Unit D: Agricultural Equipment Systems

Lesson 4: Operating, Calibrating, and Maintaining Irrigation Systems

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Describe the irrigation method used in agriculture.
2. Explain the operating principles of irrigation systems used in agriculture.
3. Describe the calibration of irrigation systems used in agriculture.
4. Explain the maintenance of irrigation systems used in agriculture.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

Plaster, Edward J. *Soil Science and Management*. Albany, New York: Delmar Publishers, Inc., 1992.

Schwab, Glenn O., et al. *Soil and Water Conservation Engineering*. New York: John Wiley & Sons, Inc., 1993.

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Available water
- Border strip irrigation
- Center-pivot irrigation
- Chemigation
- Efficiency
- Evapotranspiration
- Field capacity
- Permanent wilting point
- Sprinkler irrigation
- Subsurface irrigation
- Surface irrigation
- Trickle or drip irrigation
- Water-application efficiency
- Water-conveyance efficiency
- Water-use efficiency
- Wheel-move irrigation

Interest Approach:

Lead a discussion with students concerning average annual rainfall and the amount required by different crops to produce an average crop. Explain that irrigation is used in agriculture to supplement annual rainfall. Use the discussion to move into the first objective.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Describe the irrigation methods used in agriculture.
Anticipated Problem: What are the irrigation methods used in agriculture?

(PowerPoint Slide 3)

I. Irrigation has a long history in world agriculture. Irrigation water can be applied through several methods.

(PowerPoint Slide 4)

A. ***Subsurface irrigation*** is watering from below using capillary rise from a zone of saturating soil lower in the soil profile.
   1. The zone must be high enough that water can rise into the root zone, but not so high that it saturates the root zone.
   2. Water may be introduced into the soil profile through open ditches, mole drains, or pipe drains.

B. ***Surface irrigation*** of fields involves flooding the soil surface with water released from canals or piping systems.
   1. Surface irrigation is most suitable for level or slightly sloping land of moderate permeability. When preparing land, fields are carefully leveled to the slight slope needed for water to flood the land.
   2. A system of canals uses gravity to carry water to the farm and among the fields.

(PowerPoint Slide 5)

C. ***Border strip irrigation*** involves covering the entire soil surface of a field with a sheet of water.
   1. Each field is divided into smaller parts by the use of low dikes. Each of these sections is flooded in turn from a ditch or pipe running along the head of the field.
   2. Because of the large surface area of the water flooding the ground, evaporation causes some waste of water.

D. Furrow irrigation distributes water through furrows, with crops planted in the ridge between two furrows.
   1. Furrows are best suited for row crops.
   2. Evaporation is less of a problem than in border strips because less surface area is exposed to the air.

(PowerPoint Slide 6)

E. ***Sprinkler irrigation*** systems pump water under pressure through pipes to sprinklers that spray water out in a circular pattern.
   1. Sprinklers can be used where the soil is too permeable or too impermeable or the ground is not level.

2. Sprinkler irrigation equipment can be used for other purposes in addition to watering crops.
    a. ***Chemigation*** is applying chemicals like fertilizers or herbicides. It is used as substitute for rainfall for the activation of herbicides or for frost control.
    b. Hand-move irrigation is the least expensive sprinkler system to install. This system is very labor intensive and consists of a lightweight aluminum pipe that can be moved from place to place by a single person.

F. Solid-set irrigation uses the same equipment as hand-move set-ups, except that an entire field is set up at planting. The large number of pipes needed to supply all fields increases the cost of the additional initial equipment purchase, but almost eliminates additional labor during the growing season since the pipes remain in place until harvest.

G. Traveling-gun irrigation uses one very large sprinkler mounted on a trailer that moves across a field.
1. The sprinkler sends out a single large stream of water and can also be used to spray liquid manure and other slurries.
2. The gun is very liable to wind problems.

(PowerPoint Slide 7)

H. ***Center-pivot irrigation*** has a central pivot point with the watering line elevated above the crop.
1. As the system operates, the line slowly turns around the pivot point.
2. Center pivot has the lowest labor requirement of any irrigation method.

I. ***Wheel-move irrigation*** consists of a line of sprinklers mounted on the wheels at both ends.
1. The line of sprinklers slowly rolls down the field until it reaches the end of its hose.
2. The pattern of moisture that is distributed is rectangular and irrigates all parts of the field.

