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MANAGING LIVESTOCK WASTES ON PERMANENT PASTURES IN EAST TEXAS

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Summary

A research project was initiated in the spring of 1992 to investigate the impact of poultry litter and dairy effluent application on 'Coastal' bermudagrass, (*Cynodon dactylon* (L.) Pers.) and ryegrass, (*L. multiflorum* Lam.), and soils in East Texas. The plots were located at the Texas A&M Agricultural Research and Extension Center at Overton. Livestock wastes were applied in amounts delivering 0, 223, 446, and 891 lb/acre of nitrogen (N). Samples of forage, soil, and soil-water were collected and analyzed. Results indicate that significant leaching of NO_3^- from applied poultry litter or dairy effluent on sandy soils occurred only when 891 lb/acre N was delivered annually. Among the N rates from waste that were applied in this experiment, 446 lb/acre of N or less did not represent a hazard to groundwater quality. Some downward movement of phosphorus (P) was also indicated when 522 lb/acre P was applied annually from poultry litter onto a deep sandy soil. Uptake of P by Coastal bermudagrass and ryegrass was insufficient to utilize applied P from even a modest application of poultry litter which was based on N needs of the forage. Consequently, long-term over application of P in livestock waste, particularly the poultry litter in this study, will result in substantial P loading of the upper soil profile and an increased potential for movement into surface water.

Introduction

Concern for the protection of groundwater and surface water quality has focused considerable attention on the possible role of animal waste disposal in contamination of water resources. Regionally, specific interest has been focused on dairy and poultry operations since they constitute the primary confined animal enterprises in the humid south. Research to date has indicated that high rates of animal waste application may lead to nutrients leaching into groundwater (Lund et al., 1990; Dudzinsky et al., 1983). Some research has been done to monitor environmental impacts from waste application to cropland (Bacon et al., 1990; Bitzer and Sims, 1988). However, little is known about safe application rates for warm-season perennial grass pastures on the coarse, sandy soils of East Texas.

Keywords: Nitrate/phosphorus/dairy effluent/poultry litter/leaching.

Procedure

In response to environmental concerns a research project was initiated in the spring of 1992 on a Darco loamy sand at the Texas A&M Agricultural Research and Extension Center at Overton. An existing stand of Coastal bermudagrass was divided into eight 58-ft X 16-ft plots arranged in four blocks of two plots and eight subplots each. In the autumn, plots were overseeded with 'TAM 90' annual ryegrass. Nitrogen sources (dairy effluent or poultry litter) were main plots and N rates were subplots for this split-plot design. Annual N rates totaling 0, 223, 446, and 891 lb/acre were from four applications within each year. Subplots were fitted with runoff prevention barriers and arranged with 32-ft buffer strips between blocks to prevent overland contamination from adjacent treatments.

Forage harvests were taken monthly from each subplot from April through September. Whole-top plant samples were tested for N and P content and total dry matter yields were calculated. Cross-multiplication of these two factors allowed computation of total seasonal uptake for both N and P. Soil samples were collected from all subplots in February and August of 1993. Soil cores were composited at 12-in increments to a depth of 72-in. Samples were oven dried and analyzed for EDTA-extractable P and potassium (K), and extractable NO_3-N. Concentration of NO_3-N in soil solution was sampled at a 72-in depth using porous-ceramic-cup lysimeters installed in each subplot of two blocks in the experiment.

Results and Discussion

Increasing rates of animal waste applications resulted in larger forage dry matter yield for both bermudagrass and ryegrass. Likewise the animal wastes used (poultry litter or dairy effluent) differed in their effect on forage growth. Quantities of N and P removed from plots were influenced by the animal waste loading rate and type of waste used.

Application of dairy effluent for two years resulted in average annual N removal of 59.3, 83.2, 105.8, and 169.2 lb/acre respectively, from the 0, 223, 446, and 891 lb/acre N rates. These uptake totals include N removed in bermudagrass and ryegrass harvests collectively. This data indicates a large portion of N applied from dairy effluent was unaccounted for in forage tissue. Part of this loss may be explained by volatilization, often approaching 30% of N applied, when dairy effluent is spread on the soil surface (Christensen, 1986). However detailed analysis of gaseous losses would be required in order to account for all the N unused by the forages.

