TECHNICAL NOTES

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POPLAR TREE BUFFERS FOR NITRATE REMOVAL

This Technical Note transmits a research paper by Louis A. Licht of the University of Iowa on the nitrate removal potential of hybrid poplars. The use of deep rooted poplars should be considered when trying to reduce non-point nitrates from entering surface water.

It is important to note that this and other related research indicates that forest buffer strips can reach nutrient saturation and lose their nutrient filter capacity as they reach maturity. Periodic harvesting will allow the nutrient accumulation of woody biomass to continue.

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Paper Abstract

DEEP-ROOTED POPLAR TREE BUFFERS FOR BIOMASS PRODUCTION AND NITRATE REMOVAL

by Louis A.Licht, University of Iowa

PROBLEM STATEMENT

Recreate a wooded ecosystem in the riparian corridor separating row-cropped farm land from creeks using a new, innovative management practice designed to grow a valued, useful crop while reducing the mass of non-point source nitrates entering surface water supplies.

PROPOSED CONCEPT

Soil, manure, and production chemicals leave cropped land and pass to the surface water system; there they contaminate the downstream drinking water supply. These non-point source pollutants originate from different farming practices, but all contaminants entering the surface drainage system must pass through the riparian zone. The riparian zone is the corridor bordering all rivers, creeks, and drainages. In many fields, row crop tillage extends to the creek bank edge. This research is testing an innovative wooded buffer strip planted between the creek and crop as shown schematically in Figure 1.

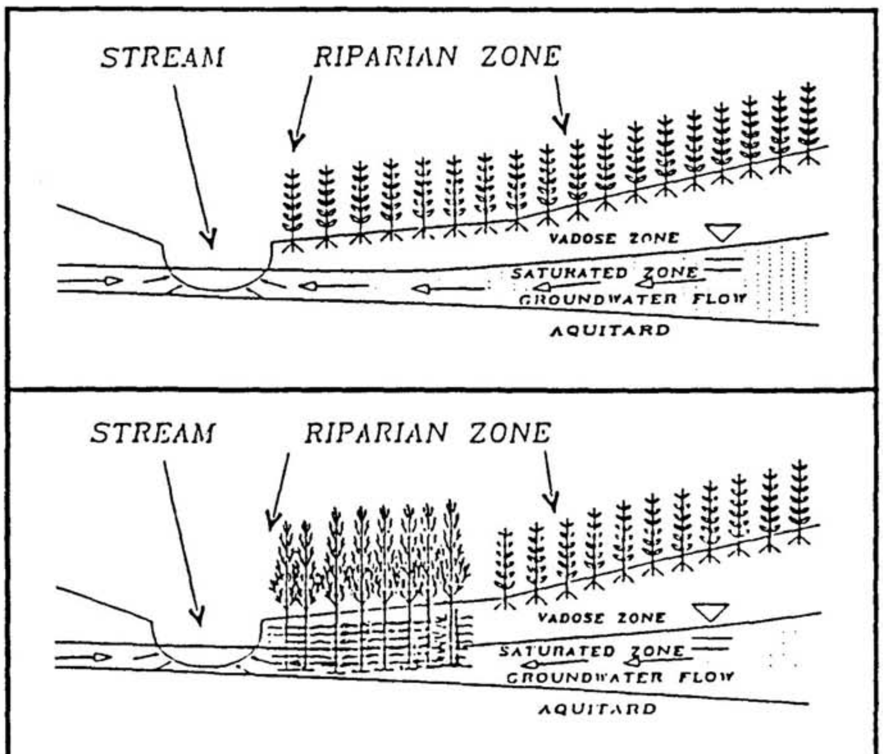

FIGURE 1: The Top Schematic Depicts Cropping in the Riparian Zone; the Lower Schematic Shows the Proposed Deep-Rooted Poplar Buffer Strip

Fundamental to this project is the idea that roots can remove nitrates from surface water and near-surface groundwater. This project tests the innovative concept that certain tree roots can be intentionally grown deep enough to intersect the near-surface water table.

Rooting depth is difficult to control when planting a seed or short plant cutting. Roots normally grow within 50 cm (20 inches) of the soil surface to meet nutrient and water needs. *Populus spp.* trees have preformed root initials located beneath the bark of stems and branches; root initials enable root sprouting from the entire planted stem's buried length. Cuttings 170 cm (5.5 ft) in length were planted vertically in 150 cm (5 ft) deep trenches dug parallel to a creek in the riparian zone. A denser tree population harvested with increased frequency is part on this buffer strip design to increase poplar's productive and environmental value. The initial planting density is 35,600 trees per hectare (14,000 trees per acre). The trees were spaced 30 cm (1 ft) apart in 100 cm (40 in) rows for an area allocation of 0.37 m^2 (3.3 ft^2) per tree in the buffer strip; 'normal' planting techniques for hardwood trees allocate 3.9 to 9.3 m^2 (40 to 100 ft^2) per tree. The treed buffer strip was four rows with a width of 3.6 m (10 ft); it was separated from the creek by a fallow strip 5 m (16 ft) wide and bordering conventionally planted corn upgrade.