J. ***Trickle or drip irrigation*** involves the use of plastic pipes on the ground running down a crop row with special emitters spaced along the pipe.
1. The emitters drip water, at controlled rates, onto the soil surface near the plants.
2. The system operates at low water volume and pressure. Problems occur with plugging of the emitters and variation in flow rates between emitters.

Use TM: 4-1 (PowerPoint Slide 8) to illustrate a border strip irrigation system. Compare and contrast the different irrigation systems.

Objective 2: Explain the operating principles of irrigation systems used in agriculture.
Anticipated Problem: What are the operating principles of irrigation systems used in agriculture?

(PowerPoint Slide 9)

II. Operating principles vary with the method used, but the basic objectives are the same.

(PowerPoint Slide 10)

A. Human dependence on irrigation can be traced to about 5,000 years ago and the practices of the ancient Egyptians.
   1. Current concepts of irrigation have been made possible only by the application of modern power sources to deep-well pumps and by the storage of large quantities of water in reservoirs.
   2. Increasing demands for water, limited availability, and concerns about water make the effective use of water essential.
   3. Irrigation is a major water user. Therefore, it is very important that systems be planned, designed, and operated efficiently.
   4. Water requirements and time of maximum demand vary with different crops. Growing crops are continuously using water. The rate of evapotranspiration depends on the kind of crop, the degree of maturity, and the atmospheric considerations such as radiation, temperature, wind, and humidity.
   5. Where sufficient water is available, the soil water content should be maintained for optimum growth.

(PowerPoint Slide 11)

B. ***Evapotranspiration*** is the amount of moisture lost due to evaporation and transpiration. It is the largest consumer of the moisture that falls to the ground.
   1. To make maximum use of available water supplies, the irrigator must have knowledge of the total seasonal water requirements of crops and how water use varies during the growing season.
   2. Rainfall must be considered when determining the crop moisture needs that must be supplied by irrigation. Not all rainfall is effective, but only the portion that contributes to evapotranspiration.

C. In planning and managing irrigation, the soil's capacity to store available water is important. This capacity is referred to as the soil water reservoir.
   1. The reservoir is filled periodically by irrigations, then slowly depleted by evapotranspiration.
      a. Water application in excess of the reservoir capacity is wasted unless used for leaching.
      b. Irrigation must be scheduled to prevent the soil water reservoir from becoming so low as to inhibit plant growth.
      c. For irrigation design and management, the water-holding capacity of the soil reservoir must be known.

(PowerPoint Slide 12)

1. ***Field capacity*** is the water content after a soil is wetted and allowed to drain 1 to 2 days. It represents the upper limit of water available to plants.
2. ***Permanent wilting point*** represents the lower limit of water available to plants.
3. The difference between field capacity and permanent wilting point is known as ***available water***.

D. Irrigators generally follow one of three basic scheduling methods, each of which has many variations.

(PowerPoint Slide 13)

1. Measure soil water and plant stress by taking soil samples at various depths with a soil probe, auger, or shovel and then measure or estimate the amount of water available to the plant roots.
2. Insert instruments such as tensiometers or electrical resistance blocks into the soil to desired depths and then take readings at intervals.
3. Measuring or observing some plant characteristics and then relating them to water stress.

Use TM: 4-2 (PowerPoint Slide 14) to illustrate moisture content in different soil types. Discuss the soil type differences in the areas in crop production near-by.

Objective 3: Describe the calibration of irrigation systems used in agriculture.
Anticipated Problem: How are irrigation systems calibrated?

(PowerPoint Slide 15)

III. Irrigation will provide maximum benefit only when it is integrated into a high-level management program. Irrigation system designers must consider the operation and management requirements for their designs. These considerations include:

A. The performance or efficiency of the system. Water delivery requirements and irrigation scheduling must be understood.

(PowerPoint Slide 16)

B. ***Efficiency*** is an output divided by an input and is usually expressed as a percentage. There are three basic efficiency concepts.

1. ***Water-conveyance efficiency***, where the output is the water delivered by a distribution system and the input is the water introduced into the **distribution systems**
2. ***Water-application efficiency***, where the output is the water stored in the soil root zone by irrigation and the input is the water delivered to the area being irrigated.
3. ***Water-use efficiency***, where the output is the water beneficially used and the input is the water delivered to the area being irrigated.

