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Drainage Research to Improve Runoff Water Quality and Soil Trafficability

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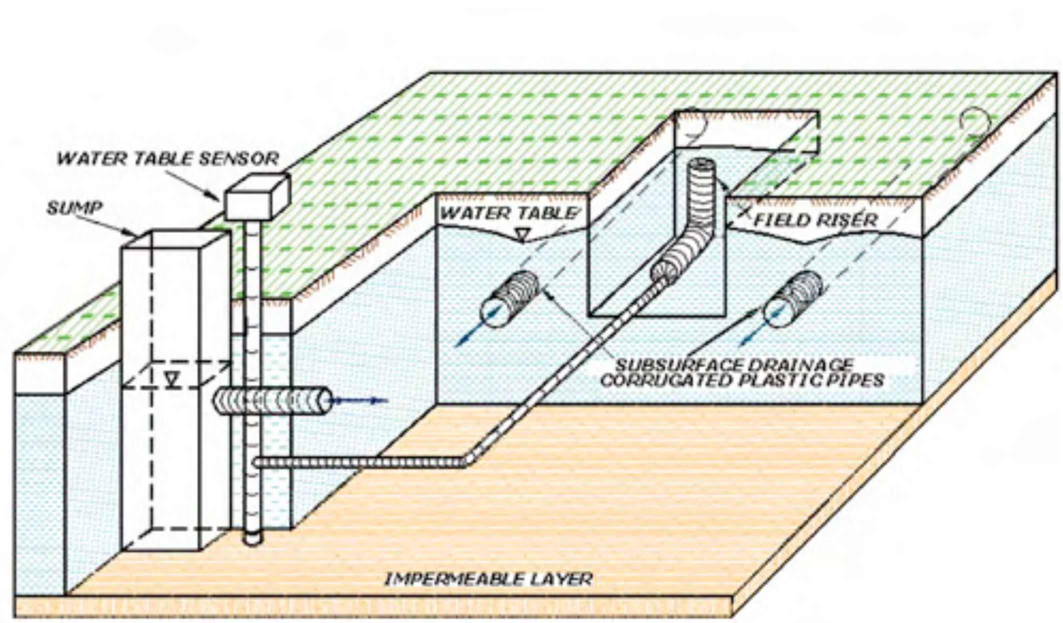
Introduction
In recent years there has been increasing concern about the quality of runoff waters from sugarcane fields. This concern encompasses not only streams, rivers, lakes, and groundwater, but also wetland areas adjacent to and/or downstream from agricultural lands. A new USDA-Agricultural Research Service (ARS) field research/ demonstration project has been initiated in the Lower Mississippi River Valley (LMRV) to quantify the potential beneficial effects of water table control in reducing runoff, and the associated reduction in losses of sediment and agrochemicals (fertilizer and pesticide) carried in the runoff. Further, the research will demonstrate to sugarcane growers the benefits of improved trafficability when the cane harvest season is excessively wet, which typically occurs about every 5 to 6 years in the LMRV. Both subsurface drainage conduit and parallel field drainage ditch systems will be considered in formulating recommendations.



Schematic of subsurface drainage system with sump and water table sensing device.

Background

Sugarcane is one of the most important crops in Louisiana's agriculture and economy. About 412,650 acres of sugarcane are grown each year in an area of high rainfall and high fluctuating water tables that often rise to the soil surface. Early research showed that a high water table during the dormant season caused significant yield decrease for sugarcane. Research conducted by the Soil and Water Research Unit of ARS in Baton Rouge has shown that the soils, particularly the alluvial silt loams and silty clay loams, responded favorably to subsurface drainage. In addition, sugarcane responded favorably to subsurface drainage of the soil profile in terms of yield increase and stubble longevity in comparison with those where fields are typically surface drained only. Further, field experiments in the 1980's by the Baton Rouge Unit's Soil and Water engineers and scientists showed that water table control (involving controlled-subdrainage and subirrigation) was particularly effective in these fine textured soils. Despite these results, farmers in the LMRV have not accepted or installed subsurface drainage as a common soil-water management practice. Lack of acceptance by LMRV farmers appears to be linked to several factors, as discussed below.

Many farmers in the LMRV do not appear to be aware of the multiple benefits of subsurface drainage. These benefits include increased crop yields, cane stubble longevity, and improved trafficability for planting, cultivation, pest management, and harvesting operations. For those farmers familiar with the practice, most are reluctant to install subsurface drainage because of the high initial cost to install the systems. A typical system may cost $450/acre to install. The improved crop production efficiency and yield increases provided by subsurface drainage will typically offset the installation cost in 3 to 5 years for sugarcane production. Complicating this situation is the fact that most lands (90%) used for sugarcane production are rented or leased, and improvements on the land (such as subsurface drainage) are not typically paid by the land owners; these costs must generally be paid by the grower. Additionally, the marketing infrastructure for sugarcane provides that the sugar mills receive a contract percentage of the selling price for the sugar produced, but the mills do not typically share in the cost of production related to land improvements (such as subsurface drainage). The costs for purchasing and maintaining the farming equipment, including the harvesting machines, are typically paid by the sugarcane grower.

