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IDENTIFYING AND MANAGING COMPACTION IN FIELD CROP PRODUCITON

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Causes of compaction

The need to conduct field operations in a timely and efficient manner has given rise to concerns regarding soil compaction. Today farmers are managing greater numbers of acres with limited increases in labor. Tractors, harvesting equipment, and other implements such as manure tankers have become larger to maintain efficiency. Even so, time pressure often results in conducting operations when soils are wet. These factors have combined to increase the incidence of the "productivity robbing" effects of soil compaction.

Typically soils are 50% solid and 50% pore space, with about half of the pore space filled with water when a soil is at its field capacity water content. Forces from wheel traffic and tillage consolidate the soil, first reducing the number and size of larger pores. The large pores are important for water and air movement. Additional force destroys the soil structure itself.

Bulk density, defined as the mass of soil per unit volume, is one measure of soil compaction. Table 1 shows the soil bulk density over three years following wheel traffic compaction from a 14-ton vehicle. In this example the field was compacted and worked lightly prior to seeding alfalfa. The change in bulk density is visible well below the plow layer and is relatively unaffected over the three years. This suggests that compaction effects are long-term and are not quickly ameliorated by natural factors such as freezing and thawing.

Table 1. Bulk density of a silt loam soil following compaction with a 14-ton vehicle.

		Year		
Depth	Compacted	1	2	3
inch		--------	g/cc	--------
0-6	No	1.19	1.30	1.32
	Yes	1.36	1.41	1.40
6-12	No	1.31	1.33	1.31
	Yes	1.59	1.50	1.52
12-18	No	1.29	1.35	1.33
	Yes	1.45	1.44	1.39
18-24	No	1.36	1.35	1.34

Yes	1.40	1.34	1.33

Diagnosing compaction

The signs and symptoms of compaction are visible by examining the response of the soil and crops. Compacted soils have imperfect drainage, resulting in ponding and increased runoff. Where the structure is destroyed the soil will be cloddy. A horizontal or platy type of structure can also develop in the upper soil layer. The latter is more common where heavy equipment is repeatedly driven over the soil.

Compaction effects are also exhibited in the growth of the plant. Uneven height growth is common. Often adjacent plants are affected with one appearing normal and the other stunted. Root system will be malformed such that horizontal development occurs at the restrictive layer. Nutrient deficiencies, especially K, can develop in response to poorer aeration in the soil. Compaction almost always causes a loss in yield. The magnitude of the yield loss is often related to the weather conditions during the growing season. Therefore, compaction may affect yield in one year and not in another.

There is no specific measurement that can be made to identify a critical level where soil compaction will reduce crop production. Measurements should be made that compare areas where compaction is suspected and where it is unlikely. For example, compare a headland with an area in the main part of the field. It is often useful to excavate the soil to examine the soil structure and evaluate plant root distribution. Be sure to note the depth at which compaction occurs.

Increasing bulk density is indicative of compaction, but the value is affected by soil texture and depth in the soil. Most farmers or crop advisors do not have the appropriate tools to make this measurement.

A common assessment device is the penetrometer, a cone tipped rod that is pushed into the soil at a constant rate. It measures the resistance to penetration and somewhat simulates what a growing root would experience. Simple penetrometers have a dial that translates the force into green, yellow, and red zones. Advanced units can be calibrated to measure and record the resistance in units of pressure. Either tool should only be used to make a relative comparison between different areas in a field. The soil water content will have a significant impact on the penetration resistance. It is recommended that measure-ments be taken when the soil is at its field capacity water content.

Yield response research

The effect of compaction has been studied at several locations in Wisconsin. One study examined the interaction of K fertility and corn yield on a Kewaunee silty clay loam soil near Oshkosh. The results of this study are shown in Table 2. Clearly, compaction reduced yield. Some of the yield loss was recovered by K fertilization, but the best yields were found when the soil was not compacted and the crop was fertilized adequately.

Table 2. Response of corn to K fertility on a compacted silty clay loam soil (2-yr. avg.)