A significantly greater quantity of applied N was removed from plots receiving poultry litter. Average annual N removal totalling 58.5, 114.0, 178.3, and 251.2 lb/acre was observed for the 0, 223, 446, and 891 lb/acre N rates, respectively. Greater N recovery is, in part, explained by the higher biomass production of forages receiving poultry litter. The high level of other macro- and micro-nutrients in poultry litter relative to dairy effluent, as well as reports of lower volatilization losses in the literature, help to explain this yield advantage from poultry litter treatments.

Soil samples taken in February and in August of 1993 indicate a significant rise in over-all soil NO_3-N as rate of dairy effluent or poultry litter increased. Results from the August 1993 sampling of soil receiving poultry litter provide the clearest and most striking response (Fig. 1). The highest N rate from poultry litter resulted in extractable NO_3-N concentrations greater than all other treatments at the 12- to 24-, 36 to 48-, and the 48- to 60-in depths. However, it should be stressed that while these results do indicate leaching of N from poultry litter, the actual amounts obtained in soil extract are quite small. The low NO_3^- concentrations in soil extracts raise questions about the usefulness of periodic soil testing for tracking NO_3^- movement in coarse sands.

Phosphorus accumulation and movement in soils was adequately described by soil test results. Both poultry litter and dairy effluent significantly increased the overall soil P level as rate of application increased. Annual P applications from poultry litter were 0, 130, 261, and 522 lb/acre for the control, low, medium, and high application rates, respectively. Results from comparisons at individual depths show that the high poultry litter application (averaging 522 lb/acre P annually) significantly increased soil P at the 0 to 12-in and the 36 to 48-in depth relative to the control plots (Figure 2). While the presence of increased P at these depths does indicate leaching of phosphorus, the high level of initial soil P argues for caution in interpretation and application at this stage. However one can state with certainty that, given the very modest P uptake by bermudagrass and ryegrass, application of poultry litter based on N content resulted in high P fertility and a potential hazard of P loss into water resources. Over application of P from dairy effluent was of lesser concern since the effluent contained approximately one third of the P per unit N that poultry litter. Annual application of P from dairy effluent averaged only 0, 42, 84, and 169 lb of P/acre for the control, low, medium, and high effluent rates, respectively.

Analysis of soil leachate showed only the highest N rate (891 lb/acre) affected the NO_3-N content of soil solution at a 72-in depth. This response held true for both dairy effluent and poultry litter (Tables 1 and 2). Both waste sources had no effect on the mean NO_3-N concentration in soil-water samples drawn from any of the lower N rate treatments. The average NO_3^- concentration in water extracted from beneath poultry litter plots (17.5 mg/l) was larger than dairy effluent (10.5 mg/l). Of equal or greater interest to regulators would be the maximum observed values from among all sampling dates (Tables 1 and 2). It could be argued that a long-term average may disguise the impact of particularly significant releases by pooling them with less concentrated samples. Still, even when individual sampling dates were considered, only the highest N rate had a measurable effect on NO_3-N concentration in leachate.

These results indicate that nitrate leaching from this soil type may depend on reaching a threshold of applied or soil N rather than exhibiting a graduated response for each additional unit of N applied. The dramatic change in soil-solution NO_3-N when waste application increased from 446 to 891 lb/acre N suggests that leaching was in part affected by this threshold phenomenon. A level may exist beyond which additional N application exceeds the ability of the plant roots to intercept and utilize NO_3^-. Further experimentation with more incremental N rates would be needed to specifically identify and confirm the existence of a defined leaching threshold.

Acknowledgements

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Literature Cited

Bacon, S.C., L.E. Lanyon, and R.M. Shlauder, Jr. 1990. Plant nutrient flow in the managed pathways of an intensive dairy farm. Agron. J. 82:755-761.

Bitzer, C.C., J.T. Sims. 1988. Estimating the availability of nitrogen in poultry manure through laboratory and field studies. J. Environ. Qual. 17:47-54.

