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SOIL DRAINAGE---EFFECTS ON CROP PRODUCTION

K. L. Wells

One of the major physical properties of soil which is important to crop production is drainage through the rooting zone. This characteristic greatly influences aeration in the rooting zone, and the degree of aeration greatly influences several important biochemical reactions of economic importance to crop production.

Ideally, any given volume of soil should be comprised of half solid material and half porespace. The more compact the soil (higher bulk density) the lower will be the proportion of porespace to solid material with a resulting lowered capability to hold air and available water. The porespace is made up of all the cracks, voids, old root channels, insect tunnels, etc which are interdispersed throughout the soil volume. These voids are normally occupied by varying proportions of air and water. If a soil is completely saturated with water, all porespace is occupied by water, leaving no space for air.

When the soil is completely saturated and the source of water is stopped, part of the porespace drains free of water due to the force of gravity in well-drained soils. These pores which drain due to gravitational forces are larger in size than those pores which hold water against the force of gravity. For this reason, the term "large porespace" is used to define those pores which drain free of water due to gravity. "Small porespace" or "capillary porespace" is the term applied to those pores which continue to hold water against gravitational forces.

Ideally, about half the porespace would be "large", thereby providing a reservoir of air for plant roots, and half would be "capillary", providing a reservoir of water. With a high proportion of "capillary porespace" drainage of water and movement of air through soil is slowed to the point that soil air content may become limiting for optimum plant growth. With an excessive proportion of "large porespace", movement of water through the rooting zone is more rapid but can result in insufficient storage of available plant water.

Soils of high clay content are noted for having a high proportion of "capillary porespace". While water may move through such soils, it does so slowly. Such soils usually become waterlogged overwinter in regions of abundant winter rainfall, and often may waterlog even during the growing season following excessive rainfall. Because of the normally high water content of such soils in the springtime, they are slow to warm, and
planting must often be delayed until enough water drains from the seed zone for it to warm up to germination temperatures.

Not all soils have slow drainage characteristics because of a large proportion of "capillary porespace". Some soils, particularly in bottomland position, broad upland flats, and those with "fragipans" may drain water slowly through the fragipan, causing a perched water table to be close to the soil surface. In this case the water table is close enough to the surface that free water backs up into the rooting zone.

Soil drainage characteristics are judged on the basis of color through the rooting zone. Uniform "bright" coloration, usually brownish, reddish, or buff indicates good drainage. In such profiles enough air is present to keep colloidal iron which coats the soil particles in its "oxidized" form, which results in the uniform "bright" colors. Mottled, gray or yellowish colors indicate poorer drainage. These colors reflect colloidal iron and manganese being present in a less oxidized state due to insufficient air in the profile.

Perhaps the greatest influence which soil drainage has on crop production in Kentucky is its effect on efficient use of nitrogen. Under Kentucky's climatic conditions much of the residual soil nitrogen as well as that applied as fertilizer is rapidly transformed to the nitrate (NO₃⁻) form during the growing season. Once present as nitrate, there is a great potential for nitrogen loss from the rooting zone either by leaching or by denitrification. Since leaching losses result from a large amount of water flushing through the rooting zone, it generally occurs only in well drained soils following excessive rainfall. On the other hand, denitrification is a biochemical process which occurs when soil air is limiting. This situation most generally is found in soils with poor (or slow) drainage. Under waterlogged soil conditions (polespace largely saturated with water), losses of nitrogen due to denitrification may be great.

Studies have been conducted for both tobacco and corn production in Kentucky to test management practices to minimize such losses. These studies have conclusively shown that the best practice to follow is to either delay nitrogen application for 4-7 weeks after planting or to split the application by using 1/4 - 1/3 at planting and the remainder 4-7 weeks later. This practice provides N when the plant is large enough to use large amounts and lowers the risk of early season losses of fertilizer N. The following table shows the results from this practice on a high clay soil which tends to waterlog following rainfall.

<table>
<thead>
<tr>
<th>Effect of Delayed N on Yield of No-Till Corn Grown on Hampshire Soil</th>
<th>Yields (bu/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>at planting</td>
<td>0</td>
</tr>
<tr>
<td>7 weeks after planting</td>
<td>0</td>
</tr>
</tbody>
</table>