Broiler Litter Plots

A research project was conducted at Watkinsville, Georgia, from 1972 to 1979 in which fate of nitrogen was studied for broiler litter applied on coastal bermudagrass (Cynodon dactylon L. pers.) plots. Two treatments (broiler litter application rates) were selected for validation since **GLEAMS** was developed to compare alternative management systems.

The research plots were 0.009 ha in size on a Cecil sandy loam soil (Typic Hapludult, clayey, kaolinitic, thermic). Multiple forage cuttings of coastal bermudagrass were made each year. Treatment B1 consisted of four applications of broiler litter per year at the rate of 11.2 t/ha per application. Treatment B2 had four applications per year at a rate of 44.8 t/ha per application. The applications were made in May, June, July, and August, for each treatment in 1972-1975. Broiler litter applications were discontinued after August 1975 but other observations were continued through 1978 to follow carry-effects.

Broiler litter was analyzed for moisture content, total N, total P for each application. Organic N, NO_3-N, and NH_4-N were not measured, and since they are input to **GLEAMS**, they were estimated for each application. In treatment B1, 3,780.5 kg total N/ha was applied during the four years of applications, and 15,122 kg/ha was applied in treatment B2.

Model simulated forage yield for treatment B1 was 88.2 t/ha forage dry matter compared with 82 t/ha observed for the 7-yr study period. The model representation may have calculated more forage removed than actually occurred. Simulated nitrogen uptake was 1,450 kg/ha for the 7-yr period which is only 38% of applied N. Dudzinsky et al. (1983) reported uptake as 71% of that applied. There was no effort to adjust the coefficient C1 in the parameters for luxury N uptake.

Simulated forage yield for treatment B2 was 105.2 t/ha compared with 98 t/ha measured. Nitrogen uptake was calculated as 1,737.2 kg/ha which is only 11.5% of applied N compared with 48% measured. Again, no attempt was made to represent a flush of nitrogen uptake.

Figure 15 shows simulated nitrate-nitrogen leached for treatments B1 and B2. Peak concentrations leached below the 122-cm root zone was 47.3 mg/L and 247.0, respectively. Peak concentration observed for treatment B1 was 68 mg/L and 273 mg/L for treatment B2 (Dudzinsky et al., 1983). Simulated and observed peak concentrations compare quite well as do the shapes shown in figure 15 and those given by Dudzinsky et al. (1983). NO_3-N leaching persisted longer for treatment B2 than treatment B1, both in simulation and observation.

Observed and simulated runoff volumes and runoff NO_3-N losses are shown in table 3 for the 7-yr period. The comparative runoff and nitrate-nitrogen losses are relatively good.

Table 3. Observed and simulated runoff and NO_3-N runoff losses, broiler litter plots, Watkinsville, GA, 1972-78.

Treatment	Runoff		Nitrate-Nitrogen	
	Observed	Simulated	Observed	Simulated
	cm	cm	kg/ha	kg/ha
B1	20.1	19.9	2.4	1.4
B2	13.5	18.8	2.9	2.7

