A Comparison of Predicted and Actual Nitrate Nitrogen Profiles as a Result of Application of Poultry Litter to a Pasture

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ABSTRACT

The disposal of poultry litter on pasture lands can result in beneficial or detrimental effects. To better understand the mechanics of these effects, this work was aimed at assessing the fate of NO_3-N from the application of poultry litter to a tall fescue pasture. The computer simulation model, POULT, was developed and compared to results obtained in the field. A significant plant response was found to the application of 8.96 Mg/ha of poultry litter. Plant uptake of N followed a similar pattern as dry matter production. The computer program reasonably predicted NO_3-N in the profile shortly after application but failed to do so at 24 days after application. Generally, the greatest discrepancy between the predicted and actual NO_3-N was in the upper portion of the soil profile where most of the root growth and development and N uptake occurs.

INTRODUCTION

Poultry litter has been used successfully by many growers in northwestern Arkansas as a fertilizer for pastures. It has been used as the only source of plant nutrients, as a supplemental source for nutrients and as a mulch for the soil (Hileman, 1967). Extensive studies have been conducted to quantify the chemical composition and fertilizer value of poultry litter (Perkins et al, 1964; Hadas et al., 1983; Sims, 1986; Gale and Gilmour, 1986). However, land disposal of poultry litter recycles nutrients back into the food production system, and some concern has been expressed about the possible contamination of domestic water supplies from continuous and/or heavy application of the litter on pastures.

Low rates of poultry litter application usually do not produce high forage yields, as shown by Huneycutt et al. (1988), and thus farmers resort to high rates of application. Siegal et al. (1975), in a greenhouse experiment, found that the application of poultry manure at an air-dry rate of 5% by weight resulted in reduced yields of forage due to the toxicity of uric acid that is contained in the litter. They concluded that NO_3-N in excess of forage requirement leached below the root zone or runoff and, therefore, might move to both surface and subsurface water sources.

The mobility of nitrates to drinking water sources has become a focus of several research studies in light of the growing emphases on environmental quality and pollution control. Recent reports of contamination of domestic water supplies from the application of poultry manure were cited by Liebhardt et al. (1979), who showed that the NO_3-N level of groundwater was raised considerably above 10 ppm as a result of excessive applications of poultry litter. Ritter and Chirnside (1984) reported higher nitrate levels in wells within 305 m of poultry houses compared to those beyond this distance.

The objective of this study was to compare predictions using the computer model POULT as described by Ibrahim and Scott (1990) with the measured field nitrate profiles after the application of poultry litter to pastures.

MATERIALS AND METHODS

Tall fescue *(Festuca arundinacea* Schreb.) was planted on 17 March 1989 at the Main Experiment Station farm, Fayetteville, Arkansas. The soil was a Captina silt loam classified as a fine-silty, mixed, mesic, Typic Fragiudult. The 0.243-ha field was limed at a rate of 2.24 Mg/ha using pelletized lime at planting. Ammonium nitrate at a rate of 0.112 Mg/ha was broadcast preplant to aid in the establishment of the grass. On 19 February 1990 0.336 Mg/ha of 13-13-13 fertilizer was broadcast. The field was irrigated several times during the summer of 1989 to reduce drought stress.

The field layout of the poultry litter application experiment was established on 27 April 1990 (Fig. 1). Eight plots in a completely randomized design with four replications and two treatments were bordered with a metal hedge-edger. The treatments were 8.96 Mg/ha of poultry litter broadcast by hand on 22 May 1990 and a control. The individual plot

