K-STATE
Kansas State University

IRRIGATION
MANAGEMENT
SERIES

Soil Water Measurements:

An Aid to Irrigation Water Management

Danny H. Rogers
Extension Irrigation Engineer

Mahbub Alam
Extension Irrigation Specialist

**Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service
Manhattan, Kansas**

Soil water status must be monitored for effective irrigation water management. The soil acts as a bank, storing water for use by the crop. Adequate soil water in the crop root zone provides for optimum plant growth. If the water in the soil is depleted below a given level, crop yields can be decreased.

Soil water measurement is useful in determining:

- How much water is available for crop use
- When to irrigate
- How much irrigation water to apply

Soil water measurement must be an integral part of any irrigation scheduling program. Soil water monitoring can help conserve water, conserve energy, and produce optimum crop yields.

SOIL WATER MEASUREMENT

There are several methods that can be used to measure soil water. Some are more useful to the irrigator than others. The irrigator will want a method that gives the soil water available for use by the crop. Most soil water measurement methods require calibration of some type to give available soil water.

GRAVIMETRIC SAMPLING

Samples are taken from the soil and weighed. After drying in an oven, the samples are weighed again and percent moisture, on a dry-weight basis, in the soil is calculated. The bulk density of the soil must be known to convert percent to water volume. The soil water volume at field capacity and permanent wilting point must be known to determine the percent of available water in the soil.

Gravimetric sampling is time-consuming and not very useful to most irrigators. Samples must be taken each time a measurement is needed. A day or more is required to dry the samples. The samples must be weighed accurately and must be taken from a different point in the field each time.

Gravimetric sampling is the only method that actually measures the presence of water in the soil. All other methods use some property of the soil to give a soil water measurement.

APPEARANCE AND FEEL TEST

Visual observation and feel of the soil is probably the most versatile method for irrigators to use to monitor soil water. A soil probe (Figure 1), auger, or spade is used to obtain a soil sample. Although not exact, comparing the appearance and feel of the soil with Table 1 and Figures 2, 3 and 4 can give an estimate of available soil water. Soil probing can be used as a check on other monitoring methods and is especially useful in monitoring the depth of penetration of irrigation applications and rainfalls. Sometimes other problems, like compacted soil layers, can be detected from the probing. Also, the irrigator is not tied to specific locations to monitor, but can check any location in the field as needed (although, as with gravimetric sampling, the exact same location cannot be resampled).

Soil samples for estimating water content should be taken from the active root zone. One sample should be taken from the upper quarter of the root zone and one or two more samples from lower levels. For example, with a 36-inch major root zone, sampling should probably be done at the 6- to 12-inch depth and the 24- to 30-inch depth.

Although measuring soil water by appearance and feel is not precise, with experience and judgment the irrigator should be able to estimate the level with a reasonable degree of accuracy.

