Sustainable Agriculture Facts
Growing for tomorrow
Technical Information for Conservation Farmers

Tile Drainage for Water Table Management

With 125 to 150 frost free days and an average of 2,500 corn heat units per year, the Morden/Portage area is one of the most suitable areas in Manitoba for corn production. However, waterlogged soils due to high water tables in this region can be a major limitation to corn production as well as other water sensitive, high-value crops such as potatoes and onions.

The Project Sites

Site	Acres	Soil	Design	Drain Spacing (m)	Depth to Drain (m)	Outlet Type	$/acre
A	27	sand over clay	random	30-40	0.9 - 1.3	gravity	510
B	21	sand	systematic	40	0.8 - 1.5	pumped	390
C	81	clay loam or sandy loam over clay	systematic	30	0.9 - 1.2	gravity	540
D	45	sandy loam over silty clay	systematic	30	1.2 - 1.4	gravity	460

The Pilot Project

In 1993, members of the Manitoba Corn Growers Association approached Prairie Farm Rehabilitation Administration (PFRA) to investigate methods of dealing with the problem of high water tables.

In 1994, under the Canada-Manitoba Agreement on Agricultural Sustainability (CMAAS), a pilot project was established to study tile drainage as a method of managing high water tables. This practice is being used in other regions of Canada and the United States, but has not been tested sufficiently in Manitoba.

Four sites were established under the project. The sites were monitored for drainage effectiveness and water quality over a period of four years.

Drainage Effectiveness

A typical example of the impact on water table drawdown can be shown using data from Site D. On August 19, 1995, 5.4 inches (13.7 cm) of rain fell on the site. Within 24 hours the water table had risen by 19 to 38 inches (0.5 to 1.0 metre) to come to within at least 3 feet (one metre) of the soil surface and at the extreme to within 16 inches (40 cm) of it. Over the next three days, the water table in the tile drained portion of the field declined at a rate of 2 to 12 inches per day to bring the water table to below the root zone. The producer felt that without the tile, significant crop loss would have occurred.

Total annual discharges were measured at Sites A and B from 1994 to 1996. Total water drained from Site A averaged 6.3 acre-feet (ac-ft), while the drained volume at Site B averaged 10.9 ac-ft. The majority of water is discharged in the spring prior to crop demand or in the fall after harvest following late season precipitation (see following graph from 1995 for Site A).

Water Quality

Water quality of the effluent was monitored to examine its potential for reuse for irrigation, and to determine its impact on the environment. Over the four year period of the pilot project, electrical conductivities (salts), nitrate concentrations and pesticide levels at the sites were monitored.

i) Salts

Electrical conductivities of the tile discharge water were generally between 926 uS/cm and 2000 uS/cm - an acceptable level for irrigation use. However, one site exhibited values of up to 5070 uS/cm due to the existence of subsurface soil salinity beginning at 0.5 m depth.

Reference Values for Acceptable Conductivity Levels

- more than 3000 uS/cm is generally not suitable for irrigation
- less than 1300 uS/cm presents little problem for irrigation
- less than 700 uS/cm is acceptable for human consumption

ii) Nitrates

Nitrate-nitrogen concentrations in the tile effluent ranged widely from 1.8 to 73.6 parts per million (ppm), depending on the time of year , crop grown and fertilizer program. The peak nitrate concentration in the tile effluent coincided with the peak tile discharge rate experienced in the spring. Secondary nitrate peaks were found in late fall, coinciding with fall tile drain flow arising from late year precipitation.

The maximum acceptable level of nitrates in water for human consumption as indicated in the Guidelines for Canadian Drinking Water Quality, 1996 is 10 ppm nitrate-nitrogen.

iii) Pesticides

Over the four years, all pesticide levels were below laboratory detection levels with one exception. In 1996, atrazine was detected at one site at 0.0002 ppm. However, this is still well within the Guidelines for Canadian Drinking Water Quality of 0.005 ppm.

Study Conclusions

Producers involved in the project feel that significant benefits have been gained. Three out of four of the producers involved in the pilot project have installed additional tile on other fields. Yield improvement has been documented at one site but was not conclusive at one other site. Producers report earlier planting dates and improved field access.

The project has identified several issues that require consideration.

