Laboratory 14A  
Evaluating Soil Sustainability 1: Soil Moisture Retention

<table>
<thead>
<tr>
<th>Lab Objectives</th>
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<tr>
<td>• To gain additional understanding about the characteristics of sustainable soils</td>
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<tr>
<td>• To measure soil moisture retention in two different agroecosystems</td>
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<tr>
<td>• To collect soil samples for organic matter determination</td>
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</table>

**Introduction / Background**

Important Note: Please complete pre-test 1 before reading this introduction.

The purpose of this laboratory is to provide you with an opportunity to explore the impact of different agricultural production systems (e.g. sheet composting, cover crops, pasture) on agricultural sustainability in southwest Colorado.

Agricultural sustainability may be characterized in a number of ways, and is sometimes described in terms of sustainable soils. Cramer (1994) describes a sustainable soil from a farmers perspective and includes the characteristics listed in Table 1.

**Table 1. Characteristics of Sustainable Soils**

<table>
<thead>
<tr>
<th>Resistant to erosion</th>
<th>Rich in soil organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soaks up rain with little runoff</td>
<td></td>
</tr>
<tr>
<td>Stores adequate moisture for growth during dry periods</td>
<td></td>
</tr>
<tr>
<td>Requires minimal inputs for optimal yields</td>
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</table>

Others have suggested that two of the most important indicators of agricultural sustainability in the arid west (and elsewhere) are soil organic matter levels and the ability of soils to store or retain water. As you will learn in the lecture component of this course, these two indicators are functionally related to each other. Simply stated, increasing soil organic matter levels are correlated with increased soil moisture.
retention. Maintaining appropriate soil organic matter levels and maximizing the potential for water storage have been identified as critical issues for the 21st century by public and private resource managers.

In part 1 of this laboratory, you will use an electronic soil moisture meter to measure and compare soil moisture levels in two different agricultural production systems. You will also draw some preliminary conclusions about how your results relate to the sustainability of the agricultural ecosystems (also known popularly as agroecosystems) that you selected for study.

Farmers, ranchers, and gardeners have developed a diverse array of production systems in their attempt to optimize sustainability, or more specifically to enhance soil organic matter levels and moisture retention. These include the use of crop rotations, sod crops, mulches, cover crops, sheet composting, intercropping, and relay cropping. In virtually all of these systems, retention of soil moisture is enhanced by creating a cover or barrier on the soil surface that retards the movement of water, usually as water vapor, from the soil to the air. Soil covers may also modify soil temperature in a favorable way.

One of the most common techniques for conserving soil moisture and adding organic matter to the soil is mulching. Mulch may be defined as any material placed on the surface of the soil for the purpose of moisture conservation, erosion management, or enhancing soil fertility. Common mulching materials are straw, leaves, grass clippings, bark mulch, plastic, or virtually any crop residue. Non-living mulches may also be known as residue mulches. In contrast, other mulches are living crops, and are appropriately known as living mulches. Living mulches are crops planted between the rows of, or surrounding the primary crop. These mulches may be allowed to grow concurrently with the primary crop, or may be killed before establishment of the primary crop (sometimes known as a killed mulch). If a living mulch is allowed to grow concurrently with the primary crop because it provides a specific benefit to the primary crop, it may also be
known as a companion crop. Examples of living mulch/primary crop systems would include subclover (Trifolium subterraneum)/corn (Zea mays), hairy vetch (Vicia villosa)/leek Allium ampeloprasum), and canola (Brassica napus)/strawberry (Fragaria ananassa). Living mulches should be carefully selected because research has demonstrated that while they provide benefits in the form of reduced soil erosion, greater organic matter, and improved water retention, they may also reduce the yield of the primary crop.

Scientists have attempted to formulate mathematical relationships between mulch rate and important soil properties. For example, Lal et al. (1980) developed regression equations that related the rate of mulching to earthworm activity. As illustrated in table 1, the mathematical relationship varied with time of year. (How would you explain this?) The data that you will collect in this laboratory will eventually be used to help develop a simple linear regression equation that will relate soil organic matter to soil water retention.

<table>
<thead>
<tr>
<th>Month</th>
<th>Regression Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>Y=1.15X + 3.30</td>
</tr>
<tr>
<td>July</td>
<td>Y=1.81X+0.45</td>
</tr>
<tr>
<td>October</td>
<td>Y=1.41X + 3.29</td>
</tr>
</tbody>
</table>

Legend

X = mulch rate tons/ha, Y = number of earthworm casts per month/ m²

Technology offers us a wide spectrum of methods and devices to estimate soil moisture content. The device that you will use to measure soil moisture and evaluate soil moisture retention in this laboratory is the Watermark™ soil moisture sensor. It is based on a method known as electrical resistance moisture estimation, or sometimes the gypsum block method. In this approach, a porous block (that is sometimes composed of gypsum) containing two electrodes is placed in contact with the soil. The two electrodes are
connected to a common wire lead that is in turn connected to a soil moisture meter. As the soil moisture gradually comes into equilibrium with the moisture inside the block, there is a change in the electrical conductivity of the porous block, as measured across the two electrodes. This change in conductivity is detected by the Watermark™ soil moisture meter and displayed digitally in units of centibars. The Watermark™ operation manual offers a table to help interpret the numerical data in real world terms, as illustrated in Table 3.

Table 3. Interpretation of Soil Meter Readings. Adapted from Watermark™ operation manual.