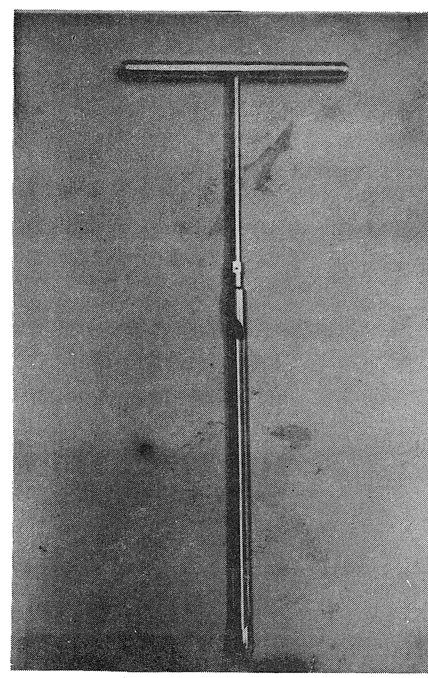


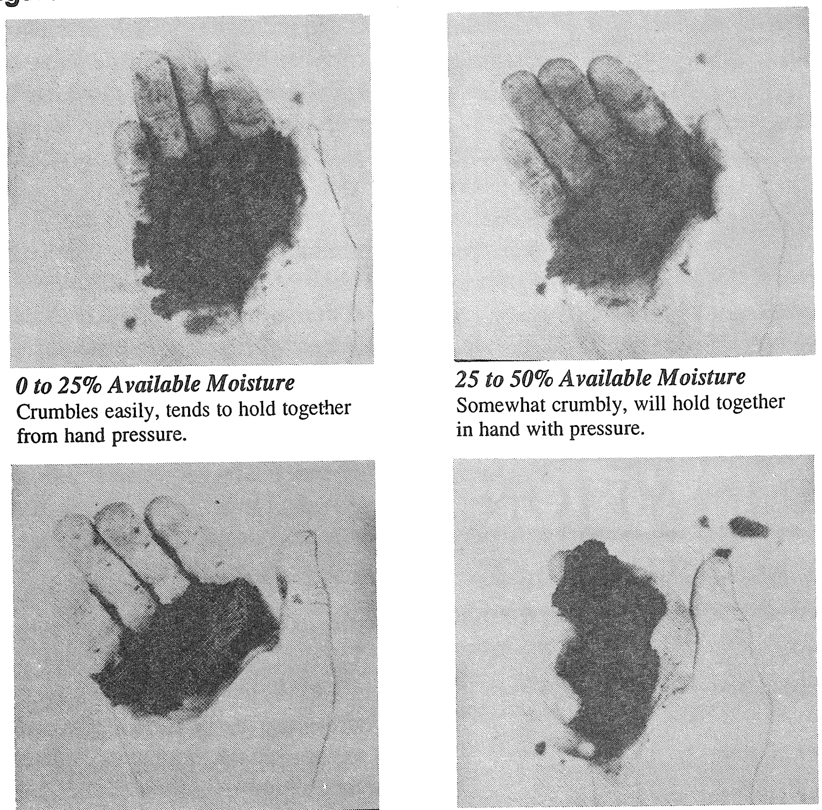
Figure 1: *Soil Probe*

TENSIOMETERS

A tensiometer is a sealed, water filled tube with a vacuum gauge on the upper end and a porous ceramic tip on the lower end (Figure 5). Tensiometers are installed in a hole made with a soil probe or auger. As the soil around the tensiometer dries out, water is drawn from the tube through the ceramic tip. This creates a vacuum in the tube that can be read on the vacuum gauge. When the soil water is increased, through rainfall or irrigation, water enters the tube through the porous tip, lowering the gauge reading. The tensiometer gives a measure of soil water tension, or the force with which the water is being held by the soil, which is related to soil water content.

Tensiometers are normally available in lengths from 6 to 48 inches. The tensiometers are placed at a location where the soil water will be monitored. A station usually consists of two tensiometers of different lengths. One station should be near the upper end of the field and the other near the lower end of the first set. The stations should be placed in an area that has a similar soil, slope and plant population and are

Figure 2: MEDUIM 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, "slick" readily.

Table 1: INTERPRETATION CHART FOR SOIL MOISTURE

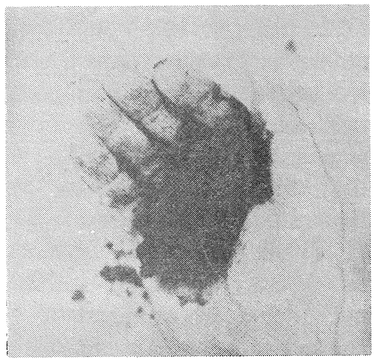
FEEL OR APPEARANCE OF SOILS

Soil Moisture Remaining	Very Light Texture	Light Texture	Medium Texture	Heavy and Very Heavy Texture
0 percent	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard baked, cracked, sometimes has loose crumbs on surface.
50 percent or less	Still appears to be dry; will not form a ball with pressure.*	Still appears to be dry; will not form a ball.	Somewhat crumbly, but will hold together from pressure.	Somewhat pliable, will ball under pressure.
50 to 75 percent	Same as very light texture with 50 percent or less moisture.	Tends to ball under pressure but seldom will hold together.	Forms a ball, "somewhat plastic; will sometimes slick slightly with pressure."	Forms ball; will ribbon out between thumb and forefinger.
75 percent to field capacity	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers; has a slick feeling.
At field capacity (100 percent)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as very light texture.	Same as very light texture.	Same as very light texture.
Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and freewater form on surface.

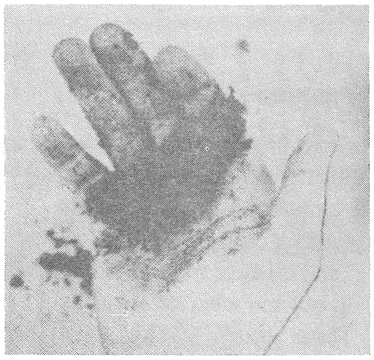
*Ball is formed by squeezing a handful of soil very firmly with fingers.

