Tifton-85 Hay Production and Nitrate Leaching in Field Under Nitrogen Fertilization

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Introduction

- Tifton-85 bermudagrass is an excellent option for hay, greenchop, and grazing because of the high yield and nutritive value
- Nitrate leaching from hay and livestock operations is a major environmental issue that could undermine the long-term sustainability of these operations in many watersheds
- Environmentally sustainable production of bermudagrass hybrids in watersheds needs to compromise on the rate of fertilizer application depending on the soil characteristics
- In watersheds where soil is mainly coarse sands, high fertilizer rates is a concern because of high N and P leaching

Objectives

1. Determine the capacity of Tifton-85 bermudagrass to remove applied N
2. Identify N application rate that optimizes forage yield and quality with minimal N leaching

Materials and Methods

Field Layout and Treatment Application

The study was conducted in an established Tifton-85 hay field within the Suwannee River basin, FL. (Fig. 1). The site has very deep, excessively drained, rapidly permeable upland soils, classified as Otela-Candler soil (sandy, siliceous, Hyperthermic, uncoated Lamellic Quartzipsamments). Individual plot size was 6 m^2 with 3-m inter plot width and alleys of 3 m wide (Fig. 2).

(a) Phase 1 Study

Four N rates (0, 33, 67, and 100 kg N ha^{-1} $harvest^{-1}$) corresponding to 0, 0.5, 1, and 1.5 X, respectively, of recommended N rate for hay production in FL. Each treatment was replicated 3X in a randomized complete block design (RCBD). Ammonium nitrate, N source, was surface applied after each harvest. Other nutrients (P, K, Mg, and S) were supplied at recommended rates. The grass was harvested at 28-d intervals. Soil samples were collected from each plot after each harvest to monitor changes in soil N content. To extract soil water after each rainfall for analysis, two lysimeters were installed in each plot at either 30 or 100 cm deep, representing depths within and below the primary rooting zones, respectively.

(b) Phase 2 Study

Based on the phase 1 study, phase 2 of the study was designed, where the N application rates were modified as follows (0, 33, 45, and 67 kg N ha^{-1} $harvest^{-1}$) corresponding to 0, 0.5, 0.67 and 1 X of recommended N rate. The experimental layout, design, setup, and data collection followed identical procedure as described above for the phase 1 study.

Laboratory analytical methods

NO_3-N concentration of soil water was determined using the USEPA Method 353.2. Air-dried soil samples (<2 mm) were analyzed for total N (standard Kjeldahl procedure), inorganic-N (KCl method), and P (Mehlich 3). Forage samples were oven-dried, ground (1-mm screen), and analyzed for total N using a modification of the standard Kjeldahl procedure, and P (Anderson ashing procedure)

N uptake efficiency (NUpE; g g^{-1}) was computed as: $NUpE = \frac{Nt}{PNS}$

where Nt = total N in the plant (g $plant^{-1}$); PNS = plant available nutrient obtained from N fertilizer (g $plant^{-1}$)

Results and Discussion

Table 1. Dry matter yield, average tissue crude protein content, annual herbage N removal, and average nitrate concentration of soil waster as a function of N application rates to established Tifton-85 Bermudagrass

N rate (kg ha^{-1} $harvest^{-1}$)	DM Yield Mg ha^{-1} yr^{-1}	Crude protein (g kg^{-1})	N uptake (kg ha^{-1} yr^{-1})	Soil-water NO_3-N (mg L^{-1})
Control	7.11	78.3	11.3	8.58
33	13.0	103.0	39.4	9.08
67	17.3	114.0	58.3	33.2
100	19.5	118.0	68.9	55.1

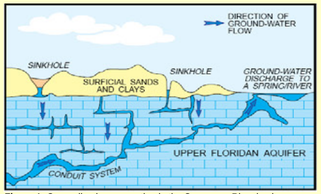

Figure 1. Generalized cross section in the Suwannee River basin showing karst features that facilitate the exchange of water between the surface and subsurface. Source: USGS

Figure 2. Experimental field showing Tifton-85 and suction lysimeters.

