Course	Agricultural Science II
Unit	Soil Science
Lesson	Effects of Soil on Water Movement and Retention
Estimated Time	Two 50-minute blocks

Student Outcome

Evaluate the effects of soil on water.

Learning Objectives

1. Explain the importance of available water to plant growth.
2. Identify the different types of soil waters.
3. Define available water capacity.
4. Explain the effect soil texture has on available water capacity.
5. Explain the effect that effective rooting depth has on available water capacity.
6. Explain the effect rock fragment content has on available water capacity.
7. Identify other factors which affect available water capacity.
8. Explain how available water capacity is determined.
9. Define permeability and identify the soil properties which affect permeability.
10. Identify the factors which affect the internal drainage of soil.
11. Explain how seasonal high water tables are determined.

Grade Level Expectations

SC/FM/2/B/09-11/a	SC/ES/1/B/09-11/a	SC/ES/2/A/09-11/a
SC/ES/2 /A/09-11/b	SC/ES/3/A/09-11/c	

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Water Removal by Plants
   - ☐ PPt 2 – Kinds of Soil Water
2. Activity Sheet
   - 🖹 AS 1 – Water Retention in Different Soils
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Three tomato plants
- ❑ Soil samples with different textures from earlier lessons
- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Retention of Water: Basics of Soil-Water Relationships – Part II. Institute of Food and Agricultural Sciences, University of Florida. Accessed May 20, 2008, from http://edis.ifas.ufl.edu/ss109.
   - ❑ Soil Plant Water Relationships. Institute of Food and Agricultural Sciences, University of Florida. Accessed May 20, 2008, from http://edis.ifas.ufl.edu/AE021.
   - ❑ Soil Quality Resource Concerns: Available Water Capacity. USDA Natural Resources Conservation Service. Accessed May 20, 2008, from http://soils.usda.gov/sqi/publications/files/avwater.pdf.
   - ❑ Soils, Water, and Plant Growth. Tree Fruit Soil and Nutrition, Tree Fruit Research and Extension Center, Washington State University. Accessed May 20, 2008, from http://soils.tfrec.wsu.edu/mg/water.htm.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Select three tomato plants of the same size but grown in different soil textures. Water all the plants the same amount to start the observation. See how long it takes each plant to wilt. After wilt is observed, water the plants and see how quickly they respond to the water. Have students observe how the soil texture affects the water retention of the soil.

Communicate the Learning Objectives

1. Explain the importance of available water to plant growth.
2. Identify the different types of soil waters.
3. Define available water capacity.
4. Explain the effect soil texture has on available water capacity.
5. Explain the effect that effective rooting depth has on available water capacity.
6. Explain the effect rock fragment content has on available water capacity.
7. Identify other factors which affect available water capacity.
8. Explain how available water capacity is determined.
9. Define permeability and identify the soil properties which affect permeability.
10. Identify the factors which affect the internal drainage of soil.
11. Explain how seasonal high water tables are determined.

Instructor Directions	Content Outline
Objective 1 *Discuss the importance of water retention and movement. Use PPt 1 to illustrate water use by plants.* ☐ PPt 1 – Water Removal by Plants	**Explain the importance of available water to plant growth.** 1. All plants need water to survive. Too much or too little can be harmful. 2. Actively growing plants are 90% water. 3. Plants need water to take up nutrients and release moisture through transpiration. 4. Plants use 300-500 lbs of water for every pound of dry weight. 5. Soils with high available water have a greater productivity potential than soils with low available water.
Objective 2 *Discuss what happens in the soil after a heavy rain. Refer to PPt 2.* ☐ PPt 2 – Kinds of Soil Water	**Identify the different types of soil waters.** 1. Gravitational water a. Fills large pores when soil is saturated b. Drains away quickly c. Plants cannot use 2. Capillary water a. This is held in smaller soil pores (capillaries) – Gravity – Cohesion b. Most is available to plants

Instructor Directions	Content Outline
	3. Hygroscopic water a. This is held tightly in tiny soil pores. – Adhesion – Roots cannot remove it b. Clayey soils contain large amounts c. Plants cannot use this unavailable water.
Objective 3 *Discuss field capacity of the soil. Also discuss the difference between available water capacity (AWC) and the wilting point. Refer to PPt 2.* ☐ PPt 2 – Kinds of Soil Water	**Define available water capacity.** 1. The potential of a soil to hold water in a form available to plants; the amount of water held between field capacity and the wilting point. 2. Reservoir of water within the soil which plants can use.
Objective 4 *Use the soil samples with different soil textures from earlier lessons. Have the samples moist and let the students handle the samples. Ask the students to describe the water-holding capacity. Discuss Figure 10.3 in the student reference. Have students complete AS 1.* AS 1 – Water Retention in Different Soils	**Explain the effect soil texture has on available water capacity.** 1. Soil texture has the greatest effect of the soil properties that influence AWC. 2. Water is held on the surfaces of soil particles. 3. Surface areas per volume of soil are dependent on the soil particle size. a. Clay has a large surface area per volume. b. Sand has a small surface area per volume. c. Silt has a medium surface area per volume. 4. Texture of different soil layers influences the downward movement of water. a. Clay can delay downward movement if it is close to the surface. b. Clay in a lower layer can pull water from layers above.
Objective 5 *Discuss the limiting factors in the soil that affect the rooting depth of plants. Have students give ideas on the effects of rooting depth on AWC.*	**Explain the effect that effective rooting depth has on available water capacity.** 1. Density of soil layers that limit rooting depth also limits AWC. a. Fragipans b. Gravelly or cobbly layers c. Bedrock 2. Soils allowing deep rooting are potentially very productive. a. Greater volume of soil for water and nutrients

