Midwest Laboratories®
13611 B Street, Omaha, Nebraska 68144 (402) 334-7770 FAX (402) 334-9121 www.midwestlabs.com

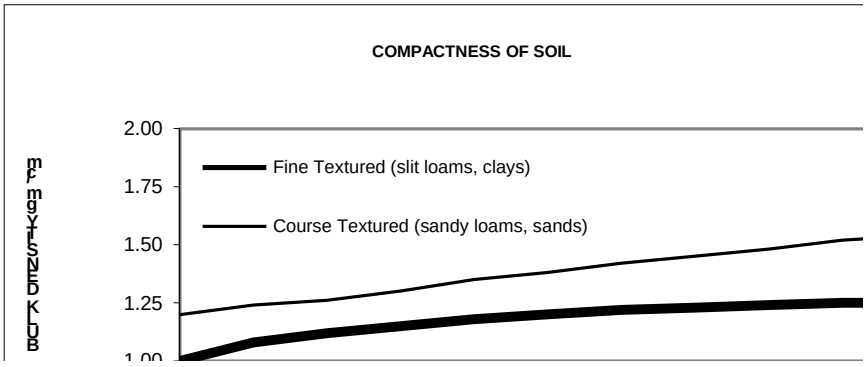
SOIL COMPACTION

Soil compaction is a problem that is often overlooked when attempting to identify causes of reduced production. Compaction is simply the arrangement of soil particles to create a density that is high enough to limit root growth, soil moisture, and aeration. A compacted condition can be naturally occurring. However, management is the cause of most compaction. Large equipment, tillage, and early planting are thought to be reasons for soil compaction. Rotation without perennial crops could also add to compaction.

Compaction can have many effects on the soil. The soil structure is an equilibrium of solids such as sands, silts, clays, and organic matter along with liquids and gases. The soil is comprised of 50% solids and 50% air and water pore spaces. Compaction will cause the aggregates to be realigned and the pore spaces are reduced. The larger pore spaces will be reduced first into smaller pores; however, the equilibrium of air and water is disrupted and most of the air is removed from the pore spaces and the water is retained. This leads to slower water infiltration, poor drainage and aeration. These factors will limit root growth and nutrient uptake.

Solids that are made up of equal mixtures of sands, silts and clays can compact easier than a more uniform soil made up of one type of particle. This is because the finer particles will align between the coarser particles. Figure 1 indicates the potential of compaction on two different soil types.

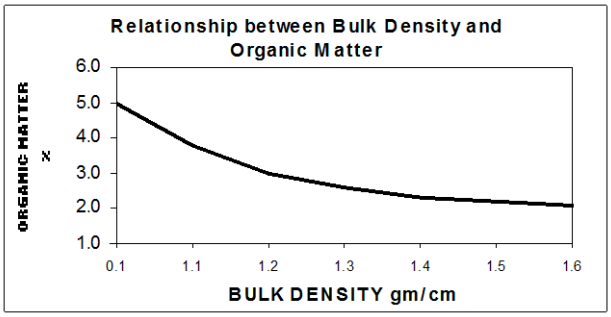
Figure 1. Bulk Density Effects on Soil Compaction



The moisture in the soil has the greatest influence on compaction. When field capacity is reached, compaction will occur at its maximum. Soil particles are easily arranged when there is moisture present.

The soil's bulk density will also be changed from compaction. Bulk density can be defined as the weight of a unit volume of dry soil that includes both the solids and pore spaces. Bulk density will generally increase as soils become compacted.
The amount of organic matter a soil contains will affect the soil's capability to be compacted. Generally, the higher the organic matter, the less the soil will compact. The soil aggregate will be coarser which will allow for better movement of moisture through larger pore spaces. Also, the density of organic matter is less than the soil, which means it will not compact as easily. Figure 2 indicates the inverse relationship between soil organic matter and bulk density.