- A major constraint is the high cost of supply and installation of tile in the case where the contractors are from out of province.
- It is often difficult and expensive to site a gravity low outlet and the need for a pumped outlet complicates an otherwise fairly simply system.
- The water quality of the tile effluent may limit the environmental sustainability of tile drainage in the absence of best management practices for nitrogen fertilizer application.

Establishing a Tile Drainage System

a) Site Selection and Design

Before installing a tile drainage system, it is necessary to gather information specific to your site. This should include data related to the topography, water table, and soils as well as historical infrared or aerial photographs to assist in designing the system.

The Water Table

The tile drainage must be installed at a depth that will allow you to manage the water table level, or the investment is not worthwhile. Therefore, determining the characteristics of the water table at each site is critical.

The characteristics of the water table will be governed to some degree by the surface and subsurface soils at the site. In general, soils used in corn production in south-central Manitoba have a coarse to medium surface texture and are underlain by an impervious layer of clay. This clay layer often restricts the movement of soil water downward through the soil profile. As a result, drastically fluctuating, very shallow water tables are common throughout the area. These shallow water table levels can range from the soil surface in the spring to as much as eight feet below the ground surface in late fall.

Temporary observation wells should be installed for at least one year prior to installing the drains to

Benefits of tile drainage:

Tile drainage has the potential to provide many benefits to the producer including:

- improved yields and better crop quality due to:
  - crops establishing a better root system,
  - increased aeration of the soil, and
  - a higher soil temperature, particularly in the spring
- protecting crops from damage due to excess water during extreme rainfall
- earlier field access in the spring for earlier planting, or after a heavy rain.
- a wider choice of crops and varieties, and
- more efficient use of machinery

monitor water table fluctuations over the year and specifically after rainfall events.

Soil Particle Size Analysis

Specific knowledge about your soils is necessary because it affects the spacing of the drains and the type of filter sock you need to use. A filter sock is a permeable cloth-like tube fitted over the entire length of the drainage tile to prevent soil particles from entering the drain. Filter socks are available in varying degrees of permeability.

In most situations, soil textures will vary throughout the field. It is recommended that soil samples be taken at a number of locations and analysed for particle size prior to drain installation.

b) Materials and Installation

Generally speaking, it is advisable to hire a tile drainage contractor with the experience and the proper equipment to install your tile drainage system.

The drainage system can be either a *random* layout - designed to target the low spots in the field, or *systematic* - a regular network designed to drain the entire field. Most systems are designed to channel the water by gravity to the low point of the field. However, it may be necessary in some situations to install a pump to draw the water out of the system.
The use of a laser-guided plow is recommended to ensure that a constant and accurate grade is maintained as the tile is laid down.

Filter socks are necessary for the majority of soils in south central Manitoba to ensure that soil particles do not fill in the drains over time. The filter sock used with the drain tile must have a low enough permeability to keep out the smallest particles found in your soil. A filter sock with an equivalent opening size of 81 microns was used in the pilot project and appears to be performing adequately.

c) Spacing and Depth

To date, 30 m spacing and an average depth to drains of 1.0 to 1.2 m has provided adequate water table control in the pilot project areas, especially in fine sand. Closer spacing (or deeper drains) should provide more uniform water table control, thereby reducing the risk of crop drown out. The additional cost could be warranted for higher value crops. Also, closer drain spacing may be warranted in lower permeability soils, such as clays, fine sandy loam or silty soils, due to reduced lateral movement of water in the soil.

Wider drain spacing (or shallower drains) may be considered but the risk of crop drown out during extreme rainfall events would increase. The level of acceptable risk should be assessed as part of the design of a tile drainage system. Further monitoring research on tile spacing and depth should be considered in light of the implications on project cost.