Comp.	Soil test K	Row K	Yield
			bu/a
No	Optimum	No	151
		Yes	168
	High	No	168
		Yes	168
Yes	Optimum	No	129
		Yes	164
	High	No	148
		Yes	151

Row K = 45 lb K_2O/acre; compaction made with a 19-ton vehicle.

A similar study was conducted at the Arlington Agricultural Research Station on a Plano silt loam soil that examined the effect of compaction prior to the direct seeding of alfalfa. Manure or fertilizer application prior to seeding may cause compaction. The entire soil area of the compacted plots received traffic with a 14-ton vehicle to create a "worst-case" situation. Table 3 shows the yield reduction associated with compaction over the life of the alfalfa stand (seeding year plus three hay years). Most of the yield loss occurred in the seeding and first hay year.

As with corn, a response to K fertility was found. It is believed that the reduction in porosity caused by compaction reduces oxygen availability to roots, limiting root respiration, and thereby limiting K uptake. Potassium fertilization maintains a higher level of K at the root/soil interface.

Table 3. Compaction and K fertility effect on alfalfa production (4-yr. total).

Comp.	Soil test K	Yield
		T /a
No	Opt	11.1
	High	10.8
	Very high	11.4
Yes	Opt	9.1
	High	9.8
	Very high	10.2

Alleviating compaction

Whenever possible soil compaction should be avoided. Practices such as limiting operations on wet soils, reducing load weight when possible, and controlling traffic will go a long way toward maintaining soil productivity. Adding extra tires (duals) will spread the vehicle weight over a greater area, but may not reduce compaction. In fact duals may encour-age operations on wetter soils, spreading its effects over a greater area. Control traffic by limiting practices, such as "chasing the combine" or driving grain trucks or "nurse" trucks for manure applications in fields.

Often subsoiling is considered when compac-tion problems are severe. Subsoiling can be conducted with a variety of tillage tools that will have a variable effect depending on soil conditions and the tool used. For example, an on-farm research study conducted recently in Manitowoc County demonstrated that subsoiling with a relatively narrow straight shank produced higher yields than an aggressive parabolic tool that shattered the entire soil volume (Table 4). It is possible that the soil structure was unfavorably affected with the aggressive tool and soil conditions were less favorable for growth following tillage. Studies conducted at other locations did not show a response to subsoiling.

Table 4. Comparison of subsoiling tools in a corn/soybean rotation on a silty clay loam soil.†

Crop		Subsoiler type	Yield
			bu/acre
Soybean			
	Year 1	No-till	30
		V-ripper	40
		Straight shank	51
	Year 3	No-till	57
		V-ripper	58
		Straight shank	59
Corn			
	Year 2	No-till	213
		V-ripper	188
		Straight shank	226
	Year 4	No-till	176
		V-ripper	172
		Straight shank	192

† Subsoiling conducted in the fall in the year Prior to planting crops.

Before deciding to subsoil it is important to diagnose the existence of compaction and to record the depth of the restrictive layer. If subsoiling is done it should be conducted no deeper than 1-2 in. below the layer. Other subsoiling considerations include:

- Avoid implements that bury too much crop residue. This may impact conservation planning goals.
- Subsoiling that inverts the soil may bring clay and less fertile soil to the surface. More stones will have to be picked 40-50 hp per shank is needed to pull most subsoilers.
- Always include untreated check strips to determine if subsoiling is beneficial.

Summary

Soil compaction problems will continue to be an issue in modern agriculture. Use common sense to manage or avoid the occurrence of compaction. Reduce loads, stay off wet soils, and control traffic. Maintain soil fertility by following soil test recommendations especially with respect to K. Use a complete starter fertilizer for corn and be sure to re-supply crop removal of K from alfalfa. Look for compaction symptoms and physically identify the existences of a restrictive layer before conducting subsoiling operations. Do not abuse the soil in the fall expecting that over-winter conditions, or other natural forces, will correct compaction.