Figure 2. Relationship between Bulk Density and Organic Matter



SOIL SYMPTOMS

Soil symptoms can be seen in the field when compaction occurs. The following conditions can be indications of compaction:

- Surface crusting is the deterioration of soil structure on the soil surface. This can often occur from too much soil preparation. Crop emergence will be a problem.
- Erosion may become more severe. Since infiltration is reduced, there will be greater soil runoff. Erosion will increase compaction since the organic matter decreases as the subsoil becomes exposed.
- Standing water is also a symptom of compaction. The porosity is decreased from compaction which reduces infiltration. Infiltration can be reduced by up to 16 times when these pore spaces are compacted.
- Herbicide problems can also occur when a soil is compacted. The movement of the herbicide into the soil can be slowed since porosity is reduced. There can also be higher rates of carryover with herbicides that rely on microbial activity for breakdown. The efficiency of the microbes under compacted conditions is reduced considerably.

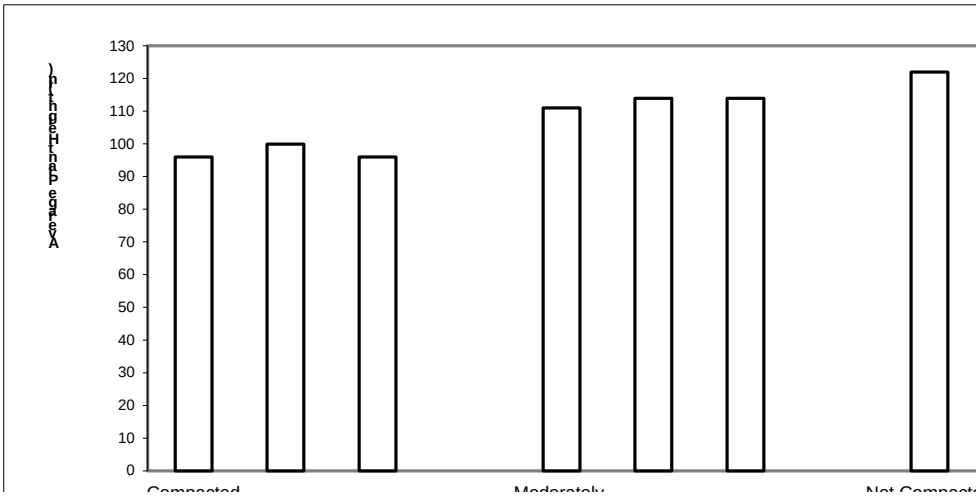
PLANT SYMPTOMS

The condition of the plants will show the effects of compaction and soil symptoms described earlier. There are many plant symptoms of compaction. These can be seen in both the above ground portion and root system.

- Slow emergence will often occur when soils are compacted. The surface crust will stress the young seedlings and delay emergence. The soils may also be wet and cool due to poor internal drainage from compaction. This will lead to disease associated with the seed.

- Uneven growth early in the season will also be a symptom of compaction. This also is due to poor aeration and reduced nutrient uptake when soils are wet and cool. This uneven growth will often continue through the season. Figure 3 indicates the difference in plant height at various rates of compaction.