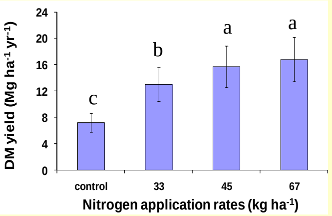

Figure 3. Total annual dry matter yield for the Tifton-85 bermudagrass as a function of N application rates.

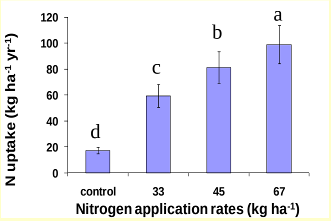

Figure 4. Herbage N removal by Tifton-85 bermudagrass as a function of N application rates.

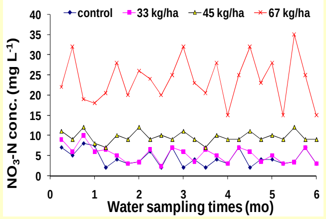

Figure 5. Average weekly NO_3-N concentration in soil water extracted from 100 cm deep.

Phase 1

The optimum total DM yield was obtained from the plots receiving the 67 kg ha $harvest^{-1}$, but yields were not significantly different from yields obtained from treatment of 33 kg ha^{-1} $harvest^{-1}$, with the least DM yield coming from the control plots (Table 1). Average herbage crude protein concentration was similar among the treatments, despite the differences in the rate of N application, and ranged between 10.3 and 11.8% (Table 1). Despite a DM yield difference between the treatments with 100 and 67 kg ha^{-1} $harvest^{-1}$, N uptake of the two treatments was similar, and was greater than those observed in the treatments with 33 kg ha^{-1} $harvest^{-1}$ and the control (Table 1). Across the sampling period, the 100 kg ha^{-1} treated plots had the greatest groundwater NO_3-N concentrations followed by the 67 kg ha^{-1} treated plots, with least N leached (<10 mg L^{-1}) occurring in the treatment with 33 kg N ha^{-1} harvest rate. The data suggested a need to evaluate N application rate between 33 and 67 kg ha^{-1} $harvest^{-1}$ that will optimize DM yield, without negatively impacting the groundwater NO_3-N concentration.

Phase 2

Dry Matter Yield and N uptake

Although there were yield increases with N application rate, the magnitude of the yield increases did not correspond to the increases in N rate, with optimum DM yield occurring in the treatment with 45 kg ha^{-1} harvest rate (Fig. 3). N uptake efficiencies decreased with N application rate with the greatest N uptake efficiency of ~0.51 g g^{-1} occurring in the plots receiving the 33 kg ha^{-1} harvest treatment, and the least N uptake efficiency of ~0.39 g g^{-1} occurring in the plots with 67 kg ha^{-1} $harvest^{-1}$ treatment (Fig. 4).

Nitrate Leaching

Although the measured NO_3-N concentrations varied over the sampling period showing "peaks and valleys", treatment effects on leached NO_3-N below the primary rooting zone was still obvious. The 67 kg ha^{-1} $harvest^{-1}$ treated plots had the greatest groundwater NO_3-N concentrations, with no significant differences between leached NO_3-N from the treatments with 45 and 33 kg ha^{-1} $harvest^{-1}$ rates, which was similar to background NO_3-N concentrations from the control plots (Fig. 5). The NO_3-N leaching patterns of plots receiving N rate of 67 kg ha^{-1} harvest treatment (>10 mg L^{-1}) could negatively affect groundwater quality, if such rates are applied to soils with coarse textures.

Conclusions

The study demonstrates that Tifton-85 bermudagrass is an efficient N remover from the soil. N rate of 47 kg ha^{-1} $harvest^{-1}$ (0.75 recommended rate) produced the optimum yield, with minimal NO_3-N leaching. The amount of NO_3-N leached from this treatment was similar to background NO_3-N concentration measured from the control plots.

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