Ohio State University Fact Sheet

Food, Agricultural and Biological Engineering

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Agricultural Water Table Management Systems

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The management of Ohio's agricultural drainage waters has important consequences for agricultural productivity and profitability, and for environmental quality. Water table management is a package of management practices and strategies that can be used by agricultural producers and land managers to manage drainage waters. The purpose of this publication is to provide the reader with a general understanding of how agricultural drainage waters can be managed to help balance production and environmental goals. This publication was designed to help persons who have a good understanding of agricultural drainage extend beyond their current knowledge of drainage water management. For background information, the reader is referred to a basic primer on agricultural drainage, *Understanding Agricultural Drainage* (AEX 320), which is available through your Ohio county office of Ohio State University Extension.

What is Water Table Management?

In simple terms, water table management is the management, control, and/or regulation of soil-water conditions in the profile of agricultural soils. Essentially, excess and deficit soil-water conditions in the soil profile can be managed to provide better plant growth conditions for the production of food. Through the implementation of proper management practices and strategies, there also can be an environmental benefit. Soil-water conditions can be managed through the use of water management structures and strategies designed specifically for the given site conditions.

Water Table Management Practices

Water table management consists of three basic practices. These are conventional subsurface drainage, controlled drainage, and subirrigation. Each of these are illustrated in Figure 1 and discussed in more detail below.

Subsurface Drainage

Cropland that is susceptible to seasonal or intermittent high water table conditions usually requires subsurface drainage improvement, which serves to lower the water table to a level equal to the drain depth (see Figure 1a.). Subsurface drainage is common throughout the flat and gently rolling areas of the Midwest, as well as in other parts of the country. Subsurface drainage improves trafficability, enhances field conditions for more timely planting and harvesting operations, and helps decrease crop damage that can result from saturated soil and standing water.

Two of the longest duration studies on the effect of drainage on crop yield were conducted in Ohio. Both studies document crop yield increases with subsurface drainage on poorly drained soils compared to no subsurface drainage on these soils.

Controlled Drainage

The addition of properly designed and constructed water control structures to a subsurface drainage system allows the drainage outlet to be artificially set at any level between the ground surface and the drain depth (see Figure 1b.). Raising the outlet after planting helps keep water available for plant use longer than does "free," uncontrolled subsurface drainage. This practice also can be used to recharge the water table between growing seasons. Most existing subsurface drainage systems can be retrofitted for controlled drainage. Controlled drainage systems require a moderate level of management so that excess soil-water conditions following heavy rainfall can be avoided.

Based upon research conducted in North Carolina, controlled drainage may provide some reduction in nitrate losses from subsurface drained cropland, and helps to increase corn and soybean yields. Although controlled drainage has long been used in Ohio's organic soils to control subsidence and iron ochre problems, the effect of this practice on crop yields and water quality in Ohio has not been fully evaluated.

Subirrigation

With subirrigation, one system provides the drainage and irrigation requirements for the crop. Water is supplied through the subsurface drainage system using control structures to regulate the water table level in the field. Irrigation water is applied below the ground surface, thus raising and maintaining a water table at an appropriate depth in the crop root zone (see Figure 1c.). The pumping system and water control structure can be managed to create a constant water table depth or a fluctuating water table. Some existing subsurface drainage systems may be retrofitted for subirrigation. Subirrigation systems require a high level of management to avoid excess soil wetness following rainfall.

Benefits of Subirrigation

As stated above, one properly designed and managed system can be used to completely meet all the water table management requirements at a site. The drainage and irrigation components of a subirrigation system are one and the same. Installing a subirrigation system usually costs less than installing a subsurface drainage system and a surface irrigation system together on the same field.

For certain soils, subirrigation is very efficient. If the system is properly designed for the site and soil conditions, loss of water through deep seepage is negligible, and runoff of irrigation water rarely occurs. The water is always applied where the crop needs it most. Most importantly, crops respond well to subirrigation when other production management factors are not limiting. In over ten years of study in Ohio, soybean yields have been consistently over 75 bushels per acre under subirrigation and a high yield management system.

Requirements for Subirrigation

A number of factors should be considered before installing a subirrigation system. Several of the more important ones are discussed below.

Soil

In general, agricultural soils that respond well to subsurface drainage improvement tend to respond well to subirrigation. Subirrigation is usually effective in soils that have a soil layer of low permeability located below the subsurface drains. This layer helps reduce deep seepage losses. The permeability of the restrictive layer should be less than one-tenth that of the soil in the crop root zone.