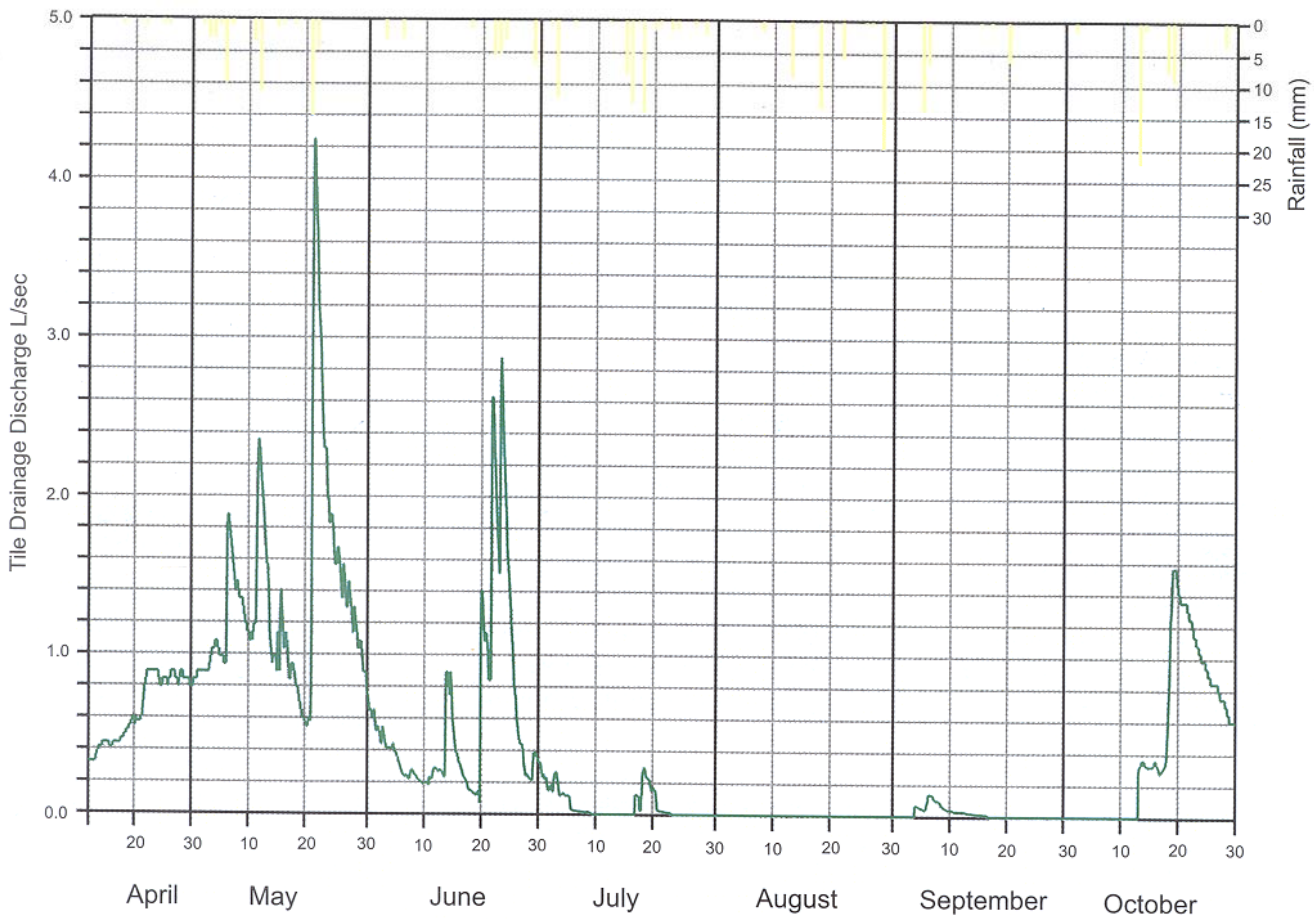
d) Frost Control

Another interesting finding towards a potential benefit of tile drainage is water table control after late fall rains. On some fields adjacent to the pilot project areas, there appeared to be a significant delay in field accessibility in the spring following the fall rains. Limited investigation suggests that if the water table is high in late fall, the water in the upper saturated zone can freeze. This frozen ice layer has been observed to persist until mid June keeping the soils wet because spring moisture is prevented from seeping downward. In the tile drained areas this ice layer was not encountered.

Canada's Green Plan

Managing Nitrogen

Well planned fertilizer management practices such as spring application rather than fall, and split applications can save money and protect water quality. Data from Site A in 1995 is shown in the graph below and can be used to calculate an example of nitrate-nitrogen loss from the system. Assuming an average nitrate-nitrogen concentration of 30 ppm in the tile effluent and a discharge volume of six acre-feet, the total amount of nitrate-nitrogen loss on the 27 acre field over the 45 day spring flow period was 18 lbs/ac. This nitrate-nitrogen leaching is of particular importance since nitrogen from fertilizers and other sources can contaminate groundwater if not properly managed.



Site A - 1995 Rainfall and Discharge

For more information about tile drainage or any other item discussed here, contact:

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