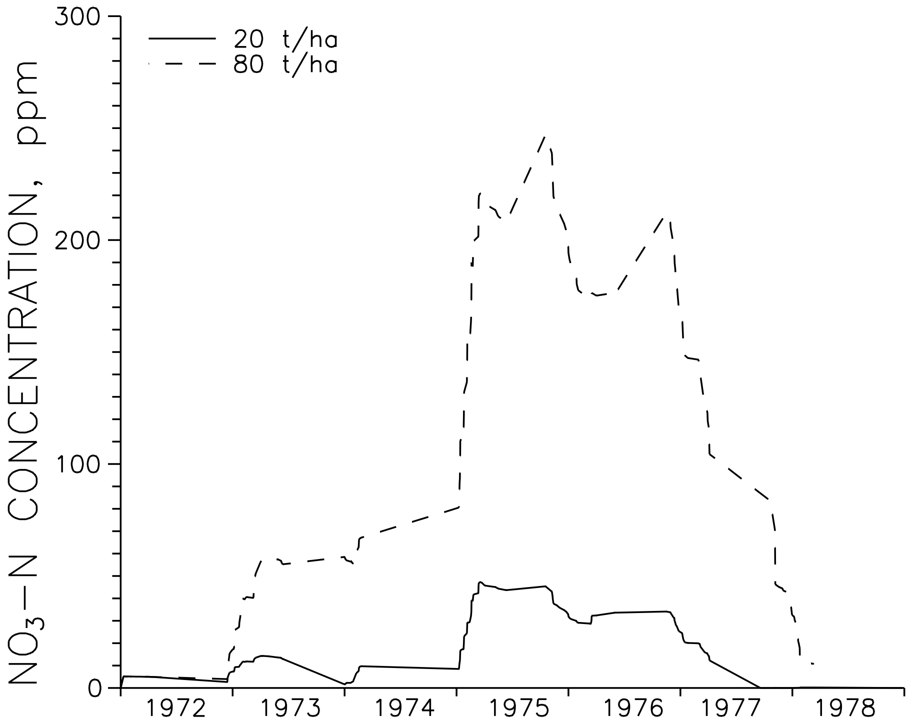

Fig. 15. Nitrate-nitrogen concentration leached below the 122 cm soil depth, Watkinsville, Georgia, broiler litter plots, 1972-78.

Results of validation for the broiler litter plots show that the **GLEAMS** plant nutrient component performs very well for the comparisons that could be made from the literature (Dudzinsky et al., 1983). Also, since there were two treatments (management practices), the results further demonstrate the model capability for comparing management alternatives.

EAST LANSING, MICHIGAN

Small watershed studies were conducted at the Michigan State University Experiment Station, cooperatively with the EPA (Ellis et al., 1978) from 1973 to 1976 to determine plant nutrient and pesticide losses from corn and soybean cropping systems. Conventional tillage was performed on two watersheds: watershed 06 with continuous corn, and watershed 07 with continuous soybeans.

Watershed 07, with a drainage area of 0.55 ha, was selected for the validation. Soils on the watershed are Spinks loamy fine sand (Psammentic Hapludalf, sandy, mixed, mesic), 82%, and Tuscola fine sandy loam (Hapludalf, fine loamy, mixed, mesic), 18%. Both are highly weathered alfisols, slightly acid, and high in phosphorus content. Average slope of watershed 07 is 7.6% with a north aspect. The watershed was in pasture for several years prior to 1972 when the sod was plowed and corn was grown.

Runoff was measured with an H-type flume equipped with a continuous water level recorder and an automatic pumping sampler. Runoff samples were collected and analyzed for sediment, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, and available phosphorus determined by the Bray P1 test. Soil cores were taken to a depth of 61 cm after major runoff events at 6 locations within the watershed. The cores were analyzed by incremental depth to 30 cm for NO_3-N, NH_4-N, TKN, and PO_4-P. Description of sampling and analyses were given by Ellis et al. (1978).

Soil cores were taken to 30 cm depth for bulk density, but laboratory determinations of water retention characteristics and saturated conductivity were not made[4]. Soil particle size analysis was not made, and background samples were not taken at the beginning of the study for nutrient analyses.

The GLEAMS model application was made on watershed 07 for 1974-75, and did not include the part-years 1973 and 1976. Since pedon data were not available for the watershed soils, generalized values the GLEAMS user manual (Part III) and the parameter editor were used to estimate parameters. Measured bulk density data were used from the May 22, 1974 sampling. Median soil silt and clay percentages for the soil textural classification by horizon were used as estimates for the erosion and nutrient components.

As reported earlier, initialization of the dynamic nitrate and ammonia pools, and the labile phosphorus pool is very sensitive for good results early in the simulation period. Nutrient data from the earliest sampling date (May 22, 1974) were used in conjunction with the user manual information to initialize nutrient pools.

Results of simulation for runoff and sediment yield are compared with observed values for MSU watershed 07 in table 4. The model over-estimated runoff volume for the snowmelt in 1974, but slightly under-estimated the snowmelt runoff in 1975. The frozen soil representation and/or initial soil water content did not result in percolation below the 51-cm root zone during January to March 1974 when simulated runoff was relatively high. This over-estimate of runoff resulted in an over-estimate of sediment yield for the 1974 winter-spring snowmelt period. Runoff and sediment yield for the 2-year period was dominated by a rainfall even with about 10.5 cm of rain on April 18, 1975. Almost 9 cm of runoff was observed compared with about half that amount simulated. Ellis et al. (1977) reported there was little snow on the relatively bare ground, and the soil was not frozen at the time of the rain. Snowmelt had occurred earlier in the month and some runoff had occurred. Approximately 80% of the rainfall was measured as runoff in the one event. The soils behaved more like a hydrological soil group D rather than group A as defined by USDA-SCS (1985). Ellis et al. (1977) reported the worst flooding in the East Lansing area in about 30 years. The soil was not frozen, and the snowpack was insignificant. As shown in table 4, GLEAMS severely underestimated the runoff and sediment yield for the month. Hubbard et al. (1982) described the drainage and ponding conditions of the two research water-sheds, and there is a notable lack of surface pondage on watershed 07 which is one of the reasons for its selection for the validation.