Figure 3: MODERATELY FINE TEXTURE–*Clay Loams and Silty Clay Loams*

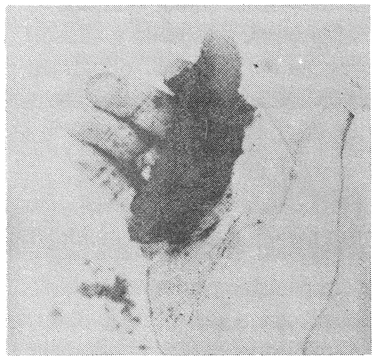
0 to 25% Available Moisture
Crumbles readily, will hold together but "balls" with difficulty and breaks easily.



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

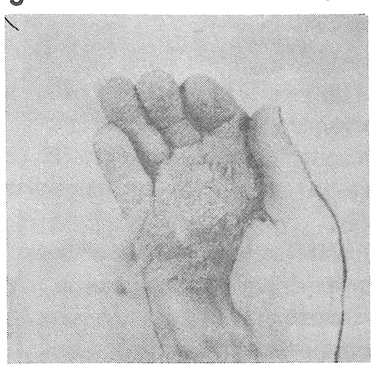


50 to 75% Available Moisture
Forms "ball" readily, will "ribbon" out between thumb and forefinger. Somewhat slick feeling.

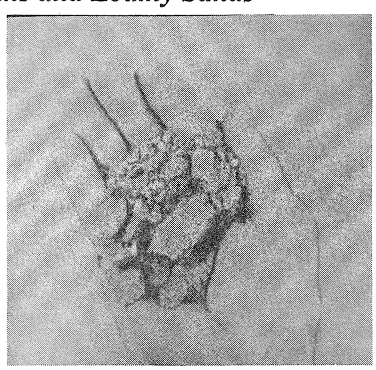


75 to 100% Available Moisture
Easily "ribbons" out. Has "slick" feeling.

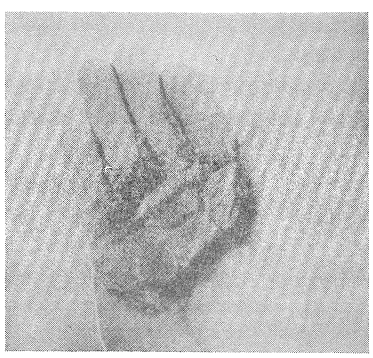
Figure 4: COARSE TEXTURE–*Sandy Loams and Loamy Sands*



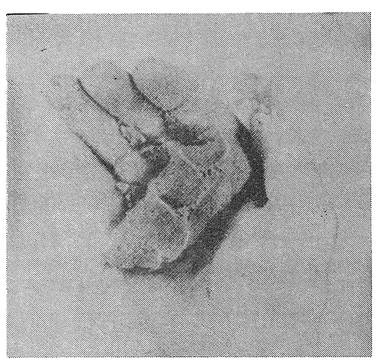
0 to 25% Available Moisture
Dry, loose, flows through fingers.



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."

Figure 5

representative of the entire field.

The tensiometers are placed in the row and angled downward toward the furrow. The depth of installation is determined by the active root zone of the crop. This active root zone depends on the crop, stage of growth and the soil. For example, for corn on a deep soil with an active root zone of 3 feet, the recommended depths would be 12 and 24 inches.

Tensiometers are best suited for sandy soils because of the range of water tension measured. The vacuum in the tensiometer will break if the soil becomes too dry. The tensiometers must be read every few days and serviced if the fluid level drops or the vacuum is broken.

ELECTRICAL RESISTANCE BLOCKS

Electrical resistance blocks or gypsum blocks are made with gypsum around a pair of stainless steel wires or wire grids (Figure 6). These grids are attached to lead wires that can be plugged into a portable resistance meter. When the blocks are placed in the soil, the water content of the gypsum block will be nearly equal to that of the soil. The flow of electricity between the wire grids varies with water content and a reading on the resistance meter will give a measure of soil water content. For best results, the blocks should be cali-brated for individual soil types to give

