Nitrate Monitoring Following Forest Fertilization in the Suwannee Valley Region of North Florida and Implications for Best Management Practices

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Introduction

Fertilizers are commonly applied in southern pine stands at establishment or periodically during the rotation to increase financial returns by enhancing growth rates and shortening the time to harvest (Jokela et. al 1991, Jokela and Stearns-Smith 1993). In recent years, sale of pine straw has grown to be as economically important as pine pulpwood (Hodges et. al 2005), and mid-rotation fertilization as a means to enhance pine straw production has become common (Morris et. al 1992).

Little is known about the environmental effects of fertilizing southern pines on sandy soils. Large areas of deep sands, with very little soil profile development, exist in the north Florida sand hills, including Suwannee County. They are classified as group G in the CRIFF (Cooperative Research in Forest Fertilization) forest soil classification system, which is widely used by forest managers to recommend fertilizer and other silvicultural treatments (Jokela and Long 2000). Group G soils are inherently infertile, yet their responsiveness to applied fertilizers is limited due to low sorption capacity. Water deficits generally limit pine productivity and responses to fertilizers on class G soils. Additionally, when fertilizing these soils the potential for leaching and groundwater contamination is a concern (Alva 1997, German 1977). Although fertilizer applications are generally not recommended for class G soils, many plantations in Suwannee County managed for pine straw production are frequently, and in some cases annually, fertilized.

Pine plantations could serve as a site for disposal of bio-solids generated from animal production and municipalities. Although many studies have examined tree growth responses and economics, few studies have investigated environmental implications for Coastal Plain soils.

Existing silvicultural fertilization BMP's recommend developing a nutrient management plan based on soil, water, plant and organic material sample analysis and consideration of expected or desired timber yields to supply nutrient inputs efficiently, so that the benefit of fertilization is captured by target vegetation and the adverse effects to water resources are minimized. Current BMP's provide periodic limits to N and P fertilization amounts, but do not address tree species or soil differences (anonymous 2003).

Objectives

Investigate the effects of mineral and broiler litter fertilizers on nitrate leaching in southern pine stands of varying ages and species in the Suwannee Valley.

- Determine resultant pine growth, pine-straw production, and insect and disease incidence following fertilization.

- Examine fertilization treatments on soil fertility, foliar nutrient status, and nitrogen content of pine needle litter over time.

On-going Research and Demonstration

Two replicated studies and one demonstration area were initiated from 2002 to 2005 in stands of varying ages and species to examine leaching potential and pine growth responses to mineral and broiler litter fertilization practices in Suwannee County, Florida (Table 1).

Table 1. Summary of on-going forestry fertilization BMP studies.

STUDY	NITRATE I	NITRATE II	NITRATE III
Location	Live Oak	Dowling Park	Live Oak
Predominant Soil Series	Foxworth fine sand (Thermic, coated Typic Quartzipsamments),	Alpin fine sand (Thermic, coated Lamellic Quartzipsamments	Foxworth fine sand (Thermic, coated Typic Quartzipsamments),
Soil drainage	Moderately well and somewhat excessively	Excessively	Moderately well and somewhat excessively
CRIFF Class	G	G	G
Species	Loblolly, Slash, Longleaf	Slash	Loblolly, Slash, Longleaf
Tree Age	2 years	11 years	5 years
Treatments	1. Untreated Control 2. 250 lb/A (18-46-0) (45 lb N as DAP) 3. 2.8 t/A Broiler litter (180 lb N/A) 4 Replicates	1. Untreated Control 2. 650 lb/A (22-13-10) (143 lb N as DAP + NH_4NO_3 + KCL) 3. 4.4 t/A Broiler litter (200 lb N/A) 4 Replicates	1. Untreated Control 2. 2005: 385 lb/A 15-0-15 (58 lb N), then 664 lb/A 15-0-15 (100 lb N) bi-annually to 2021 Unreplicated
Measurements	*Soil solution* @ 1', 4': NO_x-N, NH_4-N *Ground water* @ 30': NO_x-N, NH_4-N *Soil fertility* (0-4'): *Foliar nutrients* *Tree height & GLD*	*Soil solution* @ 1', 4': NO_x-N, *Ground water* @ 70': NO_x-N, *Soil fertility* (0-5'): *Foliar nutrients* *Tree height & DBH* *Pine litter* dry weight	*Soil solution* @ 1', 4': NO_x-N, *Ground water* @ 30': NO_x-N *Tree height & GLD* *Pine litter dry weight*

Preliminary Findings

Nitrate I

Fertilization treatments in a 2-year-old slash pine plantation indicated greater potential for leaching following fertilization with 2.8 t/A broiler litter (180 lb N) than for 250 lb/A DAP (45 lb N). Soil solution nitrate concentration peaked at 57 mgL^{-1} at one foot depth 10 weeks following fertilization and at 41 mgL^{-1} at the four foot depth 12 weeks following fertilization with broiler liter. Using DAP, soil solution nitrate concentration peaked at 11 mgL^{-1} at one foot depth 6 weeks following fertilization and at 15 mgL^{-1} at the 4 foot depth 12 weeks following fertilization. From these peak levels, nitrate concentration declined to baseline levels (and those of the untreated check) by 37 weeks after fertilization. Groundwater monitoring wells at 30 feet did not indicate increased nitrate or ammonium during the first year following fertilization.

Some fertilizer responses were observed in young pines. Using conical volume index, adjusted for differences in initial tree size, loblolly and slash pines fertilized with chicken litter had significantly greater volume than the untreated check.

Nitrate II

Mineral fertilizer treatment using 650 lb/A of 22-13-10 material (143 lb N) showed greater potential for leaching than for 4.4 t/A broiler liter (200 lb N) in an 11-year-old slash pine plantation. With mineral fertilizer the maximum nitrate concentration was observed 6 weeks following fertilization for lysimeters at both 1 and 4 feet, 114 mgL^{-1} and 51 mg/L^{-1} respectively, and then declined to baseline levels by 18 weeks. Nitrate concentration in soil solution collected with lysimeters in the broiler litter treatment peaked at 4 mgL^{-1} at one foot depth 9 weeks following fertilization and at 3 mgL^{-1} at the four foot depth 12 weeks after fertilization, and subsequently declined to baseline levels by 23 weeks. Nitrate concentration in soil solution in the untreated check did not exceed 1 mgL^{-1} through the first year following fertilization. Groundwater monitoring wells installed at 70 foot depth showed nitrate concentrations between 2 and 6 mgL^{-1} with no appreciable difference from baseline levels.

Fertilization did not result in significant treatment effects on tree height or diameter at breast height for annual dormant season measures during the first three years following fertilization.

Nitrate III

Three weeks following mineral fertilizer applications in loblolly, slash, and longleaf pine, nitrate nitrogen concentration in soil solution at one foot depth reached a peak of approximately 50 fold or more that of the control. For loblolly, we did not observe an increase in the nitrate nitrogen concentration in soil solution at the four foot depth during the year following fertilization. In the case of slash and longleaf pines, we did record elevated levels of nitrate nitrogen in soil solution at four foot, beginning 9-11 weeks after fertilization. This indicates a flux of nitrates through the soil profile under these two species, with the maximum nitrate concentration observed at one foot.

Nitrate nitrogen was slightly elevated (less than 2 mgL^{-1}) in two wells at 30 foot depth in the treated area, as compared to the control.

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