Lesson A7–4

Operating, Calibrating, and Maintaining Irrigation Systems

Unit A. Mechanical Systems and Technology

Problem Area 7. Agricultural Equipment Systems

Lesson 4. Operating, Calibrating, and Maintaining Irrigation Systems

New Mexico Content Standard:

Pathway Strand: Power, Structural and Technical Systems

Standard: **III:** Apply principles of service and repair to mechanical equipment, structures, biological systems, land treatment, power utilization, and technology.

Benchmark: **III-C:** Evaluate performance and check maintenance manuals to service and repair hydraulic systems.

Performance Standard: **1.** Describe features, benefits, and applications of types of hydraulic systems. **2.** Describe physical principles of operation. **5.** Inspect, analyze, and repair hydraulic components (e.g., pumps, valves). **6.** Inspect, analyze, and repair fluid conveyance components (e.g., hoses, lines).

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Describe the irrigation methods 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.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the 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
Overhead projector
Transparencies from attached masters

Terms. The following terms are presented in this lesson (shown in bold italics):

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. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

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?

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

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.

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.

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.

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: A7–4A as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency master to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 6 in Soil Science and Management and Chapter 18 in Soil and Water Conservation Engineering are recommended.

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?

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

A. Human dependence on irrigation can be traced to earliest biblical references.
   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.

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 a 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.
         i. ***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.
         ii. ***Permanent wilting point*** represents the lower limit of water available to plants.
         iii. 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.
   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: A7–4B as visual material to illustrate moisture content in different soil types. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 6 in Soil Science and Management and Chapter 18 in Soil and Water Conservation Engineering are recommended.

Objective 3: Describe the calibration of irrigation systems used in agriculture.

Anticipated Problem: How are irrigation systems calibrated?

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.

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

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.

Display TM: A7–4C to summarize the concepts of efficiency in irrigation. Use text material to strengthen student understanding of concepts. Chapter 6 in Soil Science and Management and Chapter 18 in Soil and Water Conservation Engineering are recommended.

Objective 4: Explain the maintenance of irrigation systems used in agriculture.

Anticipated Problem: How are irrigation systems maintained?

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.

Use text material to strengthen student understanding of concepts. Chapter 6 in Soil Science and Management and Chapter 18 in Soil and Water Conservation Engineering are recommended.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses 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 application activity. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1 = e, 2 = a, 3 = b, 4 = c, 5 = f, 6 = d

Part Two: Completion

1. Surface
2. Water-use

3. Field capacity
4. Permanent wilting point
5. Evapotranspiration
6. available water
7. infiltration

Part Three: 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 Name_____

Test

Lesson A7–4: Operating, Calibrating, and Maintaining Irrigation Systems

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the 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.

Part Two: Completion

Instructions. Provide the word or words to 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 know as _____ _____.
7. The application rate should be no greater than the _____ rate of the soil.

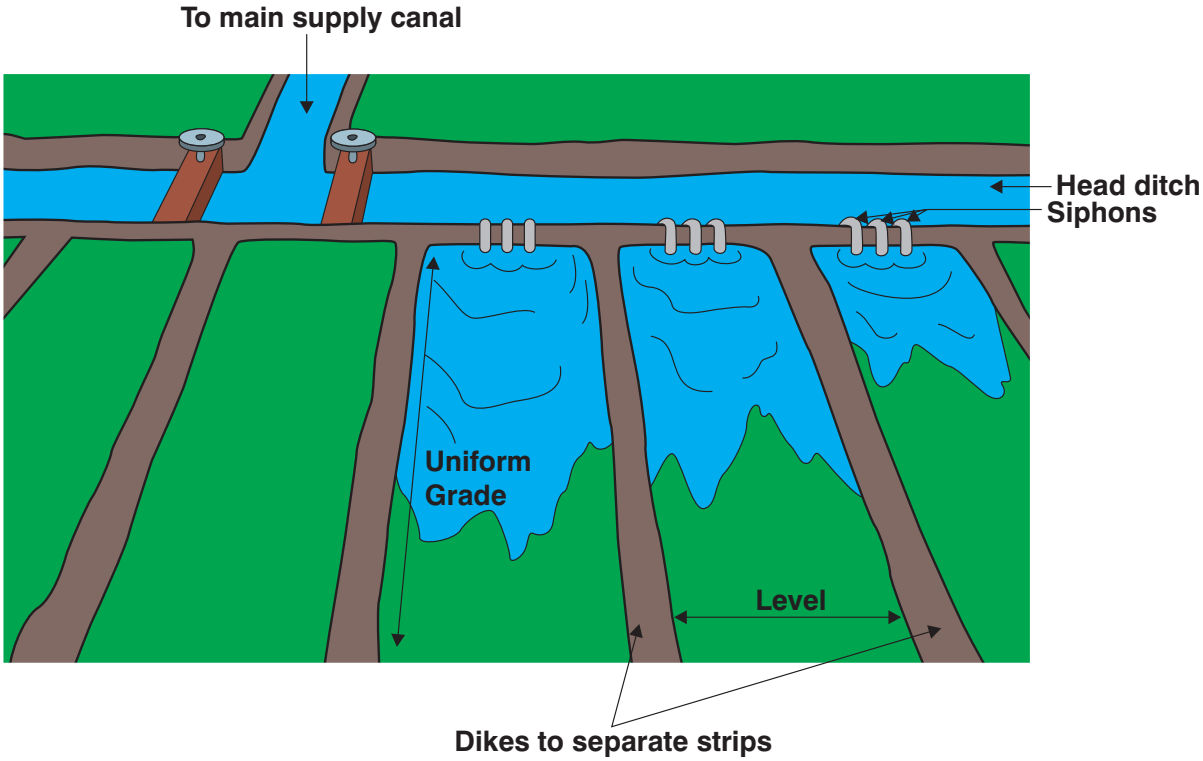
Part Three: Short Answer

Instructions. Provide information to answer the following question. Use complete sentences.

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

TM: A7–4A

BORDER STRIP IRRIGATION



(Courtesy, Interstate Publishers, Inc.)

TM: A7–4B

BEHAVIOR OF SOIL AT SELECTED SOIL-WATER DEPLETION AMOUNTS

Available Water Remaining in the Soil	Soil Type	
	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: A7–4C

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