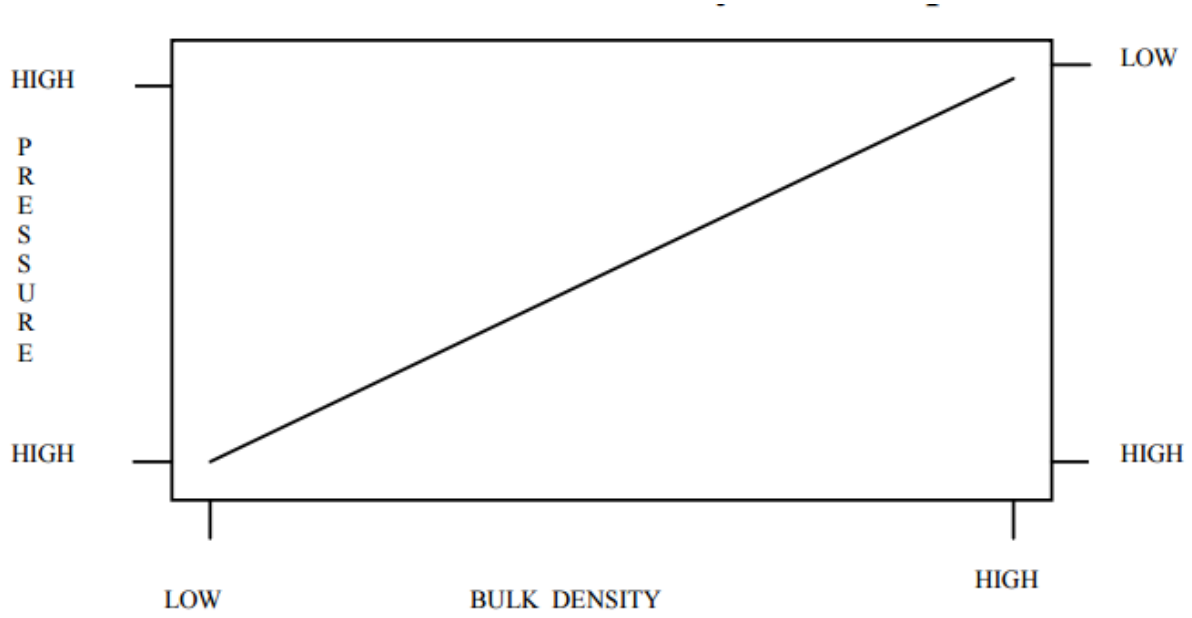
Figure 3. Plant Height of Corn Reduced from Compaction



- Purple color in corn plants is also a symptom of compaction. Poor internal drainage will reduce production of sugars in the plant. When this occurs, the plant will begin to produce a more prominent red pigment. Certain hybrids may tend to show this symptom more often.
- Rooting patterns are also affected by compaction. Often, a fibrous root system will grow horizontally along a compacted layer. This root system will generally be shallower and moisture stress can be a problem under dry conditions.
- Lodging can also be a symptom when compaction is present. The uptake of the potassium will often be reduced in compacted soils. Research has shown an increased rate of lodging as the potassium decreases in relationship to the nitrogen level.

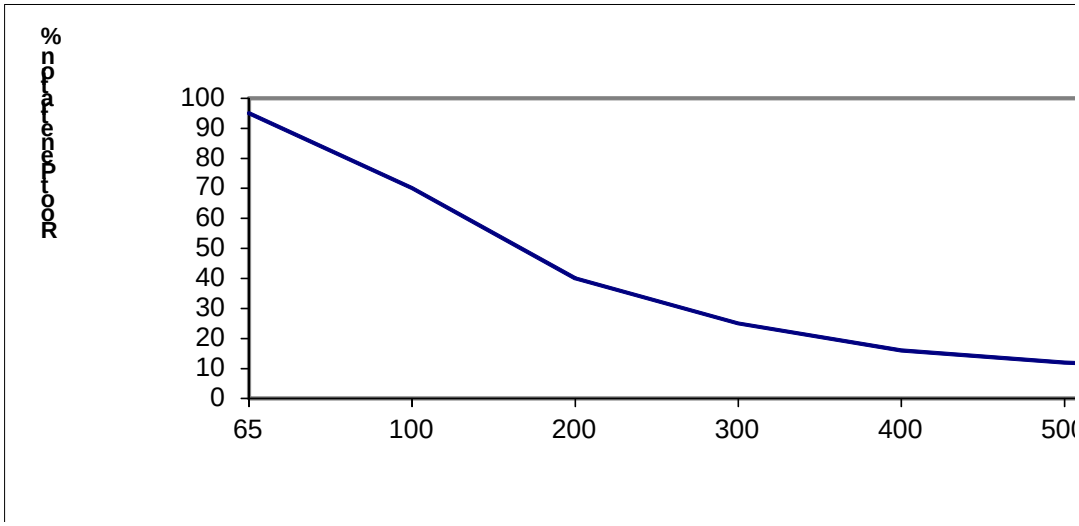
Measuring soil compaction can be very difficult since there are many parameters that will affect the compaction. A soil penetrometer can be used to measure compaction in the field. This is the measurement of pressure required to move the tip of a shaft through the soil at a constant rate. The moisture content of the soil will have an effect on compaction readings. As the soil moisture increases, the amount of pressure required to move through the soil will be reduced. Figure 4 indicates the lower amount of pressure required as the soil moisture increases at various bulk densities.