Table 5 shows the comparisons of simulated and observed runoff and sediment losses if nitrate, ammonia, and phosphorus by month for the 1974-75 period used in this validation. The over-estimate of runoff and sediment in the winter months is reflected in nutrient losses. In general, the model over-estimated in 1974, and due to the extreme storm of April 1975, underestimated losses that year.

Monthly simulated percolation volumes and associated nitrate leaching below the effective root zone, and denitrification are shown in table 6 for the study period. Percolation, leaching, and denitrification were not measured on the watersheds, but simulated values are shown here to give an idea of the magnitude of these components. Denitrification is shown for months when leaching was not simulated. Conceptually, denitrification occurs when the soil water content exceeds field capacity, that is, at some degree of saturation. Since infiltration of rainfall occurs at the soil surface, small rains can result in "excess" water content of the upper soil layers during a day with rainfall that does not result in percolation. Since the organic carbon content of the plow layer is most generally higher than the lower horizons, the energy source for denitrification is also higher in the near-surface layers. Percolation occurred only in the winter-spring snowmelt

[4] Hubbard, R. K., June 11, 1993, personal communication.

periods, but nitrate content apparently was relatively high at those times. Nitrate leaching and denitrification were about the same in 1974, but almost twice as much nitrate was lost by leaching than by denitrification in 1975.

Table 4. Simulated and observed monthly runoff and sediment yield, Michigan State University watershed 07, 1974-75.

Year	Month	Runoff Sim.	Runoff Obs.	Sediment Yield Sim.	Sediment Yield Obs.
		cm	cm	t/ha	t/ha
1974	January	3.75	0.08	4.53	0.02
	February	2.06	0.54	1.38	0.01
	March	4.09	0.08	4.82	T
	April	0	0.08	0	T
	May	0.54	T	2.58	T
	June	0	0	0	0
	July	0	0.14	0	0.25
	August	0	1.44	0	0.53
	September	0	0.03	0	T
	October	0	0	0	0
	November	0	0	0	0
	December	1.26	0	0.48	0
	Year	11.60	2.34	14.28	0.81
1975	January	3.05	2.51	2.76	0.07
	February	1.63	3.39	0.89	0.14
	March	1.82	2.67	1.23	0.52
	April	4.72	9.24	7.92	31.69
	May	0	0.04	0	0.02
	June	0	0.27	0	0.41
	July	0	0.12	0	0.04
	August	0.48	0.46	1.14	2.10
	September	0	0	0	0
	October	0	0	0	0
	November	0	0	0	0
	December	1.88	0.05	1.62	T
	Year	13.58	18.75	15.56	34.99

Three sampling dates were selected each year to represent early, middle, and late (or after) growing season. The selected dates are: July 3, August 14, and November 8, 1974, and June 2, July 21, and October 27, 1975. Model simulated and observed concentrations of NO_3-N, TKN, and PO_4-P are shown in figures 16-33. The figures include mean, minimum, and maximum concentrations observed in 6 cores analyzed to 30 cm depth on each date. Concentration data are plotted at the mid-depth level, for example, values for the 0-7.5 cm depth increment are plotted at the 3.75 cm depth.

Table 5. Simulated and observed monthly nitrogen and phosphorus losses, Michigan State University watershed 07, 1974-1975.

	Runoff						Sediment							
Year	NO_3-N		NH_4-N		PO_4-P		NH_4-N		Total N		PO_4-P		Total P	
Mon	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.