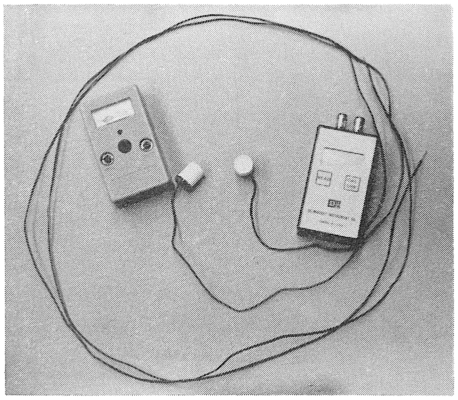


Figure 6

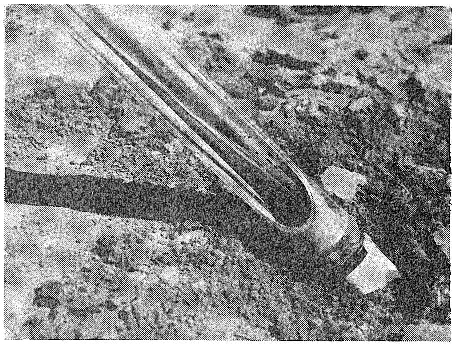


Figure 7

accurate soil water deficits.

The blocks are placed in the field similar to tensiometers. The blocks should be placed in the soil as early in the season as practical so the roots will develop around the block. The blocks are prepared for installation by subjecting them to wet-dry cycles. (Follow the manufacturer's recommendations.) A soil probe or auger is used to make a hole slightly larger in diameter than the block to the depth desired. The hole should be angled toward the furrow. The shallow blocks should be approximately under the edge of the furrow and the deep block under the furrow. Each block should be placed in a separate hole.

The last soil removed from the hole is used to make a slurry of mud in the bottom of the hole. This provides good contact between the block and the soil. The blocks are pushed into the hole with a soil probe (Figure 7). The hole should be filled with soil 3 to 4 inches at a time, tamping the soil firmly. The wire leads are brought to a single location and normally tied to a stake for easy location. The wires should be color coded or identified in some way so that the block depth is known. A differing number of knots, tied in the leads, is a good way to identify different installation depths.

Electrical resistance blocks are sensitive to a wide range of soil water conditions. Blocks are especially useful on medium and fine (clay) textured soils. The blocks are normally used for one growing season, and then are destroyed by seedbed preparation for the next crop. The meter can be used for several fields and from season to season. Blocks may not respond fast enough to soil water changes in sandy soils to be useful.

ELECTRICAL RESISTANCE PROBES

There are portable probes available that can be placed in the soil to give a water reading. Most of the probes make some type of electrical resistance measurement. One of the limitations of the probes is calibration of the probe measurements with the soil water content of a particular soil. These types of probes have not been widely used in Kansas.

NEUTRON PROBE

The neutron probe will probably not be used by individual irrigators. It is used extensively by researchers and may be used some by crop production consultants. The neutron probe is the most expensive and probably the most accurate of the soil water measuring devices available. The neutron probe uses a radioactive source that is lowered into a metal tube placed in the soil. Neutrons from the source are emitted at high velocity but are slowed by collision with hydrogen atoms on the soil. The slowed neutrons are counted by a sensor. Nearly all of the hydrogen atoms in the soil are a part of the water in the soil. Increasing the water content will increase the number of slow neutrons counted. The slow neutron count of the neutron probe is calibrated with soil water content.

The neutron probe has the advantages that the same point may be sampled as frequently as desired without disturbing the soil; the access tubes may be left in the soil for the entire season; and the measurement is a zone of substantial size which gives a better average soil water value. The procedure is time-consuming and requires special training in handling and using the equipment. The equipment is also relatively expensive.

RECORDS

A record of soil water measurements should be maintained. The soil water record, along with irrigation applications, rainfall, crop condition, stage of growth and other crop production data can help explain what takes place in a field. These records can be extremely useful in future planning and management and also help to build experience and confidence in the methods and procedures used.

SUMMARY

Soil water monitoring is necessary for effective irrigation water management. Soil water measurement can help determine (1) how much water is available in the soil for crop growth, (2) when to irrigate and (3) how much water to apply.

All soil water monitoring methods require experience and judgement. The most common method used by Kansas irrigators is the appearance and feel method, using samples collected with a soil probe. Gypsum resistance blocks and tensiometers could be useful methods as well.

Soil water records should be maintained and compared with other production data.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

L-795 October 1989

File code: Engineering 4-3 (Irrigation) 10-89–3M; 3-91–3M; 4-98–2M