(PowerPoint Slide 17)

C. Other considerations include:

1. The uniformity of distribution.

2. Use the most water-efficient system that is practical. Where feasible, trickle irrigation uses the least amount of water.
3. In surface systems, land should be leveled carefully and designed to reuse excess tail water.
4. Use the amount of irrigation water that gives the best return. Using less than the ideal amount may cause some yield loss, but it results in a savings in water.
5. Base the scheduling of irrigation on the actual crop needs, and not on a time schedule.

Use TM: 4-3 (PowerPoint Slide 18) to summarize the concepts of efficiency in irrigation. Discuss the different efficiencies and how to achieve these efficiencies.

Objective 4: Explain the maintenance of irrigation systems used in agriculture.
Anticipated Problem: How are irrigation systems maintained?

(PowerPoint Slides 19 and 20)

IV. Follow the manufacturer's recommendations found in the operator's manual when performing service or maintenance on the systems. Other general maintenance procedures are as follows:
   A. Saving water is an increasingly important consideration. For systems using a pump, saving water also means saving energy.
   B. Avoiding water pollution from unused irrigation water flowing into streams or seeping underground is another consideration.
   C. Make sure all systems are designed correctly to fit the crops, soil, and terrain. The application rate should be no greater than the infiltration rate of the soil.
   D. Maintain all systems for efficiency.
      1. Sand in irrigation water wears away at sprinkler nozzles, increasing the nozzle size and application rate.
      2. Mineral deposits can slow the flow water, reducing the flow and application rate.
   E. Water should be transported through sealed ditches to avoid seepage or through pipes, which also stop evaporation.
   F. All systems should contain devices to measure and control the water flow.

Discuss with the students the advantages of maintenance of irrigation systems. Relate this to the maintenance of other agricultural equipment you have already discussed.

Review/Summary: Use the student learning objectives to summarize the lesson. **(PowerPoint Slide 21)** Have students explain the content associated with each objective. Student response can be used in determining which objectives need to be reviewed or taught from a different angle.

Evaluation: Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the written test.

Answers to Sample Test:

Matching

1. E
2. A
3. B
4. C
5. F
6. D

Fill-in-the-blank

1. Surface
2. Water-use
3. Field capacity
4. Permanent wilting point
5. Available water
6. Infiltration

Short Answer

Measure soil, water, and plant stress by taking soil samples at various depths with a soil probe, auger, or shovel and then measure or estimate the amount of water available to the plant roots; insert instruments such as tensiometers or electrical resistance blocks into the soil to desired depths and then taking readings at intervals; and measuring or observing some plant characteristics and then relating them to water stress.

Sample Test

Operating, Calibrating, and Maintaining Irrigation Systems

Name: ____________________

Matching: *Match each word with the correct definition.*

a. center-pivot irrigation
b. sprinkler irrigation
c. subsurface irrigation
d. trickle or drip irrigation
e. water-application efficiency
f. water-conveyance efficiency

_____ 1. Output is the water stored in the soil root zone by irrigation and the input is the water delivered to the area being irrigated.

_____ 2. Central pivot point with the watering line elevated above the crop.

_____ 3. System pumps water under pressure through pipes to sprinklers that spray water out in a circular pattern.

_____ 4. Watering from below using capillary rise from a zone of saturating soil lower in the soil profile.

_____ 5. Output is the water delivered by a distribution system and the input is the water introduced into the distribution system.

_____ 6. Involves the use of plastic pipes running down a crop row on the ground with special emitters spaced along the pipe.

Fill-in-the-blank*: Complete the following statements*.

1. ____________ irrigation of fields involves flooding the soil surface with water released from canals or piping systems.
2. ____________ efficiency, where the output is the water beneficially used and the input is the water delivered to the area being irrigated.
3. __________ __________ is the water content after a soil is wetted and allowed to drain 1 to 2 days and represents the upper limit of water available to plants.
4. __________ __________ __________ represents the lower limit of water available to plants.
5. ____________ is the amount of moisture lost due to evaporation and transpiration and is the largest consumer of the moisture that falls to the ground.

