SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter 14:
Soil Compaction Impact on Corn Yield

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Soil compaction reduces soil drainage, aeration, yields, root growth, and the ability of plants to recover from disturbance, while simultaneously increasing surface runoff and soil erosion. Compaction can be severe in wet, clay soil and it is increased by the use of heavy machinery during planting and harvesting, especially in wet soil conditions. Generally, conventional-tillage (e.g., moldboard plowing, chisel-plow, etc.) leads to the development of a plow layer or pan near the interface of soil and the bottom of the tillage implement (Fig. 14.1). This chapter discusses soil compaction and possible remediation strategies to reduce these risks.

Figure 14.1 Compaction created by a tandem disk. (Photo courtesy of Thomas E. Schumacher, South Dakota State University)

Locating Compacted Zones

Compaction is caused by a downward pressure that squeezes the soil and increases the soil bulk density (Wolkowski and Lowery, 2008). Compacted zones can be located by scouting the field for reduced crop growth. Compacted areas are typically associated with areas where tillage was conducted on wet soil and areas with extensive traffic. Compaction problems can be diagnosed by:

1. Driving a metal stake into noncompacted and suspected compacted zones.
2. Digging a trench across two corn rows in a suspected area or pushing a long screwdriver into soil in the suspected compacted area.
3. Inspecting root growth (Fig. 14.2) or assessing soil hardness by crushing soil aggregate.
4. Determining the soil bulk density or penetrometer resistance (Duiker, 2002; USDA-NRCS, 2014).

Bulk Density

Bulk density of soil is the dry weight of soil in a given volume of soil. It is measured by using core method, and calculated by the weight of soil mass divided by the volume of the soil core. Most rocks have a bulk density of > 2.65 g/cm^3, whereas productive soils have bulk densities between 1.2 and 1.3 g/cm^3. Sandy soils have higher bulk densities than silt loam soils. Bulk densities can be used to identify problem areas where root growth is restricted (Table 14.1).

Tools needed to measure bulk density include a steel ring of known dimensions, a shovel, plastic bag, balance, microwave, and a knife. The steps are:

1. Push the ring into the soil (Fig. 14.2).
2. Use the shovel to recover the ring.
3. Cut the soil, outside of the ring, from the top and bottom.
4. Place soil into a plastic bag.
5. Dry using a microwave.
6. Determine the volume of the ring, vol= $\pi r^2 h$.
7. Calculate the density, dry weight/volume of ring.

Additional details for determining the bulk density are available in Arshal et al. (1996).

Table 14.1 Bulk densities where root growth is restricted in sandy, silty, and clayey soils.

Soil type	Root growth restricted
	g/cm^3
Sandy	> 1.8
Silty	> 1.65
Clayey	> 1.47

Figure 14.2 Measuring the bulk density (top images) and soil resistance (bottom images) in a field. (Courtesy of the authors)

Soil Resistance

Soil penetration resistance is the resistance that a root experiences as it tries to expand into a new soil zone. Penetration resistance is measured with a penetrometer that is pushed into the soil (Duiker, 2002; Fig. 14.3). Details for this method are provided by Duiker (2002). Root growth critical resistance values are dependent on plant species. Duiker (2002) suggested a compaction assessment can be determined by measuring resistance at a number of points across a field. Duiker reports that if the resistance exceeds 300 PSI, root growth is severely slowed. The results of these measurements are then compiled and interpreted (Table 14.2).

Table 14.2 Interpretation of penetrometer results. This analysis is based on root growth being restricted with PSI values > 300. (Modified from Duiker, 2002)

% points with values > 300 PSI	Compaction rating
< 30	little to none
30-50	slight
50-75	moderate
> 75	severe

Reducing Soil Compaction

Check Soil Moisture Prior to Field Operations

Wet soils are more prone to compaction than dry soils. To minimize compaction, it is recommended that the soil moisture content can be checked prior to field operations. For medium-textured soils such as silt loams and silty, clay loams, soil from the top 6 inches should be placed between the forefinger and the thumb and squeezed. If the ribbon breaks within several inches, the soil is most likely appropriate for additional work. If the soil stretches out for 4 to 5 inches, it is most likely too wet.

Reduce Tillage

Only conduct tillage that is absolutely necessary. Primary and secondary tillage (disking in particular) and cultivation break soil aggregates and speeds up the mineralization of soil organic matter. Tillage problems can be minimized by:

1. Carefully balancing the need for timely planting and field operations.
2. Using equipment that has an appropriate size and weight.
3. Varying the tillage depth from year to year.
4. Using tillage equipment that is well-maintained with sharp, soil-engaging leading edges.
5. Delaying tillage until the soil has an appropriate moisture content. Strip-tillage, no-tillage, and ridge-tillage systems are techniques that can be used to reduce tillage and thus compaction.

Improve Soil Organic Matter

Adding organic matter increases surface-soil friability, water infiltration, soil structure, and water-holding capacity, and reduces soil erosion. Generally, tillage breaks the soil clods, which, in turn, accelerates soil organic matter oxidation. Organic matter can be increased by adding manure, growing perennial crops, planting cover crops, reducing tillage, and not removing crop residues. The impact of adding organic matter on compaction generally decreases with increasing depth. Information on rotations and cover crops are available in Chapters 9 and 15.

Control Wheel Traffic

Grain carts can increase soil compaction and reduce yields (Table 14.3). Grain carts can have axle loads that often exceed the axle load of a combine, large manure tank, or tractor. To minimize the compaction risk from grain carts, load them in the road or headlands and don't drive across the field to catch the combine.

Table 14.3 Relationship between equipment and weight. ***(Modified from Hanna and Al-Kaisi, 2009)***

Equipment	Ton/axle
Combine with 250 bu grain	18
Grain cart with 875 bu grain	23
Large manure applicator	17
175 hp 2-wheel-drive tractor	8

Use of Deep Tillage

If compaction is between 10 to 20 inches deep in the soil, consider subsoiling. Subsoiling is a temporary solution and it should be combined with other techniques to minimize deep compaction. Subsoilers can have: 1) parabolic shanks with or without wings, or 2) straight shanks with or without a coulter. Subsoilers work by shattering the soil and they can leave the soil very rough. Secondary tillage is often needed to prepare a seedbed. Additional information on deep tillage is available in Thomason et al. (2009).

Check Air Pressure in Field Equipment

Field equipment often has tire pressures that are higher than recommended. Using the lowest recommended tire pressure widens the tire footprint and reduces the down pressure. Tandem axles will have less surface compaction than single-axle equipment. Staton (2013) recommended:

1. Tires should be inflated to the lowest manufacturer-recommended tire pressure.
2. Instructions from the manufacturer for your configuration (single, duel, or triple axle) should be followed.
3. Correctly ballasting the tractor and determining weight carried per tire.
4. Tire pressure should be checked frequently with a high-quality gauge.
5. All tires on the same axle should be set to the same pressure.
6. That if the tires contain fluid ballast the pressure should be checked with the stems in the same location.

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