Christensen, B.T. 1986. Ammonia volatilization loss from surface applied animal manure. *In* A.D. Kofoed, J.H. Williams, and P. L'Hermite (Ed.) Efficient Land Use of Sludge and Manure. Elsevier Applied Science Publishers, London. p. 24-33.

Dudzinsky, M.L., S.R. Wilkinson, R.N. Dawson, and A.P. Barnett. 1983. Fate of nitrogen from NH_4NO_3 and broiler litter applied to coastal bermudagrass. *In* R. Lowrance, R. Todd, L. Asmussen, and R. Leonard (Ed.) Nutrient Cycling in Agricultural Ecosystems. University of Georgia College of Agriculture. Spec. Pub. 23.

Lund, Z.F., and B.D. Doss. 1980. Coastal bermudagrass yield and soil properties as affected by surface-applied dairy manure and its residue. J. Environ. Qual. 9:157-162.

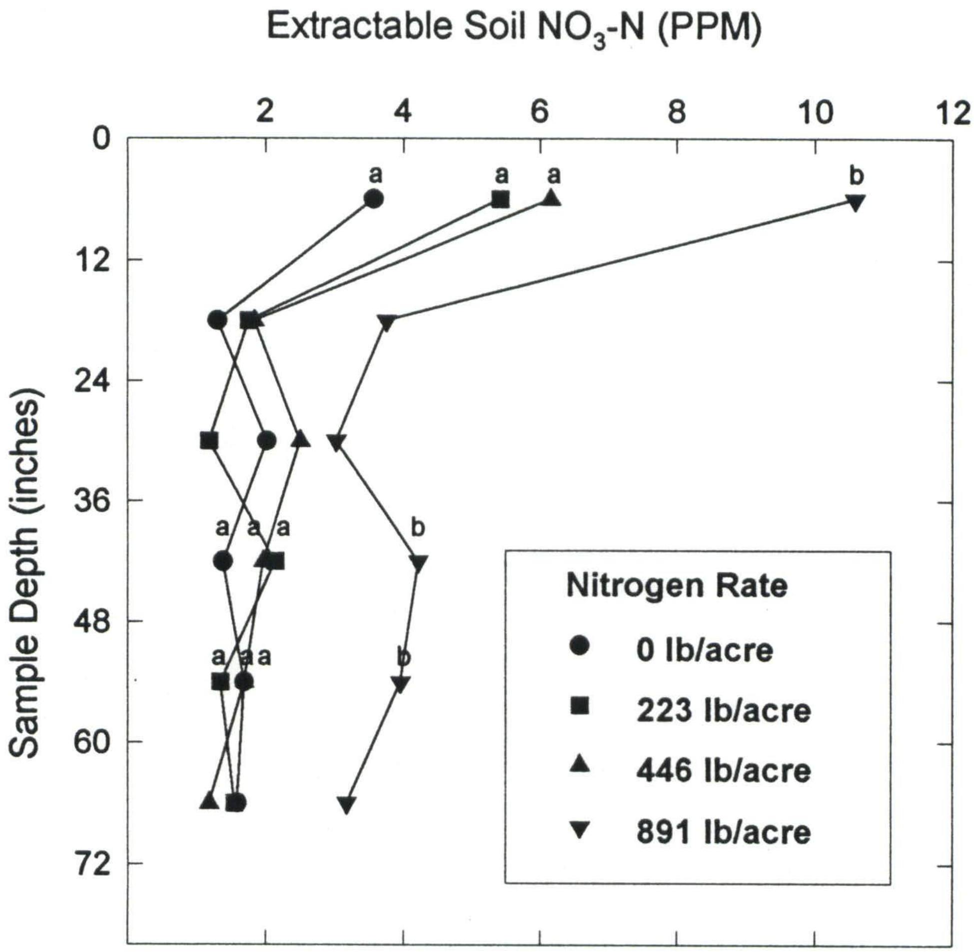

Figure 1. Extractable soil NO_3-N as influenced by poultry litter application and sampling depth. August 1993. Means followed by the same letter within depths are not significantly different ($p<0.05$).