Both vertical and horizontal hydraulic conductivities should be measured in the field before designing the system. High values of horizontal hydraulic conductivity creates the potential for lateral seepage. This allows for a wider drain spacing, which can reduce installation costs. However, losses from the edge of the field may be excessive under these conditions, especially if the adjoining field is drained.

Water Supply

Available water from a reliable source is a very critical factor for all types of irrigation. Water is needed most during the driest parts of the growing season. Streams are often unreliable, because flow rates decrease when water demand is highest. Wells, ponds, and reservoirs are used frequently for irrigation water supply. Net irrigation water requirements in the Midwest depend on crop, location, and weather. Irrigation to meet the evapotranspiration demand for a typical Ohio growing season may require as much as 5 gallons per acre per minute per day.

Drainage

The ability to drain rapidly when rainfall occurs during subirrigation periods is critical. In addition, drainage system improvements may be necessary to adequately distribute the irrigation water throughout the field. For most soils, the subsurface drain spacing is usually closer than that required for conventional subsurface drainage alone. In general, the subirrigation system will be a more intense subsurface drainage system. Surface drainage improvements, such as land grading or field ditches, may be used to help safely and efficiently avoid ponded surface water after a rain.

Topography

Subirrigation is best suited for flat or gently sloping lands (less than 1% slope) because uniform depth to the water table is much easier to maintain. A field with considerable surface undulation could result in excessive variation of the depth to the water table within the field. For this case, the field may need to be divided into zones within which the land slope variation is limited. For this type of situation, proper water table management may require a separate water control structure for each zone within the field. This will increase the cost of installation of the system, but should increase the irrigation efficiency.

Materials

The materials needed for the subirrigation system will include all the same types of materials used for a typical subsurface drainage system. In addition, the subirrigation system will require water control structures, a properly designed pumping system, and perhaps simple, water table level monitoring wells (piezometers) at several locations within each field. Water control structures are needed, at least in the main line, to maintain a uniform water table depth. Provisions for adjusting the weir setting (water level) within the water control structure must be included and should be easy to adjust and operate.

Converting from Drainage to Subirrigation

Subsurface drain spacings for subirrigation usually are 30% closer than those for drainage only. Retrofitting an existing subsurface drainage system for subirrigation may be possible in some cases by installing additional drains between existing lateral drains, water control structures and a pumping system. Extra mains are often required when laterals run upslope.

Management

Management is a very important aspect for water table management to be successful, and time requirements by the manager may be high. Until the operator or manager has gained much hands-on experience and is well acquainted with how the system works, daily monitoring of the water table both over and between the drains may be necessary. Automated water level controllers reduce time inputs, but are more costly. Raising the water table four feet in a sandy loam soil with drains 60 feet apart could take 3 to 5 days. Times would be longer for silt loam and clay soils.

Design

Information usually needed for a properly designed subirrigation system includes soil properties, topography, water supply, power supply, existing drainage specifications, crops to be grown, time available for system operation and management, and other information. The designer will determine the layout of the system, the depth and spacing of the drains, the pumping plant capacity, and the size and location of water control structures. The slope, hydraulic gradeline, and the size of drains must be determined for both subsurface drainage and subirrigation. An important final part of the design process is the economic analysis.

Potential Problems when using Subirrigation

The system operator or manager should be well aware of several potential problem that may occur with subirrigation. Sudden heavy rains during the irrigation mode may flood the crop root zone, especially if the weir setting in the water control structure is high (and thus a high water table in the field). When there is a high water table, there will be less water storage available in the soil. This problem may be solved by careful on-site management. The operator or manager should review weather patterns, and if possible allow time for the soil to partially drain before a rain occurs. This will help create some storage capacity in the soil for the expected rain.

Another major problem may be creating and maintaining a level water table throughout the field. This is especially true in soils with low lateral hydraulic conductivity, such as clays. Problems also exist in soils that lack an adequate restrictive layer below the drain depth. Careful site evaluation is very important before proceeding with design and construction.

Summary

There are a variety of water table management practices and strategies that can be used by agricultural producers and land managers to manage agricultural drainage waters in Ohio. Proper management of Ohio's agricultural drainage waters has important consequences for agricultural productivity and profitability, and for environmental quality. The purpose of this publication is to provide the reader who is knowledgeable about agricultural drainage with a better understanding of how drainage waters can be managed to help balance production and environmental goals.

