SUBSURFACE NUTRIENT LOSS FROM A CORN-SOYBEAN WATERSHED WITH AGROFORESTRY AND GRASS BUFFERS

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Introduction:
Reduction of nutrient loss from agricultural watersheds is important for profitable crop production and water quality protection. National Water Quality Inventory attributes 60% of the surface water pollution to agriculture (USEPA, 2003). Agricultural non-point source pollution is a landscape scale phenomenon and its diffuse nature complicates mitigation efforts. Dissolved nutrients from watersheds are removed in surface and subsurface flow. The subsurface flow constitutes a major pathway for movement of dissolved nutrients into surface and ground waters. Soil and environmental conditions that favor rapid flow through soil macropores and soils with restrictive layers such as claypans may contribute to significantly greater subsurface flow than other soils. For example, nutrients that are leached beyond the root zone can be transported to surface waters or directly to streams via subsurface pathways.

In order to reduce runoff, sediment, and nutrient loss, hydrological changes can be adopted. It is widely accepted that agroecosystems need to be designed to serve multiple functions: meet society's needs for food, fiber, and perhaps energy; protect the environment and conserve nonrenewable resources; and provide economic benefits (Pretty, 2002). Agroforestry buffers containing trees and grass have received increasing attention in the temperate region due to their environmental and economic benefits. Research shows that incorporation of perennial vegetation in row crop agriculture reduces subsurface nutrient losses from watersheds. Alfalfa, grass, and restored prairies have been shown to reduce nitrate and phosphorus concentrations in the soil profile and leachate as compared to annual crops (MacLean, 1977; Brye et al., 2002).

The literature lacks quantitative data on subsurface nutrient flow as influenced by agroforestry and grass strips grow on row-crop agricultural watersheds. This information could be used to examine beneficial effects of buffers on subsurface nutrient losses and to develop best management plans to improve water quality. The objective of this study was to examine differences in dissolved nutrient concentrations between crop and perennial vegetative buffers.

Materials and Methods:
The study was conducted at the University of Missouri-Greenley Memorial Research Center in Knox County, Missouri. The agroforestry watershed is 4.44 ha, and the contour grass strip watershed is 3.16 ha. Three- to 4-m wide contour grass-legume strips consisting of redtop (*Agrostis gigantea* Roth), brome grass (Bromus spp.), and birdsfoot trefoil (*Lotus corniculatus* L.) were established at 17- to 35-m interval on the watersheds in 1997. Pin oak (*Quercus palustris* Muenchh.), swamp white oak (*Q. bicolor* Willd.), and bur oak (*Q. macrocarpa* Michx.) trees were planted 3-m apart on the center of grass strips of the agroforestry watershed in 1997. Soybeans were planted on both watersheds on June 8 and harvested on October 29, 2007.

Sampling and Analysis:
Subsurface water samples at 5-, 10-, 20-, and 40-cm depths were collected with 5 cm diameter

lysimeters from March to October, 2007. Lysimeters were installed in a nested design (four depths at each location) with four replicated sets in the crop areas on each agroforestry and grass buffer watershed and upslope, middle, and low slope positions within buffers with two replications per position. Samples from lysimeters were collected after sufficient precipitation had occurred. Water samples were transported in a cooler and unprocessed samples were refrigerated at 4°C until analysis. Dissolved phosphorus (DP), nitrate-N, ammonia-N, and chloride concentrations were determined using a Lachat Quickchem 8000 auto analyzer.

Results and Summary:
Soil nitrate concentrations were higher at all four depths during the early part of the growing season and the concentration decreased as the season continued. Soybeans were planted on June 8th and no nitrate uptake occurred during the period between March 20 and June in the crop treatment. Buffer areas had lower nitrate concentrations at 5, 10, 20, and 40 cm depths than the crop areas and this pattern was maintained throughout the year (Fig. 1). The difference between treatments could be attributed to nutrient uptake by the perennial vegetation in the buffer areas as compared to the crop areas. These findings agree with subsurface drain flow comparisons among row crops and grass or alfalfa (MacLean, 1977, Randall et al., 1997; Brye et al., 2002). More samples were collected during the early part of the year due to preferable soil moisture conditions for sampling. The difference between crop and grass treatments was not significant in October samples.

Among the four depths studied, the 20-cm depth had the greatest nitrate concentrations in the crop and buffer areas. This could possibly be due to the accumulation of dissolved nutrients above the claypan or greater removal of nutrients by roots within the surface 20-cm of soil. In general, about 80% of the roots occupy the surface 20 cm soil depth and therefore greater nutrient removal may have occurred from these depths. The concentration at the 40-cm depth was much lower than the 20-cm concentrations. The claypan restricts vertical movement and thus less movement occurs resulting in lower concentrations within the claypan. Figure 2 shows that mean nitrate concentrations were higher in the crop areas than the buffer areas and the difference was larger before the crop was established.

Vegetative filter zones remove nutrients from subsurface water and store them in the biomass. Results of this study show that incorporation of perennial vegetative buffers helps reduce nutrients in the subsurface water in the claypan soils. These reductions are more important for water quality protection as over 50% of the nutrient loss occurs when the field is free of row crops either before the crop is established or after harvested.