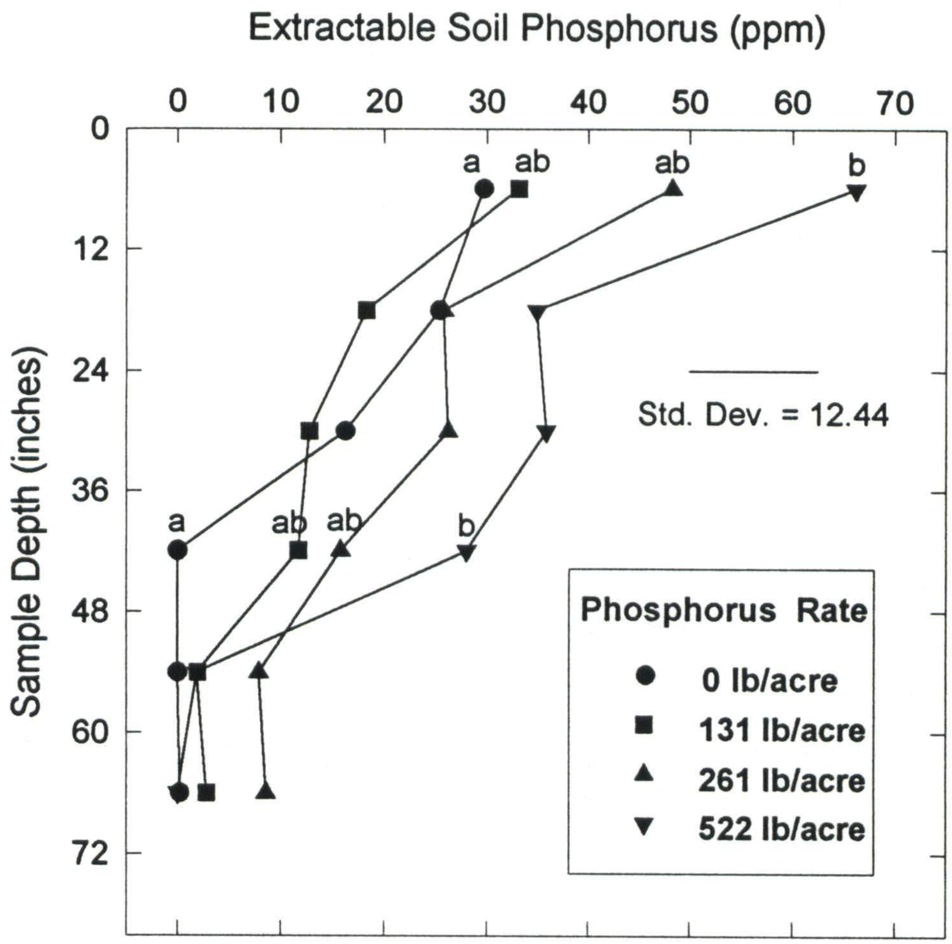

Figure 2. Extractable soil P as influenced by poultry litter application and sampling depth. August 1993. Means followed by the same letter within depths are not significantly different (p<0.05).

Table 1. Soil-water nitrate concentrations 180 cm below plots receiving poultry litter. 1992-94.

Nitrogen Rate	Mean*	Max. Observed Value	Std. Err.
	--------------------------------mg NO_3-N/l------------------------------		
0 lb/acre	1.2a	2.7	0.33
223 lb/acre	1.4a	3.2	0.50
446 lb/acre	1.7a	2.5	0.32
891 lb/acre	17.5 b	24.4	2.66

*Means followed by the same letter within columns are not significantly different ($p<0.05$).

Table 2. Soil-water nitrate concentrations 180 cm below plots receiving dairy effluent. 1992-94.

Nitrogen Rate	Mean*	Max. Observed Value	Std. Err.
	--------------------------------mg NO_3-N/l------------------------------		
0 lb/acre	3.8a	8.4	0.77
223 lb/acre	3.6a	6.9	0.62
446 lb/acre	1.3a	2.4	0.24
891 lb/acre	11.5 b	33.4	3.23

*Means followed by the same letter within columns are not significantly different ($p<0.05$).