Factors Affecting Drainage on Corn Land

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Drainage is the most important water management need on much of the corn land in the United States. Excess water on field surfaces and in the root zone restricts production on about 25 percent of the U.S. cropland, as reported by the Soil Conservation Service in a 1977 resources inventory.[1] Corn is particularly vulnerable to poor drainage. Delayed planting, plant stress during the growing season and harvest delays all contribute to reduced yields. When water fills the larger soil pores, corn growth is retarded due to oxygen deficiency, increased carbon dioxide levels, denitrification and reduced microbial activity. The overall result is lower corn yield and poorer grain quality.

Drainage of corn land is affected by a number of factors, including soil properties, land slope, type of drainage system, drain installation practices, drainage outlet and the soil/crop management system. In arid regions where irrigation is needed for corn production, drainage is also required to facilitate leaching to maintain a low salt concentration in the soil profile.

SOIL PROPERTIES

The amount of sand-, silt- and clay-sized particles in the soil determines the soil texture. Coarse-textured soils, such as sands and sandy loams, have much larger particles and larger voids between the particles. These soils drain easily unless there is an underlying restrictive layer or upward water movement that prevents free drainage. Crusting is often a problem on mediumtextured silty soils. The crust restricts water movement through the soil surface and causes water to stand on the field unless there is good surface drainage. Fine-textured soils, such as clays and clay loams, have mostly small particles and, therefore, contain very small voids (pore spaces) between the particles. These soils drain slowly.

The way the sand, silt and clay particles are joined together into stable units or aggregates is termed "soil structure." Soil structure also affects drainage. The spaces between the aggregates are interconnected with large pores where water and air can move freely. Some soils are structureless and may be single grained (like sand) or massive (where the particles are joined in a cohesive mass without aggregates and voids). Massive structure can occur in some loams or clayey soils. Water and air movement is very slow where this structure occurs.

Some clay minerals, such as montmorillonite, swell on wetting and shrink on drying, while others, such as illite, are nonswelling. Swelling clays restrict water movement when they become wet because swelling closes the pores, preventing water and air movement.

Other soil properties may also be important in drainage. Organic matter promotes good structure, and, as the organic matter content increases, the internal water and air movement are improved. Certain soils support sludge-forming iron bacteria that can clog subsurface drains. Soils with high amounts of sodium will not become aggregated or, when wetted, will disperse and become nearly impermeable to water.

LAND SLOPE

Sloping land permits water to run off the field by gravity, while flat land has wetness problems unless there is good natural or artificial drainage. Even with adequate slope, however, corn land can still have drainage problems due to side hill seepage. Land on floodplains may be subject to periodic flooding and require special attention to enhance surface water removal.

TYPE OF DRAINAGE SYSTEM

Drainage guides published by state agencies and/or the Soil Conservation Service provide useful information for designing a drainage system for corn.[2,3] Soils with good internal drainage may require only surface drainage, and fields with good surface drainage may require only subsurface drainage. However, wet soils usually require a combination of surface and subsurface drainage for most effective drainage of corn land. For the Toledo silty clay soil in Ohio, 13 years of research showed that average annual corn yield on plots with combined subsurface and surface drainage was 38 percent higher than on plots with surface drainage alone and 9 percent higher than on plots with subsurface drainage alone.[4] In addition, subsurface drained plots had only an 18 percent yield variation from year to year, whereas plots with only surface drainage had a 33 percent yield variation. A low percentage variation means less economic risk. In some cases, a permeable backfill over and around subsurface drains improved drainage.

In another 16 year experiment with Nappanee silty clay soil in Ohio, it was shown that subsurface drains spaced 30 feet apart removed 43 percent more water annually than drains spaced 60 feet apart.[5] Drain depths of 2 and 3 feet resulted in about the same volume of drainage.

DRAINAGE INSTALLATION PRACTICES

Subsurface drainage systems for corn can be installed with a variety of machines, primarily wheel trenchers, chain trenchers and drainage plows. These machines are moved on rubber-tire wheels or on tracks. Surface drainage systems are installed with wheel scrapers, bulldozers, graders, land planes and other earth moving equipment. To be effective, subsurface and surface drainage systems must be installed with proper grades and other good design features. This is the responsibility of the drainage contractor.

The soil moisture condition at the time of installation is an important factor in relation to successful drainage. Much corn land is subject to compaction and structural damage when it is wet. Drainage machines can compact wet soil and cause reduced water movement into the soil surface as well as through the upper soil profile. Slippage of wheels or tracks on wet soil smears and compacts it, restricting water movement. Trucks, cars and other vehicles associated with a drainage installation also add to the compaction problem. Therefore, wherever feasible, a drainage system should be installed when the soil is not in a plastic condition. Sometimes this may require that a drainage system be installed in the summer, even through a growing crop.

DRAINAGE OUTLET

A common barrier to drainage development for corn land is the lack of an adequate gravity outlet such as an open ditch, natural stream or large subsurface drain. If the surface and/or subsurface drainage system does not have a free outlet, water can back up into the system and flood the root zone, field surface or both. A pump drainage outlet can often be used where a gravity outlet is not available. Surface drainage systems require maintenance to avoid low areas where water can stand in the field or in the drains themselves.

SOIL AND CROP MANAGEMENT

The effectiveness of a drainage system is strongly influenced by soil care and cropping practices after the system is installed. When fine- and medium-textured soils are worked too much, particularly when they are wet, soil structure is impaired. This prevents proper movement of water into the soil surface and through the soil profile to tile drains. A well developed soil structure allows free movement of both water and air, which improves the efficiency of drainage systems. Crusting problems can be relieved with tillage or surface crop residue mulch.

Continuous row cropping for many years, without cover crops or legumes and grasses in a rotation, can lead to ineffective drainage due to impairment of soil physical properties and slow water movement. For the Nappanee soil in Ohio, drainage in the spring was greatly improved in fields being prepared for corn planting when preceded by 2 years of meadow rather than by an annual crop such as oats or wheat. Excessive wheel traffic with farm machines on wet fields can be a problem, as can compaction from livestock allowed to graze wet fields.

Improving soil drainage is one of the most important ways to increase corn yields and improve corn quality. Many factors affect drainage, and successful drainage requires close cooperation among drainage system designers, drainage contractors and producers.

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