Figure 4. Effects of Moisture and Bulk Density on Compaction



To determine the actual amount of compaction with a penetrometer, additional analyses such as soil moisture and bulk density must be performed. However, a penetrometer can be used to compare areas in a field that would be similar in soil moisture and bulk density for compaction. Crops may be affected differently in terms of root restriction and crop yield. Figure 5 shows an approximate reduction curve for most fibrous root crops such as corn and small grains. However, this would shift depending on the rooting nature of various crops.

Figure 5. Root Penetration in Relationship to Soil Compaction



Compaction can reduce crop yields as shown in Figure 6. Corn yields were reduced significantly in compacted areas in comparison with non-compacted fields.

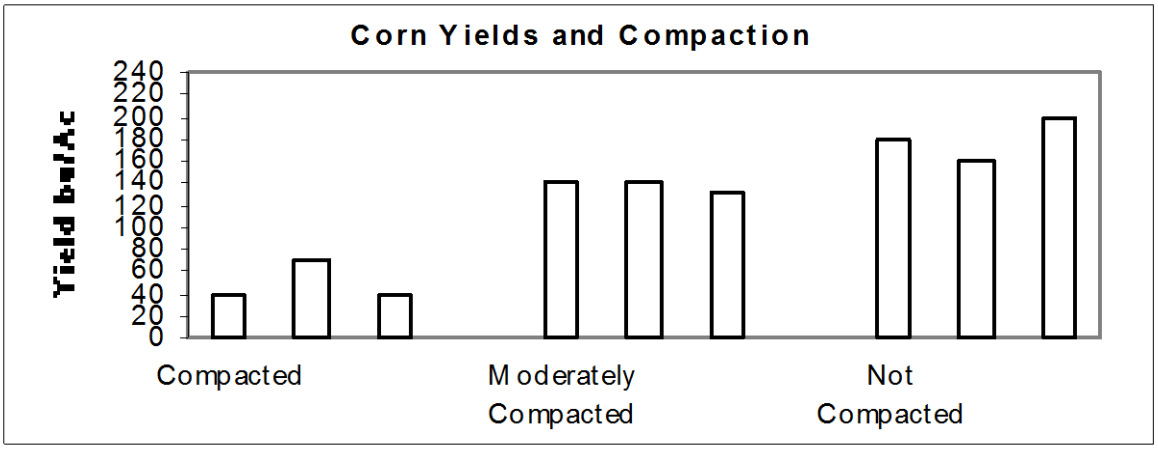


Figure 6. Corn Yields and Compaction

SOLUTIONS TO COMPACTION PROBLEMS

Soil compaction can be minimized once the causes of compaction have been determined. The following are ways to minimize compaction:

- The types of tillage equipment and number of passes should be examined for sources of potential compaction.
- Disc harrows along with large tractors and combines will cause compaction.
- Flotation tires will allow for the compacted area to spread horizontally instead of vertically and can be broken up much easier.
- Freezing and thawing will break up compaction on the surface. However, there would be very little effect on deep subsoil compaction. Subsoiling can be used to correct these deeper layers; although for the best results, the ground should be fairly dry.
- The addition of organic matter can also reduce compaction so crop rotation is essential.