# Poultry Litter Nitrogen Utilization by Eight Grass Species

L. M. Tharel and J. R. King
Natural Resources Conservation Service, Plant Materials Center
Booneville, Arkansas

## Introduction

Several studies have been conducted on nitrate contamination of water by feedlots and commercial fertilizers (McLeod and Hegg, 1984; Khaleel et al., 1980; Sommerfeldt et al., 1973; Lorimar et al., 1972), while limited research has been conducted on land-applied poultry litter and its effects on groundwater (Giddens and Barnett, 1980; Liebhardt et al., 1979).

Nitrate contamination of groundwater is an important concern for agricultural and nonagricultural industries and the general public. Certain agricultural practices are identified as contributors to nonpoint source pollution (Daliparthy et al., 1994). The ultimate receptor of animal wastes is adjacent agricultural land (Loehr, 1970). Estimates as high as 73% of all manures from confined production are land-applied (Stewart, 1980).

Land-applied poultry litter may be used as a crop fertilizer, which tends to limit the problems associated with litter accumulation. Poultry litter has beneficial impact on yield of tall fescue *(Festuca arundinacea* Schreb.) (Hunneycutt et al., 1988), orchardgrass *(Dactylis glomerata* L.) (Hileman, 1973) and bermudagrass *[Cynodon dactylon* (L.) Pers.] (Hunneycutt et al., 1988).

The objectives of this study were to evaluate the effects of poultry litter application on dry matter (DM) yield, nitrogen (N) accumulation in plant tissue, and nitrate nitrogen (NO,-N) concentrations in soil water.

## Methods and Materials

This study was initiated at the Natural Resources Conservation Service (NRCS) Plant Materials Center at Booneville in west central Arkansas. The study was conducted on a Taft silt loam (fine-silty, ciliceous, Thermic Glossaquic Fradiuoults) soil. Main plot treatments with three replications consisted of a control (0), 4, and 8 tons of poultry litter/acre on a dry-weight basis. The 4 ton/A poultry litter rate was broadcast-applied as a single application in April and October for the warm- and cool-season grass species, respectively. The 8-ton litter rate was applied as two 4-ton/A split applications in April and June for the warm-season species and October and April for the cool-season species. Nutrient analysis of the poultry litter was approximately 80.1, 68.8, and 54.3 lb/ton for nitrogen, phosphorus, and potassium, respectively.

Individual grass and fallow subplot sizes were 10 by 20 feet. Warm-season perennial grass species included 'Alamo' switchgrass *(Panicum virgatum* L.), 'T-587' Old World bluestem *(Bothriochloa caucasica* C. E. Hubb.), 'Pete' eastern gamagrass *[Tripsacum dactyloides* (L.) L.], and 'Midland' bermudagrass. Cool-season perennial species consisted of 'Palaton' reed canarygrass *(Phalaris arundinacea* L.), 'Martin' tall fescue, and 'Boone' orchardgrass.

A cool- and warm-season annual subplot included a combination of 'Marshall' ryegrass *(Lolium multiflorum* Lam.) and 'Elbon' rye *(Secale cereale* L.) planted in early fall and a forage sorghum *[Sorghum bicolor* (L.) Moench] planted in early summer. Establishment seeding rates for subplots were based on NRCS and University of Arkansas Extension Service recommendations. A 4.5-inch row spacing was used for seeded species. Bermudagrass was vegetatively established and sprigged on 1-foot centers. Eastern gamagrass seed was germinated in a greenhouse and transferred to subplots with a 1.5-foot row spacing and a 1-foot spacing between plants within the row. Cool-season perennials were seeded in March of 1992 and warm-season perennials were established mid-June 1992.

Litter was applied to the cool- and warm-season fallow subplots at the same rate and on similar dates as the grass subplots. The fallow plots were maintained free of plant material throughout the study.

Harvest regimes for seasonal distribution and total dry matter production were based on best management practices for maximizing production and/or hay production for individual grass species. Clipping height for grass species were: 6 inches for switchgrass, 4 inches for Old World bluestem and sorghum, 8 inches for eastern gamagrass, 2 inches for bermudagrass, and 3 inches for tall fecue, orchardgrass, reed canarygrass, rye, and ryegrass.

After each harvest, randomly collected samples were obtained for tissue analysis. The samples were dried at 140°F and ground in a Cyclotec sample mill (Tecator, Hoganas, Sweden) using a 0.5-mm screen. Tissue Kjeldahl N accumulation for the different grass species was calculated on an oven-dry weight basis.

