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Abstract

There is a renewed interest in educating youth, Master Gardeners, and agricultural producers about soil quality. Three soil demonstrations show how soil organic matter increases water holding capacity, improves soil structure, and increases nutrient retention. Exercise one uses clay bricks and sponges to represent mineral soils and soil organic matter and how soil water is retained. Exercise two demonstrates how soil organic matter cushions the soil to resist soil compaction and improves soil structure. Exercise three uses marbles to represent how soil nutrients are retained by soil organic matter. These demonstrations are useful within a classroom or as field exercises.

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Introduction

Humans have changed the way soils develop and function through management. In the last century, average soil organic matter (SOM) levels have declined 50 to 70% (Lal, 2004). Extension professionals have used several different soil exercises using clay (Kleinschmidt, 2011) and soil aggregates (Wortman & Brubaker, 2004) to understand soil functions. Three soil quality demonstrations for youth and adults are explained in this article.

Exercise #1: Soil Organic Matter Impact on Water Holding Capacity

Soil organic matter and clay particles with negative charges absorb and hold soil water. The objective of this exercise is to demonstrate how SOM influences water holding capacity.

Materials Required

- Two solid bricks

Two brick sponges

Procedure for Demonstrating Water Holding Capacity

The clay brick represents the mineral portion of the soil. Discuss with participants how wet clay from the soil is used to form a brick by burning off the SOM in a furnace and letting it dry. Ask participants what other products can be formed from clay (clay tile, pottery). What are the characteristics of the clay after it dries (hard and dense)? Dip the brick into the container of water, and discuss how much water is absorbed and how the water runs off the brick.

The brick sized sponge represents soil organic matter (SOM). Discuss the weight differences between the clay and the brick, and discuss differences in bulk density. (Even though they are similar in size, the brick is denser than the sponge). Dip the sponge into the water, and discuss the water holding capacity of the sponge compared to the brick. Which one holds more water? Each 1% SOM has the capacity to hold 1-2 inches of soil water (Hudson, 1994).

Exercise # 2: Soil Organic Matter Impact on Soil Compaction and Soil Structure

Soil organic matter cushions soil from compaction and, with the addition of mineral particles like sand, silt, and clay, provide structure to the soil. The objective is to demonstrate how SOM reduces soil compaction and improves soil structure.

Materials Required

- Two solid bricks
- Two brick sponges

Procedure for Demonstrating Soil Compaction and Soil Structure

SOM improves soil structure and improves resiliency to soil compaction. Position one sponge between two bricks, and slowly compress the sponge between the bricks. The sponge (SOM) will compress and return to its original shape once pressure is released. SOM acts like the sponge to resist forces that compact soil. Next place the two bricks side by side without the sponge. Talk about the negative charges associated with clay soil particles. Discuss how the soil (bricks) without the SOM (sponges) attracts positive ions like calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^{+}) that bind soil particles together. When the soil dries it may set up like cement and restrict air and water movement. For more information, consult Hoorman, Sa, and Reeder, (2011).

Question: What do you call a brick lying on top of the soil? (We call it a clod.) Clods are a man-made problem because the soil has been artificially dried out. Discuss the process used to produce a brick. Wet clay soil is heated in a furnace (SOM burnt off) and allowed to dry. Question: What do farmers do when they plow the soil? Answer: They dig up wet clay soil, let it bake in the sun, and they burn off

the SOM. The result is cloddy soil as the SOM is lost to the atmosphere in the form of carbon dioxide. Tillage injects oxygen into the soil and results in a loss of 60-80% of the SOM as carbon dioxide to the atmosphere (Islam, 2008). Tillage is like opening the damper on a wood burning stove; injecting oxygen makes the wood burn hotter and results in a loss of carbon to the atmosphere. In the last century, farmers have lost 50-70% of our original SOM levels through tillage (Lal, 2004).

Exercise #3: Soil Organic Matter Impact on Nutrient Retention

Most soil nutrients are tied up organically in the soil. The objective of this exercise is to show how soil organic matter and mineral particles can hold and retain soil nutrients like nitrogen (N) and phosphorus (P) in the soil.

Materials Required

- Two solid bricks
- Two brick sponges
- Two marbles of different colors

Procedure for Demonstrating Soil Nutrient Retention

Use the two sets of marbles to demonstrate how SOM enhances nutrient recycling and retention. One set of marbles represents nitrogen (N), and the other set represents phosphorus (P). Position the marbles between the bricks and the sponges, and squeeze slightly. The sponge protects the marbles similar to the way in which SOM holds N and P soil nutrients. SOM forms a film around clay soil particles, creating an organic-clay complex that retains soil nutrients like N, P, and sulfur. Approximately 90% of N and 50-80% of P are in an organic form (Dahl, 1977).

Remove the sponges, and roll the marbles between the two bricks. When SOM is reduced or lost from the soil profile, the soil nutrients are more exposed and may be detached by flowing water. Use one brick, and place one or two marbles against the brick surface. The nutrients tied up by the clay particle can easily detach (separate or roll the marbles along the brick surface), and the nutrients become inorganic N, P, or soluble nutrients that may flow to surface water. Carbon is the key factor in controlling and storing most soil nutrients needed for crop production (Reicoski,2006).

Conclusions

Three soil quality demonstrations were described. The first soil demonstration shows how bricks (clay) and sponges (soil organic matter) increase water holding capacity. The second experiment exhibits how increased organic matter may decrease soil compaction and improve soil structure. The third demonstration explains how clay and soil organic matter increase the nutrient holding capacity of soils. Increasing soil organic carbon in the soil is a beneficial means to store soil water, reduce soil compaction, improve soil structure and water infiltration, and increase soil nutrient storage and plant nutrient uptake.

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