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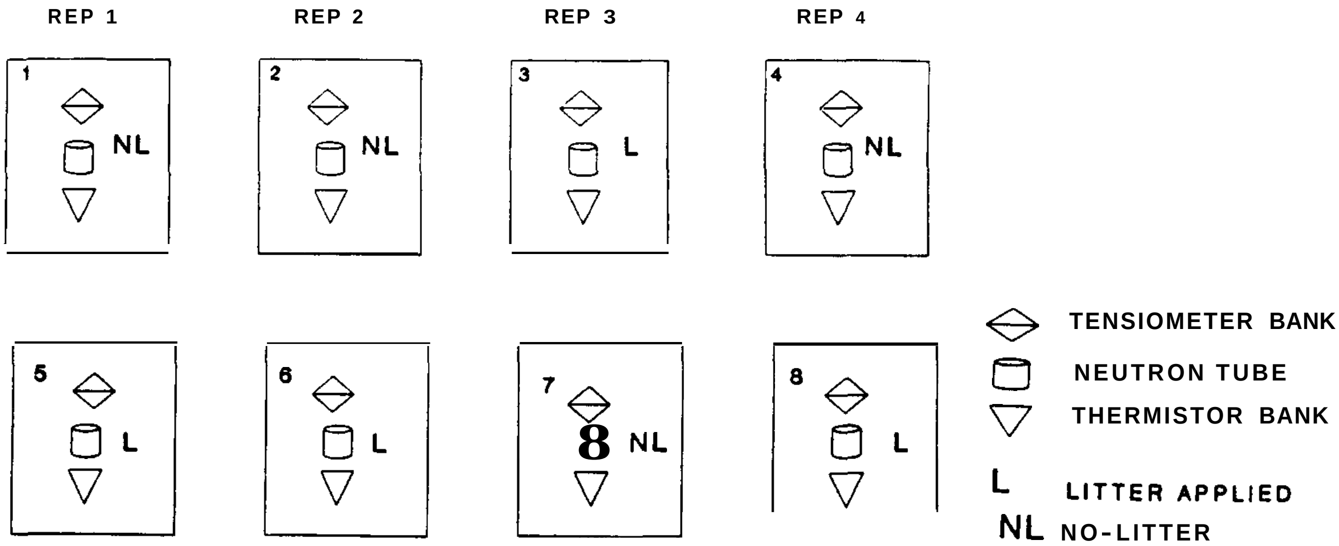

Fig. 1. Poultry litter experiment field layout

size was 4 x 6 m. Each of these plots contained a tensiometer bank and a thermistor bank by 16 May 1990. The tensiometers were installed at 15-cm increments to a depth of 90 cm. The thermistors were installed at the 5-, 10- and 30-cm depths. On 17 May 1990 the tall fescue in the plots was mowed to a height of 10 cm, and plant samples were taken for determinations of initial N content. Gravimetric samples for the determination of the initial soil water content distribution in the profile were taken just before application of the poultry litter on 22 May 1990 and at harvest. Soil samples were also taken on this date for the initial NO_3-N content determinations.

Soil water pressure readings using the tensiometers were taken three days per week starting on 22 May 1990. The thermistors were read at the same time as the tensiometers in order to determine soil temperature directly and soil water content through the use of a calibration curve that was determined using the same soil as that of the experimental site. The readings of the tensiometers and the thermistors were usually taken at 14:00 CDT. The tall fescue was harvested whenever the height of the new growth was about 20 cm. A randomly selected area of each plot was harvested, and the fresh weights and dry weights were taken to determine dry matter production. A subsample of the grass was ground for the determination of N content. Soil samples were also taken on harvest day for the determination of the NO_3-N concentrations in the profile at depth increments of 15 cm to a depth of 90 cm. The samples were frozen right after collection until analysis. NO_3-N was determined by the steam distillation method as described by Keeney and Nelson (1982).

RESULTS AND DISCUSSION

Poultry litter application to tall fescue resulted in a flush of above-ground growth (Fig. 2). Significantly higher dry matter yields were found in the treated plots as compared to the control (Fig. 2A). Much of the response in dry matter production due to poultry litter addition occurred during the first three months after application. The fescue in the control plots showed an increase in dry matter production but at a much slower rate than the treated fescue, as shown in Fig. 2B.

Plant N concentrations during the growing season are shown in Fig. 3. The N concentration of treated fescue was significantly higher than that of the control. The plant concentration of N was less than 4% throughout the experiment, which was in agreement with the poultry litter N content. Nitrogen uptake by the tall fescue was significantly higher for the treated plants than for the control, as shown in Fig. 4A. This reflected the abundance of N in the treated plots, especially during the first three months after application of the litter. The cumulative plant N uptake as shown in Fig. 4B maintained a higher rate of increase in plant uptake for the treated tall fescue as compared to the control. This was similar to the response of the tall fescue dry matter yield to the application of the poultry litter.

