



Soil Compaction in Upper Midwestern Crop Production

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Causes of soil compaction

Soil compaction is the act of pressing soil particles. Soil compaction can be caused by traffic from agricultural equipment. Compaction from wheel traffic is a result of the force applied to the soil surface by the equipment. The greater the axle load, the deeper the compaction effect. Soil water content also affects the extent of compaction from wheel traffic. Water in the soil acts as a lubricant between soil particles which causes aggregates to become less stable. When aggregates are less stable, there is a higher chance for the wheel traffic to destroy the aggregates. Drier soils have more bearing strength from the bonding between soil particles.

Effects of soil compaction

Compaction force rearranges soil aggregates by moving them closer together. Big enough forces can destroy aggregates, reducing pore space even further. Large pores are crucial for water movement and air exchange in the soil. When large pores are gone, only small pores remain, which hold water tightly and restrict air movement. This causes slower water infiltration which increases runoff and soil erosion potential. Restricted air and water movement may lead to uneven plant growth and nutrient deficiencies, especially potassium. Compaction also makes it hard for roots to penetrate the soil. When roots cannot break through the compaction, it is harder for the plant to get the nutrients and water it needs. Through these various factors, soil compaction can reduce crop yield by as much as 60%.

Diagnosing compaction

There are many tools used to diagnose soil compaction. One of the most common tools used to measure soil compaction is the cone penetrometer (Image 1). A cone penetrometer shows the amount of resistance in a soil as the user presses it into the ground. If higher traffic areas have bigger resistance values than the low traffic areas, you likely have compaction issues.



Image 1. Penetrometer used to measure soil resistance. Photo: Ross McKenzie.

Compaction effects can also be visible in the physical condition of the crop. Uneven emergence, plant growth, and root growth are often associated with compaction. To see if compaction is affecting plant growth, look at aerial images of the area of interest. If there is poorer plant growth in a pattern, such as stripes, there is a potential compaction issue.

The easiest and lowest cost method to look for compaction is a shovel. Dig out a clump of soil slightly deeper than the potential compaction layer and look at the structure. Two types of soil structure can point to compaction issues: massive and platy. Massive structured soils are one big clump of

soil and are hard to break apart (Image 2a). Platy structured soils break apart into flat horizontal plates (Image 2b). The ideal soil structure is granular. Granular soils easily break apart into rounded smaller units that keep their shape when wet.

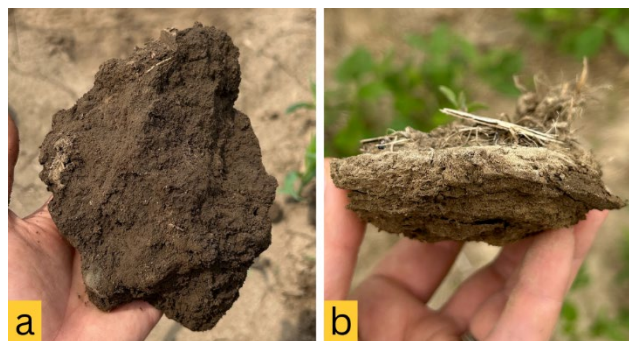


Image 2. a) Massive soil structure. b) Platy soil structure. Photos: Gabi Bolwerk - University of Minnesota Extension.

Managing soil compaction

Work the field when it is fit

The best way to manage the risk of soil compaction is to avoid compacting the soil in the first place. Although it may be tempting to work wet soils, avoid doing so until the soil is dry enough. Often, waiting an extra day or two before working the soil will increase soil strength and reduce the risk of compaction.

Properly inflate tires

Tire pressure should be set at the low end of the recommended pressure for field operations. Lower pressure corresponds with less force applied to a given area of soil. High pressure is more likely to lead to compaction.

Minimize axle loads

The heavier the axle load, the deeper the compaction in the soil profile. In fields that get tilled deeper than 4 inches, keep axle loads under 5 tons. In fields with well-structured soils, keep axle load under 10

tons. Unload combines and grain carts more often to reduce compaction due to added weight. Use a lighter tractor to do lighter work when possible.

Control field traffic

As much as 80% of a field may receive traffic by different operations over the span of the growing season. Most of the compaction occurs in the first pass. Each extra pass in an existing track has a limited effect. Producers can run all their equipment in the same tracks to reduce the amount of field being driven on.

Build soil health

Farmers should consider adopting practices that improve soil health by building soil aggregates. Aggregates are structural units of soil that allow for proper air and water movement and root growth. Well aggregated soil can bear loads with higher applied pressures than poorly aggregated soil. Increasing organic matter is one way to build soil aggregates. Organic matter improves the ability of soil to rebound after force is applied to it. To increase soil organic matter, keep as much residue on the field as possible. Reducing tillage passes and intensity will also increase soil organic matter. Cover crops can increase soil organic matter and build soil aggregates. In addition, they use and store residual nutrients and reduce soil erosion, creating a more resilient soil for crop growth.

For more information, visit:
<https://z.umn.edu/compaction>