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Wetland-Reservoir System Improves Water Quality and Crop Production

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Introduction

The long-term success of the agricultural industry is based on the productive ability of our natural resources. Across Canada areas of intense agricultural production, face challenges associated with profitability, sustainability, and off-farm environmental impacts. Of particular concern are severe growing season drought associated with global warming and non-point source agricultural pollution.

Agriculture and Agri-Food Canada scientists at the Greenhouse and Processing Crops Research Centre in Harrow, Ontario have devised a highly effective wetland-reservoir system that can help increase yields and offer substantial environmental benefits.

In a wetland-reservoir system, tile drainage water and surface runoff water from agricultural fields are routed into a wetland reservoir, rather than into open-ended streams and drainage ditches. The collected water is then recycled back through a controlled drainage-subsurface irrigation system to provide subsurface irrigation during times of drought. The wetland reservoir provides wildlife habitat and serves as a sink to prevent off-site movement (loss) of water and sediments, and also provides a means for intercepting and recycling agricultural nutrients and chemicals via return irrigation. As a result, precipitation water is used more efficiently, and the discharge of agricultural sediments and chemicals into off-site surface and ground water resources is reduced substantially.

In 1999 a wetland-reservoir system was constructed by AAFC scientists in Essex County, Ontario in collaboration with the Essex Region Conservation Authority (ERCA) and Canada Trust Friends of the Environment Foundation.

Objective

The objective of this study is to determine the effect of an integrated reservoir, controlled drainage and sub-irrigation system on nitrate and phosphorus losses and yields of corn and soybean.

Materials and Methods

Experimental Design and Field Layout

- In 1999 a wetland-reservoir system was constructed in Essex County, Ontario. The dimensions of the wetland/reservoir are approximately 45.5 m long and 30.5 m wide. The system has an average depth of 2.75 m from the ground level with a storage capacity of 2300 m^3. Subsurface tile drainage as well as surface runoff from the plots are routed into the wetland/reservoir system.
- The experiment was initiated in the spring of 2000 and consisted of two treatments: Controlled drainage/sub-irrigation (CDS) and regular drainage (DR) for water quality and flow water measurement. The site was established at the ERCA's demonstration farm at Holiday Beach, ON.
- The layout of the field is shown in Figure 1. The field consists of two plots, one for controlled drainage/sub-irrigation and the other for regular drainage only. Each plot is a closed system in which all the subsurface and surface water are drained into a constructed wetland/reservoir.
- Drains were installed at 4.6 m spacing and 0.6 m depth and four stainless steal custom fabricated tipping buckets are used to measure subsurface and surface runoff.
- Samples of surface and sub-surface water are collected with four separate autosamplers which stores the water for analysis.

Agronomy

- Corn was planted at a rate of 74,000 seeds ha^{-1} in 76.2 cm wide rows on May 26, 2000 and May 20, 2001. Machine harvest yields were taken over the entire experimental field on November 15 , 2000 and November 7, 2001.
- Soybeans were planted at a rate of 580,000 seeds ha^{-1} in 38 cm wide rows on June 1, 2002. Soybean yields were harvested on October 16, 2002.
- The water from the reservoir was used for subsurface irrigation to corn and soybean during the dry growing season in 2001 and 2002.

Results

- The water from the reservoir was used to sub-irrigate grain corn and soybean during the dry season in 2001 and 2002. The CDS system increased grain yield by 91% and soybean yield by 49% relative to no irrigation under the regular drainage system (Table 1).
- The controlled drainage-sub-surface system reduced flow weighted mean nitrate concentration in tile drainage water by 14%, and total nitrate loss by 27% compared to the free drainage system (Figs. 2,3)
- The CDS treatment reduced dissolved organic and inorganic phosphorus losses in tile drainage water by 47% and 54%,respectively, relative to the free drainage treatment (Fig 4).