Instructor Directions	Content Outline
	b. Good drainage and good aeration favor root penetration 3. Soils with restricting rooting depths are more susceptible to drought and have lower available water capacity.
Objective 6 *Discuss the soil in your area. Ask the students to estimate the water storage capacity of soils containing rock fragments.*	**Explain the effect rock fragment content has on available water capacity.** 1. Horizons containing rock fragments contain less AWC. 2. Rock fragments cannot store water.
Objective 7 *Discuss the influence of soil structure and organic matter content on AWC. Ask the students what other factors might affect the available water capacity.*	**Identify other factors which affect available water capacity.** 1. Structure and organic matter a. Influence the size of aggregates b. Affect the amount of pore spaces between particles 2. Structure and density a. Dense layers with poor structure inhibit rooting depth b. Fragipans 3. Abrupt changes in soil texture from one horizon to another
Objective 8 *Discuss what soil properties provide clues for determining available water capacity. Ask students how they would calculate the AWC of a particular soil. Refer to Figure 10.6 of the student reference.*	**Explain how available water capacity is determined.** 1. Multiply AWC rate by horizon thickness by percent fine earth. a. Determine AWC rate for a particular soil texture. b. Measure the thickness of the horizon. c. To find the percentage of fine earth, subtract the percentage of rock fragment from 100%. 2. Repeat calculation for each horizon within the effective rooting depth. 3. Add together the AWCs for all horizons within the effective rooting depth.
Objective 9 *Discuss texture of the soil as it relates to permeability. Discuss Table 10.3 and Table 10.4 of the student reference.*	**Define permeability and identify the soil properties which affect permeability.** 1. Permeability is affected by the rate at which water moves through a saturated soil. Least permeability layer is used.

Instructor Directions	Content Outline
	2. Porosity, size of pores, and interconnection of pores influence permeability. a. Texture b. Structure c. Density d. Organic matter content e. Mineralogy
Objective 10 *Refer to Figure 10.7 of the student reference to discuss classes of internal drainage. Discuss what factors might indicate or affect the internal drainage of soil.*	**Identify the factors which affect the internal drainage of soil.** 1. Height of the water table 2. Length of time that soil remains saturated
Objective 11 *Explain that a seasonal high water table is the highest average depth of a saturated zone during the wettest season. Analyze the water resources in your area. When do you expect seasonal high water in your area?*	**Explain how seasonal high water tables are determined.** 1. By evidence of reduction a. Grayed colors b. Gray mottles 2. By using boreholes to measure depth and duration of water table a. Apparent water table stands in a freshly dug borehole b. Perched water table levels fall when bore is extended
Application AS 1 – Water Retention in Different Soils	Answers to AS 1: 1. The crumbly soil will have more air spaces between the particles. Soils high in humus have high water-holding capacity and act like a sponge. 2. Lack of organic matter 3. Organic matter increases water-holding capacity of the soil and helps prevent soil erosion. Other activities: 1. Grow several pepper plants in pots until each has several leaves. The divide the plants into three groups, watering each differently. Water one group so often that the soil stays wet. Water a second group when the soil surface dries. Water the third group only when the plants wilt. Have the students observe

Instructor Directions	Content Outline
	the difference in plant growth and discuss the importance of water. Have the students explain field capacity and available water. 2. Have ready for class soil samples of texture ranging from sandy to clay. Take three one-gallon cans and cut out both ends and set them on the ground. Fill each can with a different soil sample. Pour a half-gallon of water through each sample and discuss the results.
Closure/Summary	Plants need water to survive, although the amount of water needed varies widely. There are three kinds of soil water: gravitational water, available water, and unavailable water. Available water capacity (AWC), the capacity of soil to hold water in a form available to plants, is largely determined by soil texture. Soil permeability, internal soil drainage, and effective rooting depth (based largely on soil texture and structure) all work together to influence the available water capacity of a particular soil.
Evaluation: Quiz	Answers: 1. b 2. d 3. g 4. i 5. h 6. j 7. c 8. f 9. e 10. a