Populus spp. have demonstrated the ability to grow well at this denser population. Harvesting will occur on a biennial or triennial schedule, contrasted with a 'normal' growth period of decades for coniferous and deciduous trees. When cut, coppiced regrowth occurs, meaning new stems sprouting from a cut tree stump. This makes biomass harvesting possible while maintaining a vigorous, deep, perennial root system with minimum shutdown in nitrate removal activity due to root regrowth.

RESEARCH RESULTS

This research has generated the following results:

1. *Populus spp.* trees can form viable root systems at depths well below 'normal' rooting depths of 50 cm (20 in) by planting 170 cm (5.5 ft) long poplar cuttings in 150 cm (5 ft) deep trenches. Over 20 primary roots with secondary rooting grew from the average excavated root between 122 cm to 152 cm (4 ft to 5 ft) depth.

2. *Populus spp.* trees with deep root systems demonstrated a very significant difference in survival during droughts. The 1988 growing season had no substantial rainfall between May and September. Shallow planted poplars had a survival rate of 40%; the deep-rooted poplars had a survival rate of 99.4%.

3. When a plant grows fast with a high protein content, it metabolizes a large mass of inorganic nitrate or ammonium nitrogen into harvestable biomass. After two growing seasons the trees averaged over 4.5 m (15 ft) tall. The yielded poplar biomass at a rate of 46,000 kg/hectare (41,000 lb/acre) dry stem and leaf containing 330 kg nitrogen/hectare (300 lb nitrogen/acre).

4. Deep *Populus spp.* root systems and their planting method very significantly ($p<.0005$) reduces the nitrate nitrogen mass in the soil profile. Figure 2 displays the nitrate nitrogen concentration in soils sampled below corn, fallow, and the deep planted poplar tree buffer. Soils were sampled 150 cm (5 ft) deep in three soil columns for each plot. In contrast to an average 25 mg N/kg dry soil below conventionally cultured corn, the rooted trench below the trees contained nitrate concentrations averaging 2.3 mg N/kg dry soil in entire profile. Following heavy September rains, near-surface groundwater sampled from wells

6 m (20 ft) apart beneath the corn and the poplar buffer contained 92 mg NO_3^- per liter and 2 mg NO_3^- per liter respectively. (Reduction of 46X)

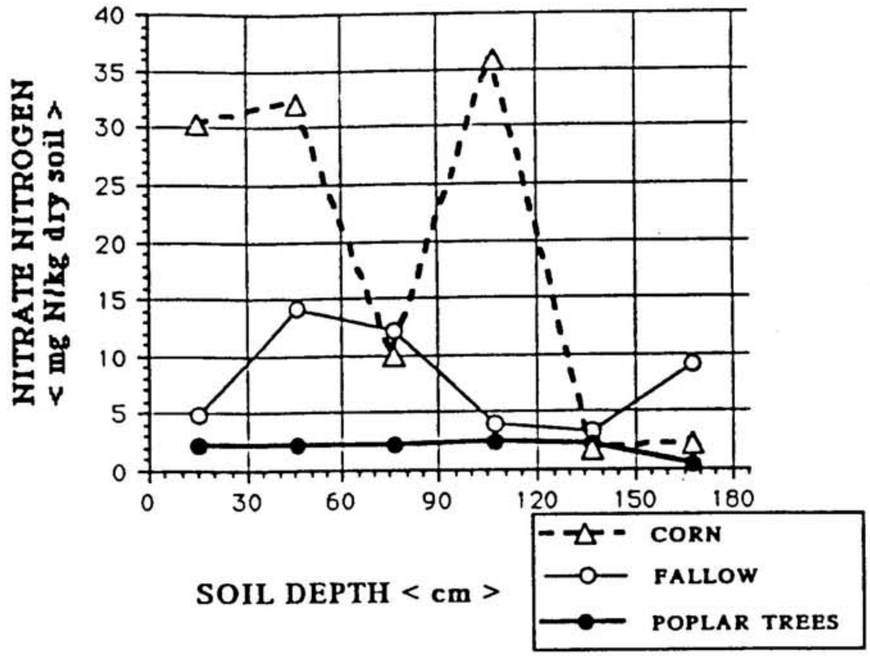

FIGURE 2: Nitrate Nitrogen Concentrations in Soil Columns Sampled Below Corn, Fallow, and a Poplar Tree Buffer Strip

MANY FUNCTIONS FOR A BROAD-BASED APPEAL

The wooded riparian buffer strip idea has an appeal because it *rebuilds an ecosystem.*. Grass buffer strips already play a role in farmer's conservation plans; their use is supported by the U.S. Department of Agriculture's Conservation Reserve Program as of 1988. As an alternative crop to grasses, *Populus spp.* trees can be planted as a component of a riparian corridor plant community within the larger agricultural ecosystem. This community performs the following functions:

- The buffer strip plant complex can slow overland water flow to settle and entrain soils.
- The buffer strip plant complex can remove phosphorus and nitrogen from water crossing the riparian corridor and grow useable and valuable feed, fuel, or fiber.
- The buffer strip plant complex can grow tall with dense foliage for wind erosion protection.
- The buffer strip plant complex can grow a variety of habitats and food sources to create niches for greater species diversification.
- The buffer strip plant complex is grown in a corridor, not a patch, so movement of wildlife can be sufficient for life cycle need.
- The buffer strip plant complex looks natural, and creates a positive visual impression.
- The buffer strip plant complex grows products not now normal to many agricultural economies; thus these trees have potential to diversify the agricultural product base.