Soil Moisture and Soil Temperature

Brief Description:

The lesson entails having students measure, record, chart, and evaluate the soil moisture and temperature of school gardens.

Objectives:

Students will:

1. Measure and evaluate which parts of the garden soil or planter soil are retaining moisture and heat during the day.
2. Evaluate which plants would be most appropriate for planting based on the soil moisture and temperature level.
3. Research and engineer the ideal soil for the school garden.

Materials:

- Soil temperature and soil moisture meters
- Atmospheric thermometers
- Clip boards
- Graphing paper
- Pencils
- Tissues for cleaning the meters
- Calculators are optional

Preparation:

1. If a soil health and properties lesson has not been taught it is suggested to do that before this lesson. Suggested lessons are *Gardening for Grades* 'It all Begins with Soil' and Nutrients for Life Foundation's Properties of Soil and/or Plant-Soil Interaction.
2. Obtain soil temperature and soil moisture meters from your county UF/IFAS office, local gardening club, garden store, or order on-line or through catalogues. One soil temperature and soil moisture meter per four students facilitates an orderly lab in which each student has multiple chances to use each kit.
3. It is recommended that students have clip boards while recording temperature and moisture, and calculators are optional for tabulating the total, mean and range.
4. This lab can be performed on any soil-based plant, whether growing in raised garden beds, raised herb beds, or in planters. It is suggested to have students measure soil temperature in two different growing mediums or containers. If you only have a garden in the ground, a container, gutter or hydroponics garden is recommended to get a good comparison.
5. Suggest breaking the garden into sections and numbering them (see Soil Moisture Table on page 45) to be able to more easily assign groups to an area. There are five Garden columns on the table. This is for those schools that have large gardens or multiple gardens and would like to take samples from all garden areas.

Time:

Each lab, the soil temperature and soil moisture, will take approximately two to four classes to complete, depending on the length of each class.

Vocabulary:

mean, mode, range, moisture, insulation, infer, predict, optimum, evaluate, variable, independent variable, dependent variable, x-axis, y-axis, atmospheric temperature, photosynthesis, germinate, saturated, inundated, retain, absorb, organic matter, compost, silt, clay and sand

Background:

Soil Moisture: All life is dependent, in some form, on water. For plants, it is water (H_2O) that enables plants to create their own food through a process known as **photosynthesis**. Water is separated along with carbon dioxide and converted into glucose (sugar), and excess is oxygen is released into the air and is represented by the chemical equation:

$$6(H_2O) + 6(CO_2) \rightarrow C_6H_{12}O_6 + 6(O_2)$$

Most of the plants grown in gardens require between one to two inches of water a week. One to two inches of rain and/or water from irrigation keeps the soil moist but not **saturated** or **inundated** with water. Dry soil will not allow plants to grow to their full potential nor produce delicious, healthy fruits, roots, stems and leaves. Roots growing in waterlogged soil may die because they cannot absorb the oxygen needed to function normally. The longer the air is cut off, the greater the root

Florida Standards:

SC.6.N.1.5, SC.6.N.1.3, SC.7.N.1.5, SC.7.L.17.2, SC.7.L.17.3, SC.8.N.1.5, LAFS.6.SL.1.2, LAFS.6.SL.1.3, LAFS.6.SL.2.4, LAFS.68.RST.1.1, LAFS.68.RST.1.2, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, MAFS.7.SP.2.4, VA.68.C.2.1, VA.68.C.2.2, VA.68.C.2.3, SS.7.C.2.12, SS.7.C.2.13, and SS.7.C.2.14

damage. The dying roots decay and cannot supply the plants with nutrients and water.

Soil types dictate the ability of a garden to retain and drain water. Soils that have a high amount of **sand**, as most do in Florida's school yards, drain water quickly and do not retain moisture well. Soils that have a high amount of **clay** retain water so well that the clay doesn't allow the plants to uptake the water. **Silt** and **organic matter** in the form of **compost** help to balance the sand and clay so that soil is able to retain and slowly drain water as it flows through the garden soils.

A moisture meter provides information on the moisture level of the soil two to six inches (five-10cm) below the surface, where the root hairs absorb water. By using a moisture meter, a gardener or farmer can determine the effectiveness of the irrigation system and the ability of the soils to drain and/or retain water. Moisture levels below three indicate dry soil and moisture levels above eight indicate inundated, waterlogged soil. The ideal soil moisture level is between three and eight on the moisture-meter-scale.