Over all the factors that are important to be evaluated before deciding to install a subirigation system, the two most important are the soil and the water supply. If the soil is not capable of responding to subirrigation, or if there is not a reliable and sufficient water supply available, then the potential for success with subirrigation is greatly reduced. Other options should be evaluated.

Current Water Table Management Research in Ohio

Numerous research and Extension personnel in the College of Food, Agricultural and Environmental Sciences at Ohio State University are actively involved in various aspects of water table management research and demonstration throughout the State. Much of this work is conducted cooperatively with a number of local, state, and federal agencies, agricultural, environmental, and industrial organizations, and other university personnel . A few of the more interesting plot and field studies and their location by county are listed below.

- Subirrigation of corn and soybean - Northwest Branch Station of the Ohio Agricultural Research and Development Center (OARDC), Wood County
- Subirrigation of corn and soybean - Wooster Branch Station of OARDC, Wayne County
- Subsurface drainage, tillage, and rotation for corn and soybean - Northwest Branch Station of OARDC, Wood County
- Subirrigation and seasonal wetland for corn and soybean production and nitrate remediation - Piketon Research and Extension Center (PREC), Pike County
- Subirrigation, constructed wetand, and water supply reservoir for corn and soybean production - Demonstration farms in Defiance County (Defiance Agricultural Research Association), Fulton County (Shininger farm), and Van Wert County (Farm Focus)
- Subsurface drainage and micro-irrigation for blueberry - PREC, Pike County
- Controlled drainage for corn and soybean - Demonstration farms in Union County
- Controlled drainage for corn and soybean - PREC, Pike County
- Subsurface drainage, controlled drainage, and micro-irrigation for pepper and melon - PREC, Pike County

Where to get Information

For more information about water table management in general, or the projects listed above, please contact any of the authors of this publication. Dr. Brown can be reached through the internet address Brown.59@osu.edu.

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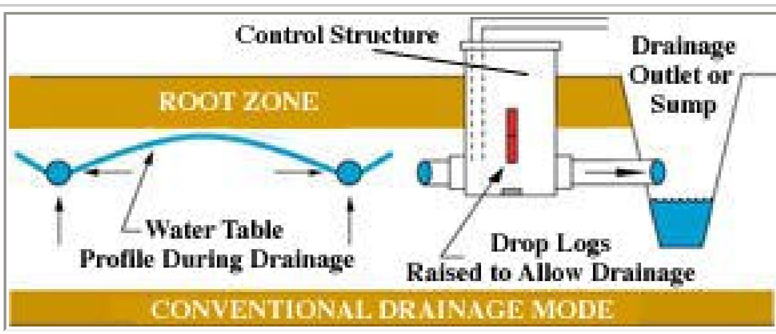

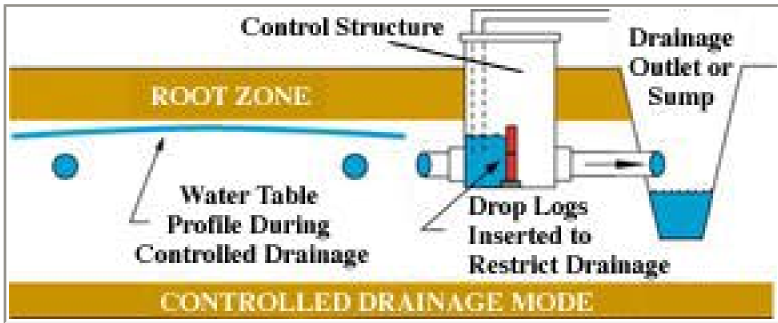

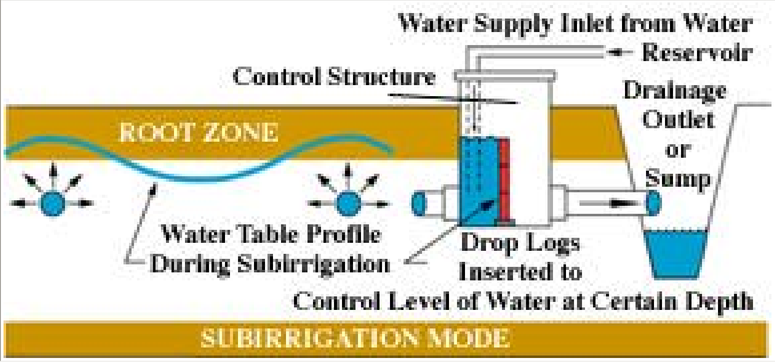

Figure 1. Three water table management practices: a) conventional subsurface drainage, b) controlled drainage, and c) subirrigation.

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