The computer program, POULT, which was used for the prediction of the soil NO_3-N profiles after the application of poultry litter, presently does not

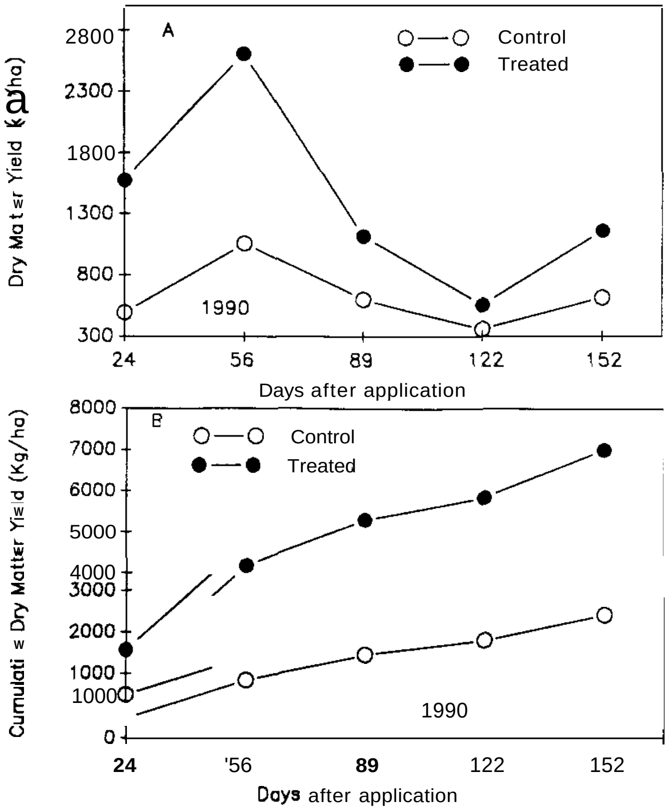

Fig. 2. Tall fescue dry matter yield (A) and cumulative dry matter (B) yield during the season.

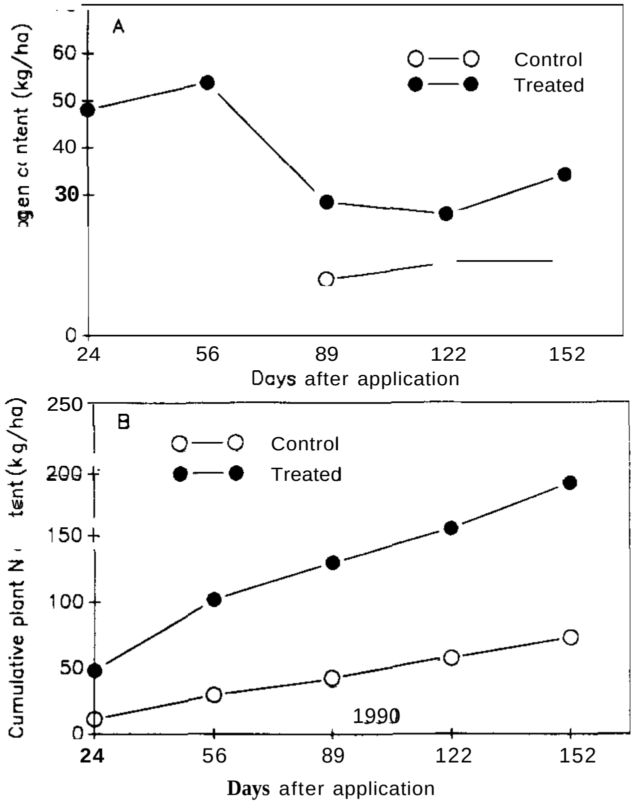

Fig. 4. Tall fescue nitrogen content (A) and cumulative nitrogen content (B) during the season.

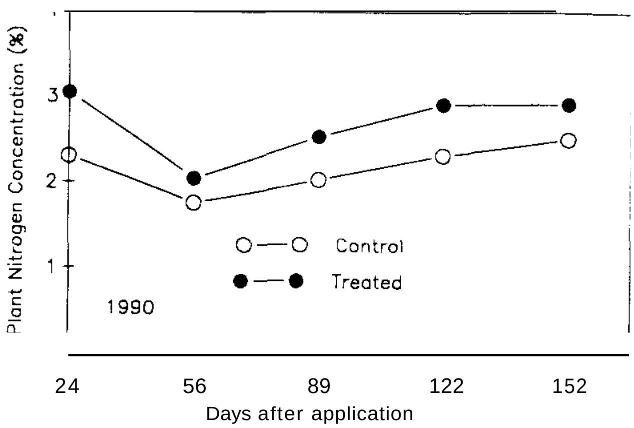

Fig. 3. Tail fescue nitrogen concentration (%) during the season.

consider the volatilization loss of the applied N from the poultry litter. The measured and predicted soil NO_3-N concentration profile one day after the litter was applied is shown in Fig. 5. There was a general agreement between the predicted and measured NO_3-N profiles except in the top 30 cm. This could be due to the fact that the soil samples taken on the first day after application contained some litter. Fig. 5B shows the same profile of NO_3-N concentration after 24 days. The model under-predicted the NO_3-N profile in the upper portion of the profile and over-predicted the NO_3-N in the lower portion of the profile. This may be because this was the time when the tall fescue was experiencing the highest rate of dry matter production and plant N uptake.