Soil Temperature: Many seeds will not **germinate**, or begin to grow, when soil temperatures are too cool, such as tomatoes and watermelons. Other plants, such as lettuce or cilantro, will not germinate when the soil is too hot. Some plants stop growing when the soil temperature becomes too cool, and some stop growing when the soil temperature becomes too hot.

For example, St. Augustine grass stops growing when the soil temperature is below 55°F, and Rye Grass stops growing when the soil temperature is above 75°F.

Many insects and fungi thrive in certain soil temperatures, generally warm soil temperatures over 80°F. For this reason, very few farmers grow plants outdoors between late July and early September in Florida. The soil is too hot during those months in Florida to grow healthy plants. Thus, knowing the soil temperature allows a farmer or home gardener to make the best choices for which plants to grow for changing seasons and weather conditions.

Generally, soil between 40°F-55°F is considered the coolest soil in which plants will grow. Soil between 56°F-78°F is considered the **optimum** or best soil temperature for growing plants. Finally, soil between 79°F-90°F is the highest soil temperature at which plants will grow.

Introduction:

*It is recommended that this lesson is performed before planting, but it can just as well be performed while plants are growing. Additionally, it is more effective to compare temperature and moisture across different classes and times of the schoolday.

1. Begin class with a starter or warm-up question, such as: "Watermelons will grow fruit at soil temperatures as low as 70°F and as high as 85°F. What is the range of the soil temperature at which watermelons will grow fruit?"
   Answer: 85°F-70°F = 15°F or
   "The optimum or best soil temperature for growing cucumbers is 64°F, cantaloupe 68°F, okra 73°F, pumpkin 75°F, squash 70°F and watermelons 72°F. What is the mean or average soil temperature in degrees Fahrenheit for growing the above fruits and vegetables?"
   Answer: 64°F + 68°F + 73°F + 75°F + 70°F + 72°F = 422°F/6 = 70.3°F
2. Allow students time to answer starter or warm-up questions. Discuss solving for the **range** and **mean** and why those forms of data analysis are important and useful for gardening.
3. Read orally, or discuss the background information on soil temperature and soil moisture. Discuss temperature and moisture based on the time of the year and which plants are most appropriate for temperature and moisture/rainfall averages for that season. Also, discuss how soil temperature does NOT change as dramatically as the atmospheric or outside temperature due to the **insular** properties of the soil.

Activity 1:

1. Using a document projector, display the soil moisture and soil temperature meters on the screen and demonstrate how to properly use, read and clean each meter.
2. Pass out one copy of each of the following handouts to every student; *Soil Moisture Data Table* and *Soil Temperature Data Table*. Display the sheet using an overhead or computer projector. Group students in groups of four and emphasize that each student will have multiple opportunities to use each meter and that each group is responsible for recording the information while in the garden.
3. Tell students that they are going to be taking soil temperatures in the garden and in another location of your choice, such as a different growing medium like the hydroponics garden or container garden.
4. Upon returning from the garden, review the data recorded for each class. Next, as a class, solve a data column to demonstrate how to solve the total, mean, mode and range for each column.
5. For the soil moisture lab, demonstrate using an overhead or computer projector, how to properly label the graph for the moisture of different parts of each garden.
6. For the soil temperature lab, post the mean soil temperatures for each class and time on the overhead or computer projector. Next, demonstrate how to properly label and plot the data points on a graph.
7. Once students have completed the data tables, assign the *Extension/Comprehension Questions for Soil Moisture and Extension/Comprehension Questions for Soil Temperature*. Allow students to work collaboratively in answering the questions, but each student is responsible for completing their own paper. When all students are finished, discuss the answers.

Extensions:

1. After collecting temperature and moisture data, have students research which plants are most appropriate for planting. Be sure to have students include the recommended amount of water and optimal soil temperature for each plant.
2. As a group have students design their "ideal" garden including measurements, number of plants, spacing of plants and irrigation, and submit for approval. Depending on space, each group can create their own garden or each class can decide which design they like the best and plant one for the whole class.
3. Unless soil amendments were added to your garden, the soil moisture is probably not ideal. There are different soil amendments that help retain moisture for better plant health. Have students research the amendments and engineer the best soil for your school garden. They will have to design an experiment similar to the soil moisture lab to test their engineered soil.

