Soil Compaction Problems of 1993

Stewart W. Melvin
Iowa State University

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The 1993 crop season will be one that few Iowa farmers will forget. Excess precipitation was common from the last half of 1992 and throughout the entire 1993 cropping season. There has been an increased concern over soil compaction problems throughout this season, and what these problems may create for the 1994 crop year. The objective of this paper will be to review how and why the problem has occurred and what should be done, if anything, to minimize the problem in 1994.

Soil Conditions—Fall 1992

Many fields were harvested under poor soil conditions in the fall of 1992, especially in western and southern Iowa. Last fall's weather was wet and cool which delayed drydown of crops, which, in turn, led to a later than normal harvest. Excess rainfall during the latter part of the growing season left most soils at or above field capacity moisture levels. Heavy harvest loads created ruts in many fields that remained all winter since little fall tillage was possible in these fields. Even no-till fields were left with harvest machine ruts throughout the winter. By freezeup, most soils were approaching saturation near the surface.

Spring Conditions—1993

Above normal precipitation continued throughout the early planting season in April and May in most parts of Iowa. Throughout the winter, snowfall and rainfall kept the surface of most soils nearly saturated. In addition, there was relatively shallow penetration of frost in soils as a result of snowcover, wet conditions near the surface, and relatively warm minimum temperatures. As a result, soils had their natural structure destroyed by puddling near the surface. Spring rains only added to the soil structure problems. When drying conditions finally did occur, these soils dried slowly since macropores were destroyed, and only very fine pores remained. Many producers complained of "hard soil crust on top of mud." This condition was especially frustrating for many no-till producers since it led to planter penetration problems, while at the same time they found that at seed depth, the soils were wet enough to create "sidewall compaction" problems from the planter openers.
Few fields were tilled this spring without having some spring compaction problems. Tractors performing field operations created compaction zones beneath wheel tracks because soils were wet at depths of 4-8 inches during field operations.

Even though many fields were compacted this spring during field operations, the compaction resulting from most spring operations probably did not penetrate more than 6-8 inches deep, since most axle loads were less than 7-8 tons. However, these compaction zones were slightly deeper than the depth of secondary tillage. As a result, seeds were planted above shallow compaction zone "bands" in many fields that had secondary tillage. There was much evidence of delayed growth patterns in many fields of crops growing immediately above these shallow compacted zones as witnessed by diagonal track patterns evident in many fields this summer.

In a demonstration field west of Ames, we completely covered plots with wheel traffic twice prior to field cultivation with a tractor with an axle load of 7.5 tons to determine the problem with shallow compaction. The effect of compaction was visually evident throughout the growing season. Soil compaction in that plot could not be found below 6-8 inches with a soil penetrometer. Since this was an extreme case of spring soil compaction, it would appear that most of the compaction in the spring of 1993 would be relatively shallow and would not require deep tillage for removal.

Fall Conditions-1993

Since the first of October, Iowa has experienced an unexpected dry period for harvest. The northern part of the state received less rainfall in late September, so soybean harvest started near the first of October. October precipitation was below normal for most of the state. Much of the soybean harvest was completed by mid October. Corn moisture was wet, so many producers have been tilling soybean ground in the last two weeks rather than harvest corn. Corn acreage harvested is also experiencing significant tillage this fall immediately after harvest. Deep tillage is being promoted in many areas on the basis of "relieving" the soil compaction that is expected by many farmers. Soils are still at or slightly above field capacity at depths 4-6 inches below the surface now, and will probably stay that way throughout the fall until freezup. Many deep tillage tools will not fracture soil to the depths of penetration under moist soil conditions. Those tools that have narrow shanks (2-3") width running at depths greater than 8-10 inches are probably making "grooves" in the soil at deeper depths.

