Reducting Soil Compaction In Reduced-till Fields

Compaction is our biggest enemy in reaching yield goals. Densely compacted soils have little space for roots, soil organisms, water or air.

Soils are a living and breathing community of worms, plants, and billions of microorganisms. Like most living things, microorganisms require oxygen and water to survive. Some microorganisms digest residue, producing organic matter. Other bacteria break down organic matter into nutrients that feed crops. Compaction can severely reduce this activity. Without these billions of microorganisms, soil can become a lifeless piece of concrete.

During compaction, soil aggregates and soil particles are crushed and packed closer together, squeezing out pore space (Figure 1). Instead of the ideal pore space of *50* percent, compacted soils may show only 30 percent pore space.

The first pores to be lost are the large ones that carry air and water when the soil is wet. As the large pores collapse, smaller, less efficient pores are formed. Water penetrates at a slower rate. Drainage and aeration are reduced. Root growth is limited and so is nutrient uptake.

Uncompacted soils (left, Figure 2) have adequate space for oxygen to enter and carbon dioxide to exit. Oxygen is necessary for the uptake of nutrients like phosphorus and nitrogen. Bacteria need oxygen to digest residue and organic matter. As the digestion process takes place, carbon dioxide is released. Since carbon dioxide is toxic to root systems, it needs to be eliminated from the soil.

The highly compacted soil on the right in Figure 2 has reduced water-holding capacity. The soil is tight and drainage is restricted. Compacting soil is like squeezing a wet sponge. Porosity is decreased and the sponge becomes useless.

Visual symptoms: plants

Purple/stunted corn. This can be mistaken as a symptom of other

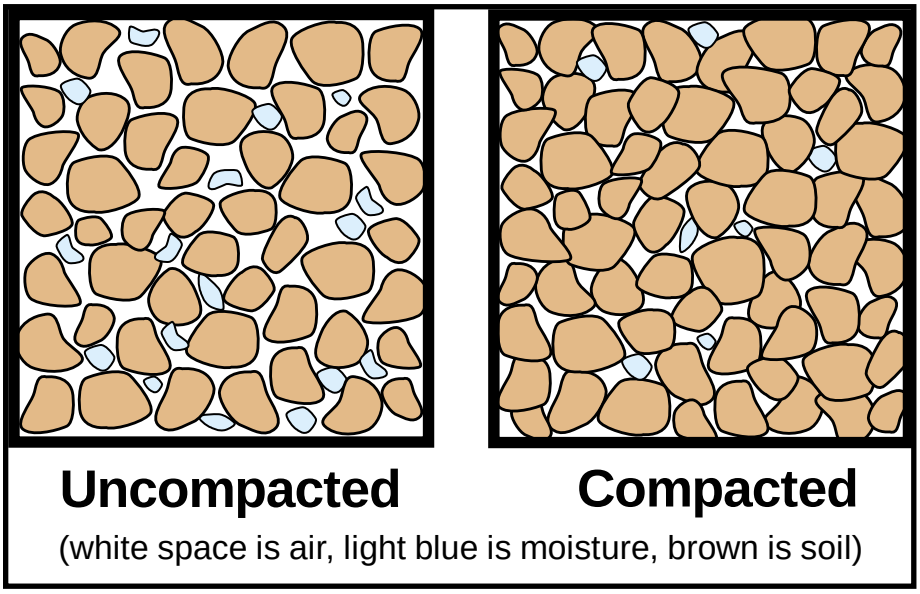

Figure 1. Effect of compaction on page space.