Evaluation:

1. Assess student performance in completing the assigned lab measurements and completed graphs for soil moisture and soil temperatures, as well as cooperation in completing the group work.

Soil Moisture Data Table

Directions: Correctly use the moisture meter to determine the moisture level of soil in each box and fill in the chart to document the moisture level in each part of the different gardens.

Section of the Garden	Garden 1	Garden 2	Garden 3	Garden 4	Garden 5
NE corner					
SE corner					
NW corner					
SW corner					
Center					
Total					
Mean					
Mode					
Range					

Extension/Comprehension Questions for Soil Moisture

Directions: Using the completed Soil Moisture Data Table, answer the following questions.

1. Which garden had the **highest** Mean for moisture?

2. Which garden had the **lowest** Mean for moisture?

3. What **variables** could account for a moisture **difference** between the gardens? (one to two sentences)

4. What **variables** could account for a moisture difference between different **sections** (NE, NW, SE, SW and Center) of each garden? (one to two sentences)

5. Which garden had the **highest range** of moisture between the **sections**? What variable or variables might explain the high range of moisture between the sections?

6. Which garden had the **lowest range** of moisture between the **sections**? What variable or variables might explain the low range or moisture consistency of the sections?

7. What changes and/or additions would you suggest to create a consistent moisture level in each garden?

8. Explain how using a moisture meter could save a farmer or gardener money.

9. Create a graph that shows the different gardens as the independent variable (x-axis) and the **mean** moisture level as the dependent variable (y-axis).

10. What patterns became apparent on **your graph** in reference to mean soil moisture level in each garden?

Soil Temperature Data Table

Directions: In this lab you will use the soil thermometers to measure the mean, average soil temperature of each of the main gardens and solve for the range between the soil's temperatures to the atmospheric or outside temperature. Next, you will use your information to infer and predict patterns that occur between outside temperature and the soil temperature.

Time of data collections:_____

	Garden 1	Garden 2	Garden 3	Garden 4	Garden 5	Mean
Outside Temperature ˚F						
Soil Temperature ˚F						
Alternative Growing Medium Temperature ˚F						
Range between Soil & Outside Temperature.						
Range between Soil & Alternative Temperature						

Extension/Comprehension Questions for Soil Temperature

Directions: Use the soil temperature chart/table to answer the following questions.

1. Which garden, if any, had the **highest** soil temperature?

2. What variables might account for a **high** soil temperature or the reason for no change between the garden soils?

3. Which alternative garden/growing medium had the **highest** soil temperature?

4. What variables might account for a **high** alternative garden/growing medium temperature?

5. Which garden had the greatest **range** or difference between the outside temperature and the soil temperature? **Explain** what variables might account for a **high range** between the outside and soil temperatures?

6. Which garden had the greatest **range** or difference between the soil temperature and the **alternative garden/growing medium** temperature? **Explain** what variables might account for a **high range** between the soil temperature and alternative garden/growing medium temperature in that garden?

7. Using the information from your chart, which gardens would you plant plants that thrive in **cooler** soil and which garden would you put plants that thrive in **warmer** soil?

8. Using the data from your chart, **explain** the **numerical pattern** that developed between the outside/atmospheric temperature, the soil temperature and the alternative garden/growing medium temperature.

9. Looking at your chart, what could be **inferred** about the relationship between the soil temperature and the atmospheric or outside temperature?

10. Using the **mean** outside temperature, soil temperature and alternative garden/growing medium temperature data from your class **plus** two other classes, create a line graph that shows the relationship between the time of day, the atmospheric temperature, soil temperature and alternative garden/growing medium temperatures between different class periods. On the x-axis, place the time of data recordings and on the y-axis place the temperature in ascending order from 40°F to 90°F. Be sure to **title** your graph and **label** BOTH axes!!!

11. Looking at your graph, what **patterns and relationships** developed between the outside temperature, soil temperature, alternative garden/growing medium temperature AND the time of day?

Soil Moisture and Temperature

Sample Pre-Post Test Assessment

Directions: Answer each question using precise terms.

1. What material in soil is best for allowing water to drain and move through the soil?

2. Explain why water is vital to the health and survival of plants.

3. How does soil temperature control the germination or sprouting of plants?

4. What material in the soil is best for retaining water in the soil?

5. What causes plants to die if the roots are inundated or receive too much water?

6. Why is it difficult to grow fruits and vegetables in extremely warm soil temperatures?