As the season progressed, the computer model was able to generally give better predictions of the NO_3-N profiles in the lower portion of the soil profile. The pattern of under-prediction of the NO_3-N in the upper portions continued (Fig. 6A and B). This suggests that the computer model was over-predicting the NO_3-N plant uptake throughout the growing season. Work is underway to reconcile the computer model predictions with the field results.

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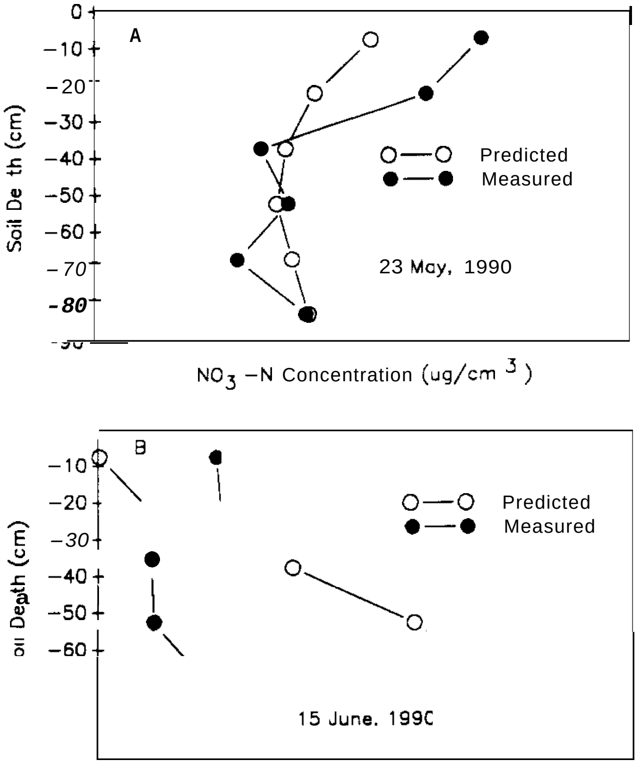

Fig. 5. Nitrate nitrogen concentration profile (A) one day and (B) 24 days after application of poultry litter.

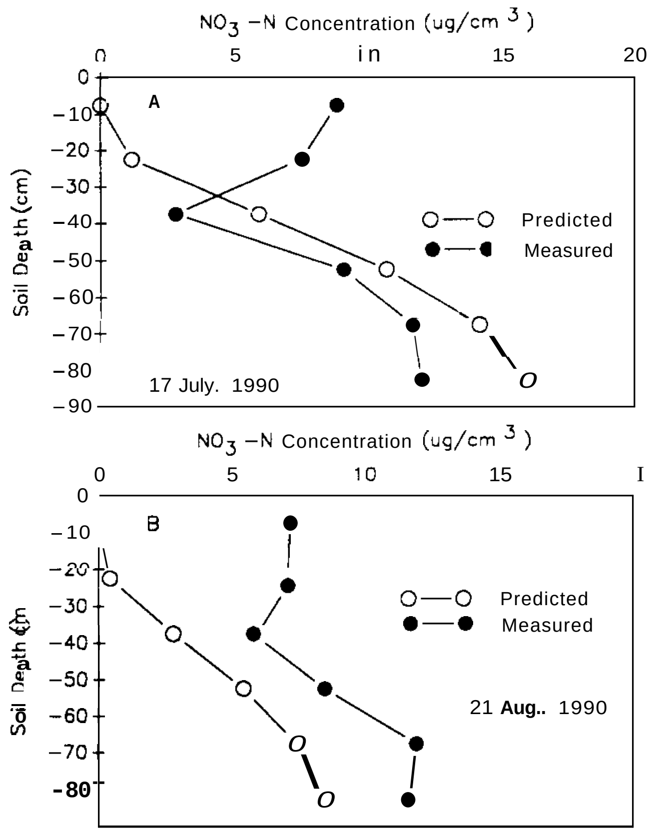

Fig. 6. Nitrate nitrogen concentration profile (A) 56 days and (B) 89 days after application of poultry litter.

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