**Lance M. Tharel, Assistant Manager of the Natural Resources Conservation Service - Plant Materials Center, 6883 S. St. Hwy. 23, Booneville, AR 22927. Phone: 501-675-5182; Fax *501675-5466.***

In May 1993, porous ceramic tip soil moisture samplers (Soil Moisture Equipment, Santa Barbara, CA, Model No. 1920) were installed at a depth of 18 inches. A 2-inch mechanical auger was used to install the samplers at the desired depth. A small quantity of bentonite clay was added to the hole to isolate the samplers from the soil below. Similarly, a small amount of pure silica-sand (200-mesh) was added and the sampler inserted into the hole. Silica-sand was then added to an approximate 6-inch depth. Extracted soil was added to a level above the soil moisture sampler and a bentonite plug was used to isolate the samplers and ensure against water channeling into the hole. The remainder of the hole was backfilled with soil while tamping out continuously with a metal rod.

A vacuum was drawn on soil moisture samplers prior to water collection. Rainfall events dictated sampling frequency. Sampling occurred once a month from November through May of each year. Water was then stored until nitrate N and phosphorus were analyzed on each sample.

## Results and Discussion

Seasonal DM yield (Table 1) for the observed grass species ranged from 1,660.0 to 10,765.3 lb/A for the control (zero litter); 4,840.8 to 22,932.3 lb/A for the 4-ton/A litter application; and 7,387.0 to 26,903.9 lb/A for the 8-ton/A rate, Yield response was observed for individual grass species with each additional 4-ton/A increment of litter. Greater responses were observed between the 0- and 4-ton/A rate for tall fescue (74.3%) and bermudagrass (69.0%) than for other species. Dry matter yields for eastern gamagrass indicated the lowest increase (31.4%) in production with the addition of 4-ton/A of litter.

Generally, the cool-season perennial species produced lower DM yields at the 0- and 4-ton/A rates than other species except for Old World bluestem. Yield increases between the 4- and 8-ton/A litter rates were less than half of the DM yield observed for increases between the 0- and 4-ton/A rates. The largest DM yield observed was for the annual rye, ryegrass, and forage sorghum combination for the three litter treatments. The warm-season annual contribution was 76.2,62.9, and 62.7% of the total production at 0-, 4-, and 8-ton/A litter rates, respectively.

Seasonal DM distribution indicates that the majority of production occurred by the middle of the growing season. Producers should consider limiting applications past the midpoint in the growing season to facilitate maximum uptake of N resulting from applied poultry litter.

Tissue N accumulation (Table 2) in grass species with 0-ton/A litter ranged from 38.9 to 165.3 lb/A N; from 173.1 to 450.7 lb/A N with 4-ton/A litter; and from 236.3 to 696.5 lb/A N with 8-ton/A of applied litter. Tissue N removed by grass species increased with each additional 4-ton/A litter application. Similar to forage DM yield, there were substantial differences in N accumulation between species and between litter rates. An interesting comparison between two warm-season perennials is the N accumulation for Old World bluestem (38.9 lb/A) and eastern gamagrass (115.4 lb/A) at the 0-ton/A rate of litter.

Changes in N removal between the 0- and 4-ton/A and 4- and 8-ton/A rates were more similar for tall fescue (75.1 and 61.4%, respectively) and orchardgrass (67.1 and 55.6%, respectively) than for other grass species evaluated. Percentage changes between the 0 and 4-ton/A rates for eastern gamagrass (42.7%), Old World bluestem (77.5%), and switchgrass (66.4%) were greater than for changes between the 4- and 8-ton/A rates for the same species (14.8,27.6, and 26.1%, respectively). The coollwarm-season annual combination removed substantially more litter applied N at all three application rates than other evaluated species. The annual combination of a cool/warm-season species removed 159 and 185.1 lb more N/A at the 4- and 8-ton/A rate, respectively, than the perennial bermudagrass species.

Laboratory analysis determined that one ton of poultry litter contained approximately 80 lb N. Depending on the grass species and the application rate, average recovery of N as a percent calculated on total N applied ranged from 54.1 to 140.6% for 4-ton/A and from 36.9% to 108.8% for 8-ton/A of applied litter. Generally, all grass species evaluated were more efficient at N recovery at the 4-ton/A than at the 8-ton/A application rate. Nitrogen utilization for orchardgrass was slightly greater at the 8-ton/A (60.9%) than for the 4-ton/A