From 1993 to 2000, the percentage of Louisiana sugarcane harvested with a modern chopper harvester (Cane Combine) increased from 0 to 75%, and in the next few years 100% of the cane may be harvested by the chopper harvester. The change from the soldier harvester system is being brought about by the development of high yielding, usually lodged, cultivars and by pending restrictions on burning cane.

Improved trafficability for operation of modern cane combine and transport equipment in sugarcane production harvesting operations during wet seasons will likely be a major future benefit provided to the grower by water table control (e.g. subsurface drainage). Improvements in stand longevity, such as a 6-year cane cycle (rather than the current 4-year cycle for plowing out and replanting cane) and higher sugarcane yields, should increase overall profitability of sugarcane production for the grower.

Project Objectives and Considerations
Comprehensive research is needed to study the effects of using water table control to minimize agrochemical losses with surface runoff and leaching, thus improving water quality from sugarcane lands. The project design will allow study of the interactive effects of water table control, and cultural management practices for sugarcane production, on water quality in terms of nutrients and pesticides loss with runoff waters and sediment. For research plots with surface drainage only, two different post-harvest crop residue management treatments will be conducted to study effects of residue management on crop growth, yield, water quality, and soil trafficability. Finally, data from these field experiments will help in the development or enhancement of models to simulate the performance of water table control systems for sugarcane production that have the ability to predict water quality, trafficability and potential sugarcane yield.

Istallation of subsurface drainage system at St. Gabriel, LA using a chain-type trencher with laser grade control.

Site Characterization and Plot Design
The experimental site is located on the St. Gabriel Sugarcane Research Station of the Louisiana Agricultural Experiment Station, which is about 12 miles from the Louisiana State University Campus in Baton Rouge. The site was established on soils of the Commerce association, with intermingled silt loam and clay soils. The study is being conducted on twelve (12) 0.50 ac. plots six (6) of which include corrugated plastic tubing for water table control, and six (6) are surface drained only (the conventional drainage practice for sugarcane production in LA).

Description of Research and Demonstration Site
The field experiment will be conducted on relatively large, replicated plots (e.g., 80 x 270 ft) to create realistic conditions of farming operations and to serve as a demonstration site for farmers. Such an experiment will be equipped for automatic operation of the water table control systems through sumps and surface drainage only and instrumented for electronic data collection.

The research plan also includes procedures to develop techniques for measurement of trafficability parameters in terms of soil physical properties related to soil strength and soil moisture. This research phase will also involve field experimentation, laboratory investigation, modeling and simulation methods.

Construction of surface drainage ditch systems for runoff waters collection

from research plots using special designed bucket and laser for precision ditch slope of 0.2%

Treatments

The field experiment for post-harvest trash management on surface drainage only plots at 0.2 % land slope has two (2) trash treatments and three (3) replications:

1. Residue removal (burning) as presently conducted in sugarcane production in Louisiana,
2. Residue left in field (not removed) but swept from the row tops into the furrows for incorporation into the soil and/or chemical/biological treatments.

For plots with laser installed subsurface drainage at 0.2 % grade, two different water table levels as treatments will be chosen to study the effects of a future residue management on water quality and trafficability.

Surface runoff from sugarcane fields up-slope from the experimental site has been diverted into subsurface culvert pipes to route it around the site and to discharge it to a surface outlet downslope from the site. A National Weather Service Class-A automated weather station is located approximately 490 ft from the experiment site. Meteorological data (e.g., rainfall, air temperature, soil temperature, relative humidity, pan evaporation, wind speed and direction, and total radiation) from the weather station's automatic data-logger will be used in conjunction with the study. Evapotranspiration (ET) will be estimated from pan evaporation and the modified Penman equation.

Plot Design

Each subsurface drainage plot, has three (3) experimental and three (3) buffer 4-inch diameter subsurface corrugated plastic drain tubes installed at a 41 ft spacing and a 3.25 ft depth, a 4 x 4 x 10 ft steel sump to control drainline outlet water levels, and a shallow flume equipped with a velocity-head sensor at the surface runoff outlet. Each of lateral drainlines are connected into 6-inch downslope main and 4-inch at upslope main drainlines to provide for additional subsurface drainage at the turning areas for harvesting and transport equipment. Trafficability at the ends (turn-rows) of the fields has been a major problem with getting heavy cane combine and transport equipment stuck in the fields during wet harvest seasons.