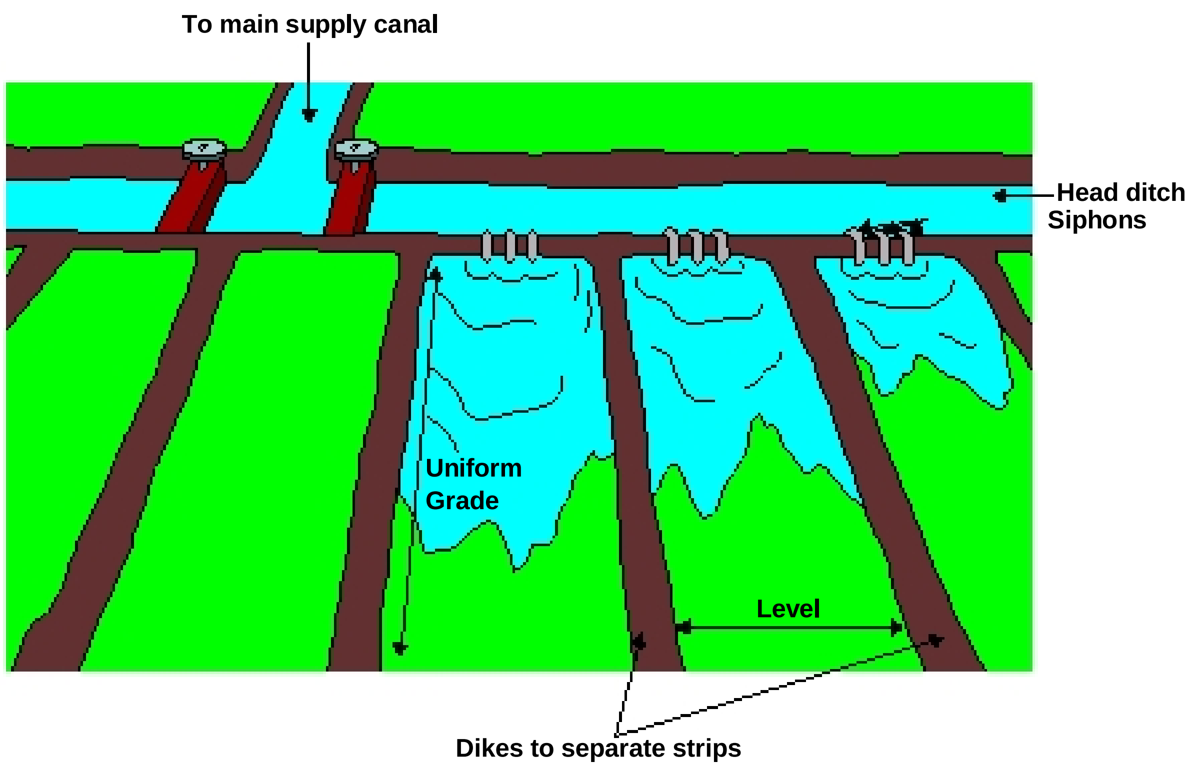
6. The difference between field capacity and permanent wilting point is known as _________ __________.
7. The application rate should be no greater than the ____________ rate of the soil.

***Short Answer**: Answer the following question*.

Irrigators generally follow one of three basic scheduling methods. What are two of those three methods?

TM: 4-1

BORDER STRIP IRRIGATION



TM: 4-2

BEHAVIOR OF SOIL AT SELECTED SOIL-WATER DEPLETION AMOUNTS

	Soil Type	
Available Water Remaining in the Soil	**Sands**	**Loamy sand/sandy loam**
Soil saturated, wetter than field capacity	Free water appears when soil ball is squeezed	Free water appears when soil ball is squeezed
100% available (field capacity)	When soil ball is squeezed, wet outline on hand but no free water	When soil ball is squeezed, wet outline on hand, but no free water
75 to 100%	Sticks together slightly	Forms a ball that breaks easily
50 to 75%	Appears dry; will not form a ball	Appears dry; will not form a ball
Less than 50%	Flows freely as single grains	Flows freely as grains with some small aggregates

TM: 4-3

EFFICIENCY IN IRRIGATION

Efficiency—output divided by input.
Usually expressed as a percentage.

Three types of efficiency:

1. Water-conveyance efficiency
   - Output is water delivered by distribution system
   - Input is water introduced into the system
2. Water-application efficiency
   - Output is the water stored in the soil root zone
   - Input is the water being delivered to the area being irrigated
3. Water-use efficiency
   - Output is water beneficially used
   - Input is the water being delivered to the area being irrigated