A common observation is that the surface soil in many fields is firm even in relatively wet conditions. In many soils, it appears that the condition of the surface soil has not improved significantly since spring, and may have further degraded as a result of the breakdown of soil structure near the surface. This structural breakdown is more common in fields where there was little surface residue to absorb some of the energy of the raindrops during this summer’s many precipitation events. Soils with lower organic matter near the surface probable experienced more structural breakdown as a result of prolonged saturated or nearly saturated near the soil surface.
Soils with lower organic matter inherently have lower soil structural stability. The predominant structure of some of these soils is what is known as a massive or structureless where soils retain single grained properties, with little or no macroporosity. Soils under these conditions can have a restricted infiltration rate and can generate higher than normal amounts of surface runoff during precipitation events since the surface has a low permeability for water. These soils have high surface soil strength which has assisted with harvest. Soils have been able to hold up the harvest loads without rutting and resisting further deep compaction.

The major soil management question that needs an answer is whether tillage should be performed on damaged soils this fall or not? Some of the variables that need to be considered are previous crop, water and wind erosion potential, conservation compliance plan, soil type and next year's cropping and tillage plan.

If residue cover must be maintained as a result of conservation compliance requirements, the question of whether to till may be mute. Since the compaction problem is predominately shallow, winter freezing and thawing may relieve much of the problem before next spring. If the winter is relatively dry, with a minimum of snow cover and with a large number of freeze-thaw cycles of this surface layer, much of this fall's compaction problem will disappear. On the other hand, if the soil stays wet, and is insulated with a snow cover, the problem may remain next spring, much like it was in 1993.

If the soil does not have an erosion potential, and particularly if it is poorly drained, there may be some benefit in some shallow fall tillage to develop a macropore system to assist with drainage. Under wet conditions, it is unlikely that anything other than shallow tillage (8 inches or less) will be effective. Even though there is a perception of major deep soil compaction problems resulting from the 1992 wet harvest, there has been little evidence of other than shallow compaction problems in most fields. Therefore, deep tillage during the fall of 1993 may not be warranted in most fields. If there is evidence of deep compaction, ie. slow internal drainage, deep rooting problems, water standing in old ruts, etc., deep tillage in the future may be considered.

Many of the deep tillage tools today cannot effectively shatter soil from the cutting point to the surface under wet soil conditions. For a given geometry of the tool, a given soil type and moisture content, and the previous compaction state of the soil, there is a "critical depth" to which a tool can work where soil is sheared from the depth of operation to the surface. If the tool is run deeper than this critical depth, soil below the critical depth will flow sideways around the tool rather than move upward in front of the tool. This will create "groves" in the soil below the critical depth with high density sidewalls which are more harmful than beneficial. In addition, the cost of energy is wasted by operating the tool at below critical depth. Therefore, tillage should not be done at depths below the critical depth of the tool that is being used. Deep tillage tools with a wide blade or with wings and those which operate at a low angle of entry tend to have deeper critical depths than those with narrow blades at higher angles of entry.
Before any tillage is done this fall, soil examinations should be performed to determine what the problem is, where it is located, and what is needed for soil improvement. The best tool for this is with a spade. Examine the structure of the soil at various depths in the field. Where the natural structure of the soil has been damaged, as evidenced by massive structure, with natural planes of breakage horizontal rather than vertical, tillage may be beneficial by creating new fracture planes in the soil to assist with natural amelioration processes of freezing and thawing, wetting and drying along with soil biological processes.

Many damaged soils could benefit from rotational cropping systems which include grasses, legumes or small grain rather than a row crop next year. If low wet areas have had evidence of physical damage during the last 12 months, perhaps a small grain crop could be considered in these critical areas in 1994, which would permit deep tillage or the installation of an improved drainage system in the late summer of 1994.

Summary and Conclusions

Even though there is a major concern regarding soil compaction in the fall of 1993, it appears that it is more of a problem of the surface layer of soil rather than at subsoil depths. If that is the case, natural processes may remove much or all the problem before the spring of 1994. For poorly drained soils with little wind or water erosion potential, shallow tillage may be of value this fall to restore macropores to improve the permeability of the surface soil. Under wet conditions, deep tillage is not recommended unless equipment is used that can operate effectively at the depths where compaction problems are known to be present and the tool can effectively improve the soil condition at that depth. Unless such precautions are taken, only tillage of the poorly structured shallow layer of soil should be performed.