**Table 1.** Seasonal *dry* **matter yields of** grass **species as influenced by 0-, 4-, and 8-tons/acre of applied poultry litter.**

| Species | Litter application rate (tons) 0 | 4 | 8 |
|---|---|---|---|
| | | lb/A | |
| Coollwarm-season annual | 10,765.3 | 22,932.3 | 26,903.9 |
| Bermudagrass | 4,004.7 | 12,936.6 | 18,524.7 |
| Tall fescue | 2,109.7 | 8,213.9 | 11,187.4 |
| Eastern gamagrass | 6,048.9 | 8,818.1 | 10,077.6 |
| Old World bluestem | 1,660.0 | 4,840.8 | 7,387.0 |
| Orchardgrass | 2,370.0 | 6,906.8 | 11,906.6 |
| Reed canarygrass | 3,531.3 | 7,644.1 | 11,557.3 |
| Switchgrass | 4.735.2 | 11.268.7 | 13.704.5 |

**Table 2. Seasonal nitrogen removal by grass species fertilized with variable rates of poultry litter.**

| Species | Litter application rate (tons) 0 | 4 | 8 |
|---|---|---|---|
| | | lb/A | |
| Coollwarm-season annual | 165.3 | 450.7 | 696.5 |
| Bermudagrass | 60.9 | 291.7 | 511.4 |
| Tall fescue | 48.8 | 193.5 | 360.9 |
| Eastern gamagrass | 115.4 | 201.9 | 236.3 |
| Old World bluestem | 38.9 | 173.6 | 239.6 |
| Orchardgrass | 57.4 | 173.1 | 390.8 |
| Reed canarygrass | 91.1 | 232.9 | 405.4 |
| Switchgrass | 78.7 | 232.8 | 314.3 |

(54.1%) litter rate. Similar to orchardgrass, Old World bluestem at the 4-ton/A rate was the least efficient (54.1%) at N recovery. Eastern gamagrass and Old World bluestem N recovery values at the 8-ton/A litter rate averaged 36.9 and 37.3%, respectively, which were the lowest values recorded for all species.

At the 4-ton/A rate, the cool/warm-season annual (140.6%) and bermudagrass (90.9%) were more efficient than other species in N recovery and were 108.8 and 79.8%, respectively, effective in litter applied N recovery at the 8-ton/A rate.

Nitrate-N concentrations in soil water under study plots receiving zero poultry litter resulted in mean $NO_3$-N concentrations that were generally lower than for the 4- and 8-ton/A application rates (Table 3). Mean $NO_3$-N soil water concentrations at the 18-inch depth were usually lower in May 1994 than in December of the same year. Mean values recorded for June 1993 were baseline means prior to the application of poultry litter at the 4- and 8-tonlA rates. Higher mean $NO_3$-N concentrations were detected in soil water collected with the addition of poultry litter at the 4- and 8-ton/A application rates.

**Table 3. Effect of variable poultry litter rates applied to various grass species on soil moisture $NO_3$-N concentrations (ppm).**

| Species | Date | | |
|---|---|---|---|
| | June 1993 | May PN4 | December 1994 |
| | | 0 Tons/acre | |
| Cool/warm-season annual | 33.05 | 0.45 | 1.18 |
| Bermudagrass | 8.84 | 0.50 | 0.83 |
| Tall fescue | 15.39 | 0.35 | 2.75 |
| Eastern gamagrass | 50.31 | 1.27 | 0.66 |
| Old World bluestem | 4.10 | 5.23 | 0.49 |
| Orchardgrass | 21.54 | 1.47 | 4.12 |
| Reed canarygrass | 0.38 | 0.47 | 0.44 |
| Switchgrass | 3.01 | 0.27 | 0.52 |
| Summer fallow | 48.08 | 47.60 | 49.38 |
| Fall fallow | 42.39 | 50.20 | 55.15 |
| | | 4 Tons/acre | |
| Cool/warm-season annual | 28.14 | 1.30 | 3.01 |
| Bermudagrass | 6.80 | 0.20 | 0.53 |
| Tall fescue | 7.75 | 1.70 | 0.36 |
| Eastern gamagrass | 57.53 | 10.00 | 18.69 |
| Old World bluestem | 10.16 | 2.17 | 7.69 |
| Orchardgrass | 2.57 | 0.20 | 1.55 |
| Reed canarygrass | 1.95 | 0.47 | 0.33 |
| Switchgrass | 2.03 | 3.60 | 1.64 |
| Summer fallow | 39.66 | 37.90 | 48.37 |
| Fall fallow | 43.91 | 45.10 | 68.77 |
| | | 8 Tons/acre | |
| Cool/warm-season annual | 41.98 | 5.10 | 10.85 |
| Bermudagrass | 10.20 | 17.80 | 51.76 |
| Tall fescue | 36.04 | 1.92 | 9.37 |
| Eastern gamagrass | 39.30 | 20.52 | 112.86 |
| Old World bluestem | 13.92 | 19.92 | 39.27 |
| Orchardgrass | 15.90 | 5.47 | 16.21 |
| Switchgrass | 3.54 | 5.63 | 46.98 |
| Reed canarygrass | 1.67 | 0.83 | 4.51 |
| Summer fallow | 61.38 | 40.91 | 92.27 |
| Fall fallow | 42.99 | 24.50 | 81.68 |

