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Contending with Soil Compaction

Kenneth L. Wells
University of Kentucky

Lloyd W. Murdock
University of Kentucky, lmurdock@uky.edu

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, Kentucky 40546

COOPERATIVE EXTENSION SERVICE

Department of Agronomy

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Why Do Soils Compact

Most compaction results from use of machinery on soil which is too wet to work well, or from overworking soil and destroying natural structure. The resultant pressure from tires and tillage tools compresses more soil into a given volume. Regardless of reason, the proportion of solid soil material relative to total volume of soil increases. In the process, natural soil aggregates are broken down and large pores become smaller, generally resulting in soil more difficult for plant roots to penetrate.

Moldboard plowing wet ground compacts soil 8-12 inches deep when the tractor wheel travels in the open furrow at the edge of the previously plowed round. Disk harrows are the tillage tools which can cause the most compaction. The weight of a disk transmitted to the soil on the bottom edge of each blade creates enough pressure on a wet soil to compact a zone 4-8 inches thick just below the disk blades. Compaction seems to be more commonly observed in tobacco production where soils are often over-worked and worked wet.

Wheel tracks from implements used on a wet field can also contribute to the compaction problem. The trend to much larger and heavier equipment during the past several years means that axle weights have increased significantly. A four-wheel drive tractor, a large combine with a full grain hopper, a loaded manure wagon, and loaded fertilizer spreaders or trucks exert great pressure on the soil below wheel tracks. These can compact soil 12-20 inches deep. When the degree of compaction is sufficient to diminish pore space to the point that oxygen diffusion, water movement and root penetration into and through the soil are limited, crop yields are likely to be lowered.

There is no specific bulk density value at which this takes place, due to the fact that soil texture, organic matter content, and structural stability vary from field to field and greatly influence the size and shape of pores in any given soil. Poorly structured soil is easier to compact than well structuredsoil. Soil with a reasonable amount of organic matter will generally have better structure than soil with little or no organic matter. Soils of sandy textures are generally more easily compacted than loam or silt loam textures. And most importantly, wet soils compact more easily than moist or dry soils.

Can Soil Compaction Decrease Fertilizer Uptake?

Obviously, when compaction is serious enough to limit root proliferation through soil, nutrient and water uptake will be limited since a much smaller volume of soil is being explored. If compaction is great enough to prevent root growth in the bottom of the plowsole, plowdown of broadcast fertilizer will be of little use to the growing crop. USDA-ARS research at Morris, Minnesota, has shown no root growth at all in the 10-12 inches of soil directly under a wheel track. In fields where there are wheel tracks on both sides of planted rows, it was estimated that as much as 60 percent of broadcast fertilizer may be inefficiently used because of wheel track compaction. It was also reported that such a pattern can reduce the total mass of nodules on soybeans by as much as 30 percent, thereby limiting fixation of atmospheric nitrogen. Studies of fertilizer placement methods have shown benefit from a band or starter placement of fertilizer on some compacted soils.

If soils are compacted to the point that root growth and oxygen permeability are reduced, crop yields can be reduced. And, yields may be reduced for more than one year. In a Purdue study, corn yields four years after compaction were still much lower than those from uncompacted soil. That study suggested that chisel plowing was not very effective in improving yield from compacted soil as compared to deep subsoiling. This indicated that the bottom of the compacted layer was deeper than the chisel plow reached. Reduced tillage and no-tillage have been found to minimize compaction problems, probably because they promote improved soil structure.

Contending With Compaction

Compaction problems can easily pop up following a season in which land preparation has been delayed by wet weather. Even though the surface may dry out enough to permit traffic, deep compaction can result on fields where subsoil is still wet. While compaction can be recognized when a wet soil surface layer is worked or trafficked , it's harder to be aware that wet subsoil overlain by a dry surface can be compacted. Soils which percolate water slowly through the subsoil are prime candidates for such compaction. Deep wheel tracks in a field indicate compaction is taking place, even though they are subsequently filled and smoothed during field preparation.

The question is how to overcome soil compaction. It is relatively easy to prescribe prevention of undue compaction (stay off wet fields and minimize use of disks, moldboard plows, and heavy equipment). It is not easy to prescribe how to alleviate the problem after it occurs. Some often stated misconceptions about cures for compaction and the real facts are:

- overwinter freezing and thawing of compacted land plowed in the fall will cure the problem. Research does not support this. Although it may help in the short run, overwinter freezing and thawing may never totally cure deep compaction.

- if you traffic over a wet field only once, you won't do much damage. Tests have shown that the first pass over a field results in about 80 percent of the total compaction which resulted from three additional passes over the field in the same tracks.

- adding more fertilizer will alleviate plant mineral stress. It may, but this practice treats a symptom of compaction instead of contributing to the cure.

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- compaction is a fleeting problem which will disappear. It won't, despite the wide range in effect it has on crop production due to year-by-year weather and management variation. A significant concern is the long term use of large, heavy equipment and its implication for deep compaction. While breaking up compacted layers in the plow layer is mechanically possible, options are extremely limited and often impossible for compacted layers below the plow layer.

What can be done to "uncompact" compacted soil? In trying to come up with a technique, remember the principle of what you're trying to do...increase the porosity of the soil. Identify [1/] the depth and thickness of the compacted layer because this will influence what type of tool to use in breaking it up. When tillage or subsoiling is to be used, be sure the compacted zone, whether shallow or deep, is dry enough to shatter when the operation is performed. Fall is generally best because subsoil is usually drier then and will shatter better. Incorporation of residues as deeply as possible will also help. Long-term work at Michigan State University has shown that rotations can help, particularly those with alfalfa in them. Sweet clover is also a deep rooted legume crop considered to be useful in rotations to help compacted soils. Trials on several fields in Kentucky indicate that corn yields can be increased 10 to 20 percent by subsoiling severely compacted soil.

Not all soils will benefit from subsoiling. Subsoiling a field which is not compacted is of no economic benefit. Taking time to determine if a field is really compacted and then identifying the depth to and thickness of compaction is the first step to take in contending with the problem. With this information, options can then be identified for consideration or attacking the problem.

K. L. Wells, Extension Soils Specialist

[1/] A tiling rod or a 3-ft length of 3/8-inch diameter steel rod sharpened on one end and having a handle welded to the other end are easy tools to use in identifying compacted layers. Such tools should be marked in 6-inch increments and should uniformly be pushed into soil when the moisture content is about right for plowing. Under these conditions, compacted layers can be "felt" due to resistance in pushing the rod through the soil, and depth to and thickness of the compacted zone can be identified.