References:

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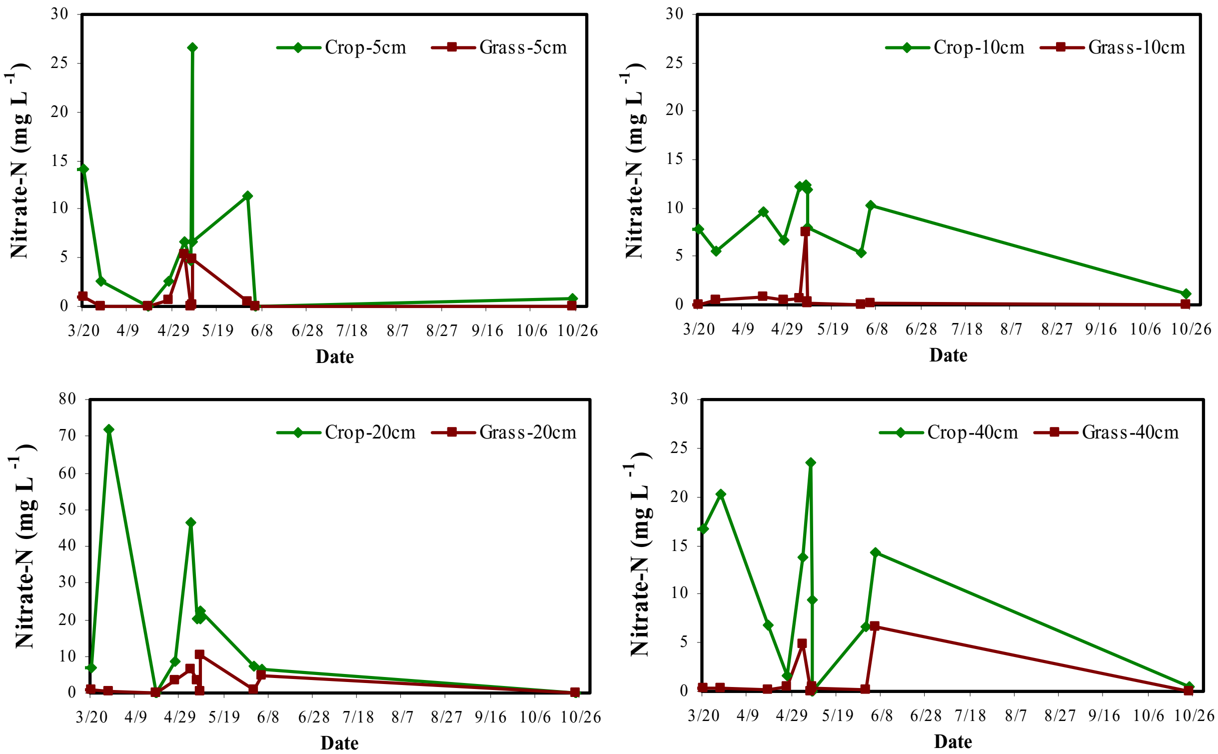

Figure 1: Nitrate-N concentration during 2007 sampling at 5, 10, 20, and 40 cm depths for crop and grass buffer treatments at the Greenley Research Center.

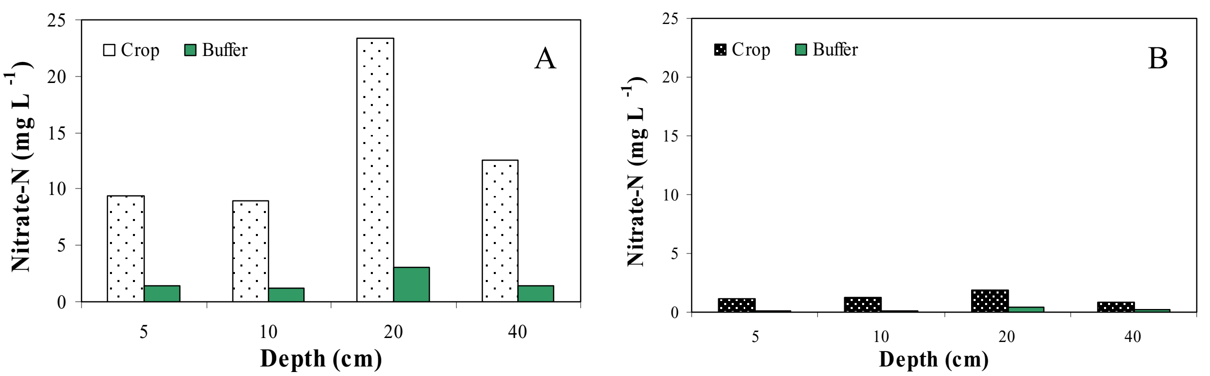

Figure 2: Mean nitrate-N concentrations at 5, 10, 20, and 40 cm depths in the soybean and grass buffer treatments before (A) the crop was planted and during (B) the cropping period at the Greenley Research Center.