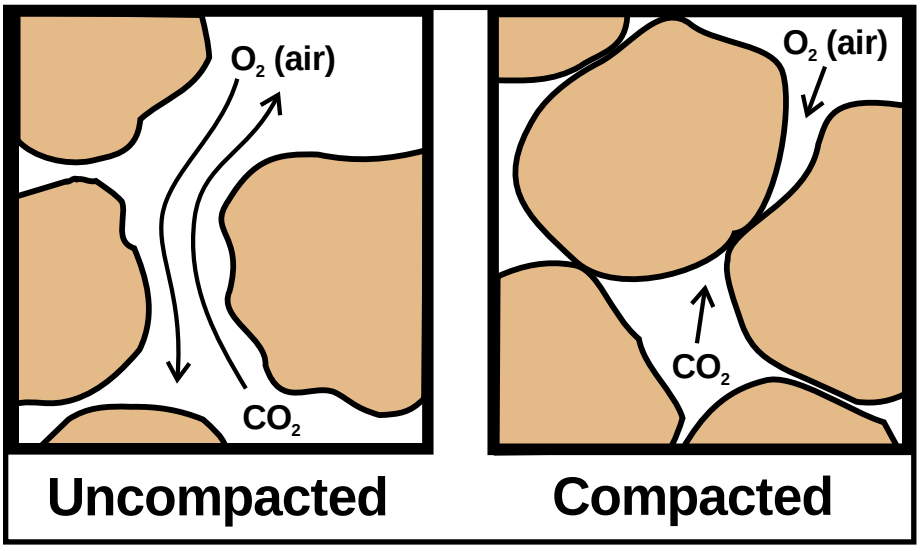

Figure 2. Effect of compaction on aeration.

problems such as phosphate deficiency or herbicide carryover. Compaction reduces availability of nutrients, causing stunted growth and discoloration.

Uneven growth. This is especially noticeable in corn and is usually caused by wheel tracks and hard pans.

Shallow root systems in a compact soil grow sideways and become malformed because of the hard pan. In uncompacted soil, roots grow in a diagonal downward direction.

Slow- or non-emergence. Severe crusting may cause the plant to leaf out underground. Once that happens, tiny plants may not emerge. Some corn and soybean varieties have more pushing power than others.

Dry weather stress results where compaction causes shallow root systems. Wilting and firing of plants occur.

Crusted soil is one of the most obvious characteristics of a compacted soil. Crust can form under the weight of equipment or develop naturally. Remember, a wind-driven raindrop has enough energy to shatter soil particles. Crust is most common on soils with high silt and clay content, but can develop on sandy soils.

Cracks in wheel marks, which run parallel to rows, most commonly occur in fine-textured soils.

Subsurface compaction or hard pans develop after using a disk or moldboard plow.

Table 1. Effects of different tillage on soil compaction, as measured in soil strength that inhibits root growth.

	Soil strength-lbs/in^2			
	Moldboard plow	Chisel plow	Spring disk	No-till
Surface	80	90	180	210
4 inches	110	150	280	260
8 inches	100	180	260	210
12 inches	140	200	240	205
16 inches	190	200	230	205

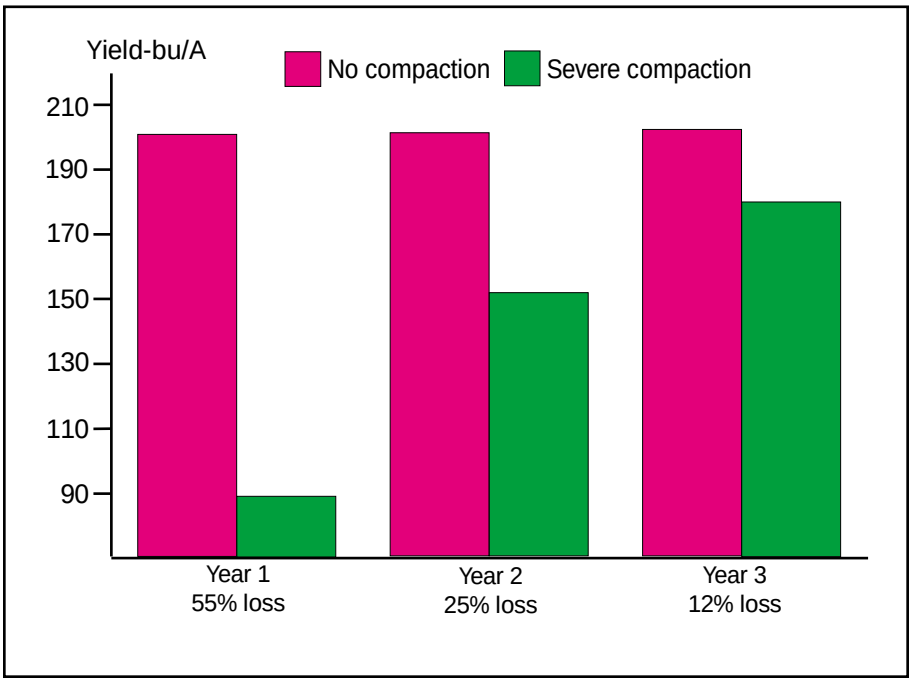

Figure 3. Yield losses due to compaction.

