to .20 in./ft.	.65 to .30 in./ft.	1.0 to 0.5 in./ft.	1.10 to .55 in./ft.
75 percent to field capacity (100 percent)	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball, is very pliable, slicks readily if relatively high in clay.	Easily ribbons out between fingers, has slick feeling.
Moisture deficiency	.20 to .00 in./ft.	.30 to .00 in./ft.	0.5 to .00 in./ft.	.55 to .00 in./ft.
At field capacity (100 percent)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.
Moisture deficiency	.00	.00	.00	.00

1/ Ball is formed by squeezing a handful of soil very firmly.

Figure 1

MEDIUM TEXTURE

Loams and Silt Loams

-- 0 to 25% Available Moisture --
Crumbles easily, tends to hold together from hand pressure.

-- 25 to 50% Available Moisture --
Somewhat crumbly, will hold together in hand with pressure.

-- 50 to 75% Available Moisture --
Forms "ball" readily, will "slick" slightly with pressure.

-- 75 to 100% Available Moisture --
Forms "ball" easily, fairly friable, "slicks" readily.

Photos Courtesy Okla. Ext. Service

Figure 1

MODERATELY FINE TEXTURE

Clay Loams and Silty Clay Loams

-- 0 to 25% Available Moisture --
Crumbles readily, will hold together but "balls" with difficulty and breaks easily.

-- 25 to 50% Available Moisture --
Does not crumble, forms readily, will "ball" with pressure.

-- 50 to 75% Available Moisture --
Forms "ball" readily, will "ribbon" out between thumb and forefinger. Somewhat slick feeling.

-- 75 to 100% Available Moisture --
Easily "ribbons" out. Has "slick" feeling.

Photos Courtesy Okla. Ext. Service

Figure 1

COARSE TEXTURE

Sandy Loams and Loamy Sands

-- 0 to 25% Available Moisture --
Dry, loose, flows through fingers.

-- 25 to 50% Available Moisture --
Looks dry, will not form ball with pressure.

-- 50 to 75% Available Moisture --
Will form loose ball under pressure, will not hold together even with easy handling.

-- 75 to 100% Available Moisture --
Forms weak ball, breaks easily, will not "slick".

Photos Courtesy Okla. Ext. Service

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