<table>
<thead>
<tr>
<th>Meter Reading (centibars)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>Soil is saturated – no irrigation needed</td>
</tr>
<tr>
<td>10-30</td>
<td>Soil moisture adequate for crop growth</td>
</tr>
<tr>
<td>30-60</td>
<td>Irrigation needed for optimal growth in most soils</td>
</tr>
<tr>
<td>60-100</td>
<td>Irrigation needed for optimal growth in high clay soils</td>
</tr>
<tr>
<td>100-200</td>
<td>Soil is probably too dry for maximum yields</td>
</tr>
</tbody>
</table>

Materials and Methods

Materials

- Soil moisture sensor / meter with cable
- GPS Unit
- Soil Probe or Rebar (7/8 in internal diameter)
- PVC Pipe (6-18 in, ½ in diameter)
- Hammer
Soil sample bags (Cloth)

Lab Data Sheet(s)

Methods

- Obtain the necessary equipment with the help of your lab instructor

- Before taking soil moisture samples, consult with your lab instructor(s) about conditioning the soil moisture sensor by soaking it overnight in tap water

- Consulting with your instructor(s) and lab partner (if you are working with a partner), decide where you will take your soil samples, and record the two types of agroecosystems you select on the lab data sheet

- Proceed to the sampling/study area, select a central sampling point, and record this location with the handheld GPS unit in degrees latitude/longitude and meters of elevation

- Collect small (about 5 g) soil samples from the central sampling point and at approximately 1 meter from the central sampling point and place in the cloth or paper sampling bags (These samples will be used in the next lab for organic matter determination)

- Using the soil probe or rebar/hammer, create a sampling hole about 6-8 inches deep at the central sampling point

- Pour water into the hole until filled

- Wet the area around the sampling hole thoroughly in a 1 meter diameter circle around the soil sensor until you believe the soil is saturated

- Using the soil probe or rebar/hammer, create a 2\textsuperscript{nd} sampling hole about 6-8 inches deep and about 1 meter from the central sampling point

- Pour water into the 2\textsuperscript{nd} hole until filled

- Wait approximately 1 hour
• Place the soil moisture sensor into the 1\textsuperscript{st} hole
• Place the PVC pipe gently over the top of the probe and apply gentle pressure to seat the probe securely in the soil
• Thread the sensor leads through the PVC pipe so that they are easily accessible above ground
• When you are ready to take a reading, connect the sensor leads to the alligator clips of the moisture meter
• Press the read button on the moisture meter
• Record the two digit moisture reading in the lab data sheet
• Record a reading for soil moisture in the 2\textsuperscript{nd} hole, using the procedures described above
• Return to the area after approximately 1 week and take another reading, using the procedure above
• Collect two small soil samples (about 5 g) for organic matter analysis in part B of lab 14. The first sample should be near the central sampling point. The other should be approximately 1 meter away from the central sampling point, or near the 2\textsuperscript{nd} moisture sample location.

**Laboratory Pre-Test**

Before beginning the laboratory, you are required to complete the lab pre-test and have it checked and signed by your lab instructor. The purpose of the pre-test is to help ensure that you understand the major concepts and procedures before beginning the lab.

<table>
<thead>
<tr>
<th>Laboratory 14A Pre-Test</th>
<th>Evaluating Soil Sustainability 1: Soil Moisture Retention</th>
</tr>
</thead>
</table>
| 1 What are two of the most important indicators of agricultural sustainability in the arid west? | A Soil Organic Matter Levels  
B The ability of soils to retain or store water  
C Both A and B are correct  
D I do not know |
| 2 Which of the following statements are correct, with regard to mulches? | A They help to retain soil moisture  
B They may alter soil temperature  
C They may increase soil organic matter levels  
D All of the above |
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
</table>
| 3 What is the purpose of this lab?                                      | A To explore the impact of different agricultural production systems on agricultural sustainability  
B To estimate soil water content with an electrical resistance type device  
C To collect samples for organic matter analysis  
D All of the above |
| 4 Which of the following are characteristics of sustainable soils?      | A Resistant to erosion  
B Rich in soil organisms  
C Both A and B are correct  
D None of the above are correct |
| 5 Which of the following are correct descriptions of a living mulch?    | A They are crops planted between the rows of the primary crop.  
B They can reduce soil erosion  
C They may reduce yield of the primary crop  
D All of the above |
| 6 What methods have been used by farmers, ranchers, and gardeners to enhance sustainability? | A Mulching  
B Intercropping  
C Both A and B  
D None of the above |
| 7 Scientists have developed regression equations that relate the rate of mulching to earthworm activity. | True / False |
| 8. The method you will use in lab to estimate soil moisture is known as the electrical resistance moisture estimation | True / False |
| 9 Which of the following statements correctly describe the procedures you will use in this lab? | A You will collect small (about 5 g) soil samples for soil organic matter analysis  
B You will take two moisture readings, about 1 week apart  
C You will place the sensor probe in dry soil  
D Both A and B are correct |
| 10 What reading on the moisture meter indicates that irrigation is needed for optimal growth in high clay soils? | A 0-10 centibars  
B 10-20 centibars  
C 40-45 centibars  
D 60-100 centibars |

By my signature I affirm that I have read the laboratory, completed the pre-test above, and have a reasonable understanding of the procedures involved in this laboratory.

Student Signature & Date

Instructor Signature & Date
Laboratory 14A  
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Table 3 Soil Moisture and GPS Data for Two Agroecosystems

<table>
<thead>
<tr>
<th>Date</th>
<th>Agroecosystem Type</th>
<th>Reading (centibars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Initial Readings (Central Sampling Point)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second Readings (1 meter from Central Sampling Point)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agroecosystem Type</th>
<th>Latitude / Longitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By my signature I affirm that I have completed this laboratory, calculated and recorded the results above, and have checked the results with the lab instructor. I have also consulted with the lab instructor with regard to the above interpretation of the results.

Students Signature & Date | Instructors Signature & Date

References