	kg/ha						kg/ha							
1974														
Jan	0.76	T	0.09	T	0.01	T	T	T	6.68	0.08	0.02	0.01	2.59	0.04
Feb	0.47	0.03	0.01	T	T	T	T	T	2.53	0.02	0.01	T	0.98	0.01
Mar	1.12	T	T	T	0.01	T	T	0	6.29	0	0.03	T	2.44	0
Apr	0	0.01	0	T	0	0	0	T	0	0.01	0	T	0	T
May	0.10	T	0.01	0	T	0	T	T	3.20	0.01	0.02	T	1.28	T
Jun	0	T	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0.08	0	0.02	0	0.02	0	0.01	0	0.82	0	0.10	0	0.43
Aug	0	0.10	0	0.05	0	0.07	0	0.02	0	1.63	0	0.15	0	0.83
Sep	0	T	0	T	0	T	0	T	0	0.02	0	T	0	T
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	1.35	0	2.06	0	0.14	0	0.04	0	0.82	0	0.15	0	0.50	0
Year	3.80	0.22	2.17	0.07	0.16	0.09	0.04	0.03	19.52	2.59	0.23	0.26	7.80	1.31
1975														
Jan	0.91	0.14	1.40	0.39	0.31	0.04	0.04	T	3.71	0.24	0.64	0.01	2.32	0.13
Feb	0.76	0.36	0.39	0.84	0.15	0.09	0.01	T	1.22	0.50	0.20	0.01	0.76	0.25
Mar	1.23	0.40	0.49	0.91	0.16	0.10	0.01	0.01	1.62	1.73	0.26	0.04	1.00	1.15
Apr	0.88	0.52	0.19	0.85	0.38	0.58	0.01	0.50	10.56	45.68	1.58	0.58	6.47	31.09
May	0	0.04	0	T	0	T	0	T	0	0.04	0	T	0	0.03
Jun	0	0.07	0	0.03	0	0.05	0	T	0	1.18	0	0.05	0	0.83
Jul	0	0.01	0	0.01	0	0.01	0	0.01	0	0.11	0	0.01	0	0.06
Aug	0.09	0.26	T	0.37	0.14	0.23	T	0.08	2.40	4.14	1.33	0.23	2.52	2.83
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0.35	T	0.02	0.01	0.32	T	T	T	2.00	0.07	0.69	T	1.92	0.03
Year	4.22	1.80	2.49	3.41	1.46	1.10	0.07	0.60	21.50	53.69	4.70	0.93	14.99	36.40

Even though soybeans was grown on the watershed, nitrogenous fertilizer was applied on planting day each year. Simulated NO_3-N in the 0-7.5 and 7.5-15 cm depths were only slightly less than the minimum observed concentration, and the simulated concentration in the 15-30 cm depth was about the same as those observed (Fig. 16). By mid-August, GLEAMS significantly under-estimated nitrate-nitrogen concentrations at all depths. Conceptually in the model, legumes take up nitrate and ammonia when the combined concentrations in the layers of water uptake exceed 5 ppm. Figure 17 indicates that possibly nitrogen uptake was over simulated rather than fixed compared with the field observations. By November 8, 1974 (Fig. 18), following a fall fertilization, the model simulated NO_3-N was well within the variability of observed values.

Table 6. Monthly simulated percolation, NO_3-N leached, and denitrification, Michigan State University watershed 07.

Year Month	Percolation (cm)	NO_3-N Leached (kg/ha)	Denitrification (kg/ha)
1974 January	0	0	0.31
February	0	0	0
March	0.29	0.54	0.75
April	1.62	3.18	0.89
May	3.25	7.28	2.43
June	0	0	0.22
July	0	0	0.04
August	0	0	0
September	0	0	0.09

October	0	0	0.04
November	0	0	4.93
December	0	0	0
Yearly Total	5.16	11.01	9.70
1975 January	0	0	0
February	0	0	0
March	0	0	0.14
April	4.84	13.54	3.52
May	0.42	1.32	1.53
June	0	0	0.40
July	0	0	0.19
August	0	0	2.05
September	0	0	0.03
October	0	0	0.08
November	0	0	0.32
December	0.91	4.24	2.12
Yearly Total	6.17	19.10	10.36

Following fertilization at planting in 1975, the June 2 simulated nitrate-nitrogen (Fig. 19) was slightly greater than the maximum observed in the 0-7.5 cm depth and slightly less in the 7.5-15 cm depth. This probably resulted from the actual application depth being greater than that stated in the report (Ellis et al., 1978) which is the value used in the model. The simulated concentration for the 0-7.5 cm depth on July 21, 1975 (Fig. 20) was far greater than observed, but simulated and mean concentrations for the other depths were practically identical. Again, by the end of the 1975 growing season, the model under-estimated the NO_3-N concentrations (Fig. 21).

Total Kjeldahl nitrogen includes all species other than NO_3-N, and is a rather stable constituent compared with nitrate. TKN concentrations by depth are shown in figures 22-27 for the selected sampling dates. Simulated values were well within the variability of field data on all dates for all depths except the 7.5-15 cm depth on July 21 and October 27, 1975. Simulated values were only slightly greater than the maximum observed values on those dates. The study period is very short, but in the series of dates shown here, there may be a tendency for the model to under-estimate mineralization to ammonia and nitrate in the cool fall season, and this could partially account for the under-estimate of NO_3-N.