Standing water collects when rain or irrigation water does not rapidly enter soil due to crust or compacted conditions. It pools on surface or runs off to another site. Excessive soil erosion from water may also occur.

Increased pull or horsepower is needed to pull tillage equipment through dense, compacted ground, compared to loose, uncompacted ground.

Slower decomposition of residue is caused by an inadequate supply of oxygen. Occurs when soil is compacted or waterlogged.

Nitrogen deficiency results in compacted soils from gaseous loss of nitrogen caused by denitrification.

Herbicide carryover is common in compacted soils because microbial activity is reduced, causing poor herbicide performance.

Causes

Though equipment tires are generally blamed, there are other causes as well.

Soil type. Low organic matter soils have a tendency to compact more than high organic soils. In some soils very fine materials are washed from the surface or fill subsoil pores. This results in greater compaction. In other soils the tremendous weight of glacial ice has been a natural compacting force.

Excessive tillage. Back in the ‘40s, a three-ton tractor plowing eight inches deep caused little compaction. Today, 4-wheel drive tractors that weigh up to 20 tons, combined with shallower tillage, produce more compaction than ever.

Working wet soil. In the spring, working the soil even a half to a full day too early can cause compaction. Check moisture level at the depth you plan to till. The first trip is the most important. Up to 80 percent of compaction can be caused by the first tillage.

Overusing disk. The disk is a compacting tool. The edges of the blades exert tremendous pressure on the subsoil at their point of contact.

Slow speeds. Higher speed equals less compaction. The faster a vehicle travels, the less compression is exerted under the tires.

Tire slippage. Pulling large implements with too small a tractor can create tire slippage. As drive tires slip, the weight of the tractor plus the shearing force of the tires can drive compaction deep into the subsoil.

Extra trips. Many fertilizer programs are designed so that a separate operation is used to apply each nutrient. Whenever possible, combine fertilizer application with tillage operation when you apply other crop protection products.

Low organic matter. Organic matter promotes coarser and stronger soil aggregates. At lower moisture levels, aggregates stick together to maintain larger pores than if broken down into individual particles. Organic matter is also much less dense than the mineral components of the soil. Prairie soils with five to eight percent organic matter are less likely to compact than soils with only one to four percent organic matter.

The costs

Impeded root growth. Generally, roots cannot grow into a soil with a strength above 270 lbs/in^2. Minnesota data in Table 1 show various soils strengths under different tillage methods. On plowed ground, soil strength is not high enough to restrict root growth. But look what happens when tillage is reduced. It approaches a level that can restrict root growth. Under spring disk at 4 inches, where soil strength is 280 lbs/in^2, a hard pan develops that is strong enough to restrict root growth. Under no-till, it develops high soil strength all the way down.

Reduced fertilizer efficiency. In Iowa State University tests, compaction reduced nitrogen uptake 30 percent, potassium uptake 70 percent, magnesium uptake 20 percent, and calcium uptake 10 percent. Compaction reduces oxygen levels in the soil causing denitrification. Nitrogen is lost by conversion into gaseous forms that are released into the atmosphere.

Decreased soil porosity. Water infiltration into the soil is limited.

Reduced yield. **In Purdue University** tests (Figure 3), the corn plot yielded 200 bu/A where there was no compaction. Where the crop was subjected to severely compacted soil during the first year, yield dropped to less than half, raising the cost per bushel. Freeze and thaw cycles eased the severity in subsequent years.

Preventing

Don't use disk. Since disk blades create a hard pan, field cultivators or combination tillage tools are preferable. Another advantage of these tools is that they can be operated at faster speeds, thus reducing compaction.

Use lighter equipment. This includes avoiding giant harvesting equipment that can cause compaction in a wet fall.

Use wider tires such as flotation or dual tires that spread compaction out horizontally at a shallower depth.

Subsoil. Such a practice is effective if done when soil is dry enough to shatter the layer. It must be deeper than the compacted layer.

Ban livestock from unfrozen fields. They can compact fields into a concrete mass.

Build organic matter to bind aggregates together to promote good soil structure, which prevents soil compaction. Such aggregates are not easily broken down by secondary tillage or traffic.