The 4-inch diameter corrugated plastic tubing for the project was donated by the Plastic Pipe Institute-Corrugated Polyethylene Pipe Association (PPI/CPPA), Washington, D.C. The member company of PPI/CPPA selected by PPI to donate the pipe for St. Gabriel project was Advanced Drainage Systems, Inc., Columbus, Ohio. The drainage contractor awarded the competitive contract to install the drain pipes was Luttrell & Sons Drainage, Inc., Dundee, Kentucky.

Experimental Measurements
The primary measurements to be made on the experimental site will include:

1. Water table depth vs. time at the mid-point between subsurface drainlines or at plot center.
2. Surface runoff volume vs. time, and sampled proportional to runoff volume.
3. Subsurface drainage discharge vs. time, and sampled proportional to outflow volume.
4. Soil temperature vs. time at 3 to 4 depths.
5. Soil moisture vs. depth and time (especially in the surface soil), re: trafficability.

The water table depth (WTD) at the mid-point between drainlines in the experimental area of each plot, or at the plot-center in the surfaced drained only plots, will be monitored with an in-situ manometer-type sensor. This WTD monitoring system consists of a short section of perforated pipe, buried at the plot-center or mid-point between drains, that is connected via a small-diameter unperforated tube that extends to a WT riser-pipe located at the plot border near the drainage sump or runoff sampling equipment. An electrical water level sensor will be used in each riser-pipe to measure WTD vs. time via an electronic data-logger system.

Sugarcane variety LCP85-384 widely used in Louisiana was planted (August, 2000) parallel to subsurface drainlines and to surface drainage ditches for surface drainage only plots.

Sampling and Measurements Procedure
A custom designed flume equipped with a velocity-head flow sensor will be used to measure runoff rate and volume. For each treatment, a refrigerated automatic sampler will collect flow from the flume proportional to each surface runoff event in the amount of 50 ml per 1000 liters of runoff. After collection the samples will be taken to the laboratory and analyzed for sediment, nutrients and pesticides. Effluent flow from three drainlines of each subdrained experimental area will be measured by a flow meter on the sump-pump discharge line. The flow meter will be electronically connected to a data-logger to record cumulative flow versus time. Composite samples will be collected from the discharge line through an orifice-type tube that partitions 0.05% to 0.1% of the total flow volume for each storm event depending on length and intensity of the storm event. Samples collected from subsurface drainlines discharge will be analyzed in the laboratory for pesticide and nutrient content.

The surface drainage runoff samplers acquired for the project were model 900MAX, American Sigma, Inc., Loveland, Colorado. The runoff flumes fabricated to the project engineers design by Corrosion Control Systems, Inc., Medina, New York.

Expected Results

Previous field experiments with sugarcane show that excess soil water, especially during the dormant season for sugarcane (i.e., winter months), decreases yield and stubble longevity. We expect that with water table control on our research plots, sugarcane yield and stubble longevity will improve since we will maintain an optimum water table depth with respect to the root zone. Our predictions are that water table control will increase the number of production years by 2-3 years from a single planting, and will increase yield as much as 25% with respect to Louisiana's traditional 3 years production yields using surface drainage only. We expect that water table control (e.g. with subsurface drainage or perhaps deeper drainage ditches) will also improve trafficability for heavy equipment (modern "chopper" harvester and loading/transporting wagon), especially in the turning areas at the ends of the field. After intense rainfall events and following runoff, subsurface drainage will increase infiltration of remaining surface waters so that lowering the water table will progress faster. The top soil layer will dry more rapidly to allow heavy equipment operation on the field sooner.

Progress

The project site was precision-land-graded with laser-controlled equipment in October 1998, the subsurface drainage sumps were installed in December 1998, and the upslope water runoff diversion culverts were installed in February 1999. The subsurface drainage system and two plastic film barriers were installed in April 1999 with a laser-controlled chain-type trencher. The water table depth monitoring system in each experimental plot was installed during May 1999, and all electrical and telephone conduits/lines were installed from June to August 1999. The surface drainage system for all experimental plots was constructed in the spring of 2000. Sugarcane was planted on the site in mid-August, 2000.

Surface runoff measurement and sampling systems (flumes and automatic samplers) will be installed by the summer of 2001. The new St. Gabriel research site will be fully operational and automatic data collection begins by the fall of 2001. L&W

Mention of the trade or manufacturer names is provided for information only and does not constitute endorsment by USDA-ARS.

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