The water samplers did not collect soil water from May until November because of high transportation rates and low precipitation during that period. The lower $NO_3$-N concentrations recorded for May 1994 possibly were affected by various factors such as grass species growth rate when plants are more active in nutrient utilization during a period of high evapotranspiration and lower precipitation, resulting in lower soil moisture content.

Mean $NO_3$-N concentrations for December 1994, indicated the possibility for greater potential of $NO_3$-N leaching than during the summer months. Increased $NO_3$-N leaching occurring mostly during the late fall and early spring periods in the north central or northeastern United States when evapotranspiration is low has been reported by Chichester (1977) and Daliparthy et al. (1994).

## Conclusions

Application of poultry litter at the 4- and 8-ton/A rates increased dry matter production, N accumulation in plant tissue, and $NO_3$-N concentrations in soil water. Differences in DM production were more pronounced between 0- and 4-ton/A than mean differences observed between the 4- and 8-ton/A application rates. The cool/warm-season annual combination of rye and ryegrass and forage sorghum produced more DM at the 4-ton/A (9,996 lb/A) and 8-ton/A (8,379 lb/A) than the next highest producing grass species, bermudagrass.

Nitrogen accumulation efficiency on a percentage basis of total N applied indicated that the cool/warm-season annual combination and bermudagrass were more effective at N uptake than other species. Nitrate-N soil water concentrations were lower in May than December 1994. Increased plant growth and evapotranspiration may have contributed to these observations.

## Literature Cited


Chichester, F.W. 1977. Effects of increased fertilized rates on nitrogen content of runoff and percolate from monolith lysimeters. J. Environ. Qual. 6:211-217

Daliparthy, J., S.J. Herbert, and P.L.M. Veneman. 1994. Dairy manure applications to alfalfa: crop response, soil nitrate, and nitrate in soil water. Agron. J.86:927-933.

Giddens, J., and A.P. Barnett. 1980. Soil loss and microbiological quality of runoff from land treated poultry litter. J. Environ. Qual. 9:518-520.

Hileman, L.H. 1973. Response of orchardgrass to broiler litter and commercial fertilizer. Rep. Ser. 207, Arkansas Agricultural Experiment Station, University of Arkansas, Fayetteville, AR.

Huneycutt, H.G., C.P. West, and J.M. Phillips. 1988. Responses of bermudagrass, tall fescue and tall fescue-clover to broiler litter and commercial fertilizer. Bull. 913, Arkansas Agricultural Experiment Station, University of Arkansas, Fayetteville, AR.

Khaleel R., K.R. Reddy, and M.R. Overcash. 1980. Transport of potential pollutants in runoff water from land areas receiving animal wastes: a review. Water Research 14:421-436.

Liebhardt, W.C., C. Golt, and J. Turpin. 1979. Nitrate and ammonium concentrations of ground water resulting from poultry manure applications. J. Environ. Qual. 8:212-215.

Loehr, R.C. 1970. Animal waste management—problems and guidelines for solutions. Presented at the Symp. on Agriculture and the Quality of the Environment of the Seventies, Chicago, IL. American Association for the Advancement of Science, Washington, DC.

Lorimar J.C., L.N. Mielke, L.F. Elliot, and J.R. Ellis. 1972. Nitrate concentrations in ground water beneath a beef cattle feedlot. Water Resources Bull. 8:999-1005.

McLeod, R.V., and R.O. Hegg. 1984. Pasture runoff water quality from application of inorganic and organic nitrogen sources. J. Environ. Qual. 13:122-126.

Sommerfeldt T.G., U.J. Pittman, and R.A. Milne. 1973. Effect of feedlot manure on soil and water quality. J. Environ. Qual. 2:423-427.

Stewart, B.A. 1980. Utilization of animal manures on land: state-of-the-art. *In* Livestock Waste: Renewable Resource. Proc. 4th Int. Symp. on Livestock Wastes. ASAE, St. Joseph, MI. pp. 147-9, 155.



,