Figure 1. Experimental layout

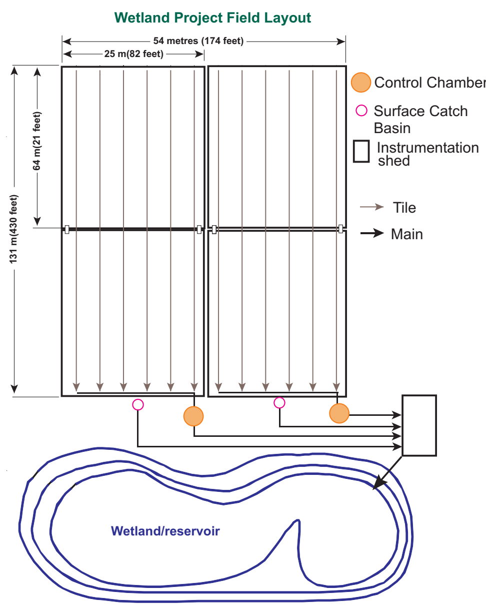

Table 1: Effect of controlled drainage/sub-irrigation (CDS) and free drainage (DR) on corn yields in 2000 and 2001 and soybean yields in 2002.

Treatments	Yields (kg/ha) 2000	2001	2002
Free Drainage/no irrigation (DR)	6663.1	3705.7	2216.2
Controlled Drainage/Sub-irrigation (CDS)	7155.0	7063.9	3307.5

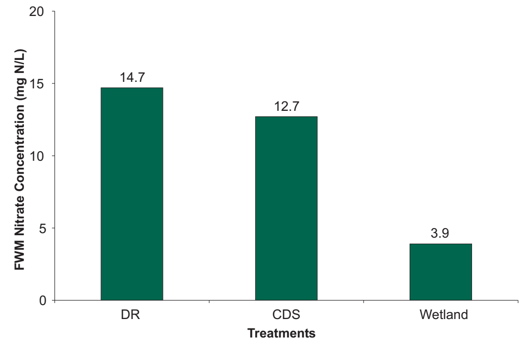

Figure 2: Flow weight mean (FWM) nitrate concentrations for the free drainage (DR), controlled drainage/sub-irrigation (CDS) and wetland reservoir for the period from June 1, 2000 to December31, 2002.

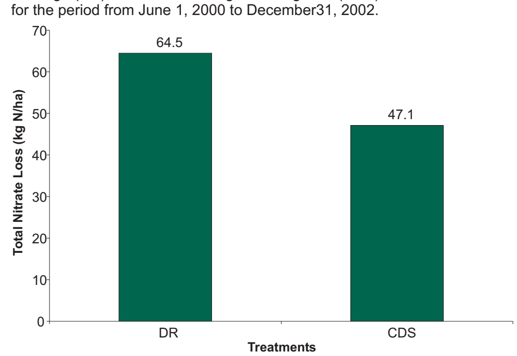

Figure 3: Total nitrate loss for the free drainage (DR) and controlled drainage/sub-irrigation (CDS) treatments for the period from June 1, 2000 to December 31, 2002.

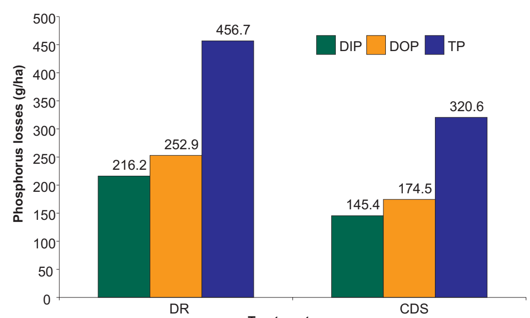

Figure 4: Cumulative loss of dissolved inorganic phosphorus (DIP), dissolved organic phosphorus (DOP) and total phosphorus (TP) in tile drainage water for the controlled drainage/sub-irrigation (CDS) and free drainage (DR) treatments for the period from June1, 2000 to December 31, 2002.

Conclusions

The CDS system combined with wetland-reservoir can be highly effective for improving crop yield and reducing non-point source pollution from agricultural fields. (Ie. Increased corn grain yield by 91%, and soybean yield by 49%; minimized discharge of agricultural sediments and chemicals into off-site surface and groundwater resources)

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