USE OF A PENETROMETER TO ASSESS SOIL COMPACTION

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Soil compaction is the process or condition of increasing density of soil due to compression of soil particles closer together and elimination of pore spaces, usually due to heavy loads, repeated impact, or shear stress. Compaction is a problem that obstructs the growth of plant roots, which affects the health of crops, pastures, and landscape vegetation. Compacted soils can also hinder water infiltration, creating excess stormwater runoff and increasing risk of flooding. In efforts to mitigate soil compaction, a quick and simple way to assess the level, extent, and depth of compaction is usually needed. A static cone penetrometer (Figure 1) is one method to obtain these soil compaction measurements. The procedures described below are specific for the use of a DICKEY-john® static cone penetrometer (a.k.a., soil compaction tester), which gives results over a range of depths in units of pounds per square inch (psi) (DICKEY-john®, 1987), but there are similar types of penetrometers from other manufacturers that can be used to assess compaction.

Figure 1: Static cone penetrometer, a.k.a. soil compaction tester. (Photo Credit: Steve Yergeau)

OVERVIEW

A penetrometer consists of a pressure gauge mounted at the top of a pointed rod, which is pushed into the soil. The pressure gauge provides a measure of the resistance of the soil to penetration by the probe. The pointed tip of the penetrometer is designed to represent a plant root and “feel” the resistance from soil that a plant root would. Excessive resistance

representing soil compaction is measured and reported as the depth reached when "critical compaction" occurs. Critical compaction implies root-limiting resistance. The penetrometer is pushed into the soil within each test area until the gauge reads 300 psi; this process is repeated at various locations at the site. The distance that the rod penetrates the soil up to the 300 psi reading is measured and recorded, with deeper penetrometer depths indicating less compact soils. A minimum of ten measurements per acre are usually collected from each study area during the compaction survey. The average depth to soil compaction can be calculated from these measurements and used in subsequent data analyses.

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EQUIPMENT

- DICKEY-john® soil compaction tester with locking ring and ½-inch and ¾-inch tips
- Adjustable wrench
- Rubber O-ring
- Tape measure
- Logbook/data sheet(s) for project
- Site information (soil type and/or texture) [Optional]
- Location/address of study site [Optional]
- Map(s) or photograph(s) of study site [Optional]

INSPECTION

Prior to data collection, field personnel should visually inspect the instrument gauge to ensure it is working properly. The locking ring should be securely attached to the rod at the end of the gauge (Figure 2) to prevent any movement of the rod during storage or transport to the site. The indicator gauge should read "0" before sampling. If not, pull on the instrument rod or gently tap the gauge. If it does not return to "0," contact the manufacturer. The gauge is also filled with silicone, which is used to dampen the shock to the gauge during operation or storage. If silicone is leaking from the gauge, contact the manufacturer. To ensure that accurate data are being collected, two individuals should perform soil compaction sampling. One is to operate the instrument while the other records depth into a logbook or on a data sheet.

Figure 2: Soil compaction tester with locking ring in place. (Photo Credit: Steve Yergeau)

PROCEDURE

1. Determine whether the soil is firm or soft, based upon a feel of the soil's consistence, and pick the appropriate tip to use:
    a. If the soils are firm or compacted, the ½-inch tip should be used.
    b. If the site has loose or friable soils, then the ¾-inch tip is to be used.
2. Install the appropriate tip by screwing it onto the soil compaction tester and record the tip size onto the data sheet or in the logbook (Figure 3).

Figure 3: Installation of the soil compaction tester tip. (Photo Credit: Steve Yergeau)

3. Install the rubber O-ring at the end of the rod. Ensure that the rubber O-ring is at the end of the rod where it meets the tip (Figure 4).

Figure 4: Installation of the O-ring. (Photo Credit: Steve Yergeau)

4. Remove the locking ring by unscrewing the nuts from the ring with an adjustable wrench (Figure 5) and sliding the ring off the penetrometer.

Figure 5: Removal of the locking ring. (Photo Credit: Steve Yergeau)

5. Grab the penetrometer by the handles and insert the pointed end of the rod into the soil.

6. Apply even pressure to the handles of the instrument to keep the rod point penetrating the soil at a slow and even pace. Be sure to keep the instrument as vertical as possible during data collection (Figure 6).

Figure 6: Proper technique for starting the soil compaction assessment. (Photo Credit: Steve Yergeau)

7. Push the penetrometer into selected locations at the site until the gauge reads 300 psi.
    - NOTE: The inner ring of the gauge is read when the ½-inch tip is installed and the outer ring is used when the ¾-inch tip is installed (Figure 7).

Figure 7: DICKEY-john® soil compaction tester pressure gauge showing the inner and outer scales for the ½ inch and ¾ inch instrument tips, respectively. (Photo Credit: Steve Yergeau)

8. Grab hold of the penetrometer rod near the soil surface and pull the penetrometer from the ground (Figure 8). The O-ring on the rod should mark the point of the soil surface.

Figure 8: Grip the instrument rod and remove it from the soil. (Photo Credit: Steve Yergeau)

9. Measure the distance that the rod has penetrated into the soil from tip of the instrument to the point on the rod where the rubber O-ring has stopped (Figure 9).

Figure 9: Take measurement of depth with a tape measure. (Photo Credit: Steve Yergeau)

10. Record the depth (in inches or centimeters) in a logbook/data sheet.

11. Reset the O-ring by sliding it to the end of the rod where it meets the tip of the penetrometer (Figure 4).
12. Carefully wipe off the instrument with a rag or paper towel before taking additional measurements.
13. Take depth measurements in a minimum of ten locations per acre at the site.

ADDITIONAL SOIL INFORMATION

Factors that contribute to the level of resistance measured by the penetrometer are the soil texture and soil water content. If these procedures for using a penetrometer are part a long-term study, obtaining this additional information (soil texture, % water) will help explain the level of resistance measured at your site.

In conclusion, to manage compaction, one first needs to determine whether soil health is at risk due to compaction and the extent of compaction. This risk can be evaluated with the proper use of a penetrometer. This understanding will help in the management of activities that can lead to compaction and provide possible solutions.

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REFERENCES

DICKEY-john Corporation. (1987). Installation Instructions: Soil Compaction Tester. DICKEY-john Corporation, Auburn, IL.