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BERMUDAGRASS-WHEAT FORAGE SYSTEMS FOR DAIRY WASTE MANAGEMENT

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Summary

Our objective was to evaluate 'Coastal' bermudagrass [Cynodon dactylon (L.) Pers.] and Coastal bermudagrass-wheat (Triticum aestivum L.) forage systems for dairy manure disposal with minimal potential for ground-water pollution. Dry matter yields, nitrogen (N) loss from surface application, nitrate (NO_3) content of soil water, and changes in soil N, phosphorus (P), salt, and pH were measured. A field study was begun in May 1992 on established Coastal bermudagrass sod to provide annual rates of 0, 100, 200, and 400 lb manure-N/acre in four equal applications. Dry matter yields increased linearly as the manure-supplied N rate increased. Total dry matter yield for bermudagrass and bermudagrass-wheat at the highest manure rate in 1993 was 6989 and 5868 lb/acre, respectively. Wheat overseeding resulted in lower bermudagrass yields for two subsequent harvests, but did not reduce soil moisture content of the upper 36-in. soil profile. Nitrogen loss from surface-applied manure occurred primarily in the first 6 hr of exposure and was as high as 36% after 96 hr of exposure. Phosphorus content and pH of the upper 6 in. of soil increased as manure rates increased and were the same for both forage systems, but N and salinity did not change. Highest N recovery (41%) occurred for the bermudagrass-only forage system. Nitrate-N content of soil water was less than 1.0 ppm.

Introduction

Disposal of dairy waste solids (manure) resulting from steadily increasing herd size and herd numbers in North Central Texas has become a problem for dairy managers. Public concern for both surface and ground water quality also has increased. Current law mandates land application or containment to prevent runoff. Ideally, under land application, crops would utilize all nutrients applied and produce acceptable yields. While both N and P are needed for plant growth and can be supplied by manure, each is a potential pollutant of surface and ground water. This study was designed to evaluate Coastal bermudagrass and Coastal bermudagrass overseeded with winter wheat as management systems for dairy manure disposal.

Key Words: Manure / dairy waste / Coastal bermudagrass

Procedures

A field study was begun on established Coastal bermudagrass sod in May 1992. Soil at the site was a Windthorst fine sandy loam (fine, mixed, thermic Udic Paleustalfs) which was initially sampled to a depth of 42 in. for soil analysis. Manure treatments equivalent to 0, 100, 200, and 400 lb N/acre applied in four equal applications per year were arranged in a randomized complete-block design with four replications. Plots measuring 11.5 by 20 ft were separated by alleys measuring 5 by 20 ft. Replications were separated by a 10-ft wide alley containing a 10-in. high ridge of soil to prevent contamination of downslope treatments. Soil water samplers constructed of 1.5 in. diameter PVC pipe and porous ceramic cups were installed 18 and 36 in. below the soil surface in two replications in all but the 200 lb N treatment. The PVC pipe was capped. Vacuum was applied (0.78 in. mercury) and water samples were collected by means of two 0.125 in.(inside diameter) tubes inserted through holes in the cap of each pipe. Attempts to extract soil water via the ceramic cups were made shortly after rainfall events of at least 0.5 in. via the ceramic cups during the period from 2 Nov. 1992 to 31 March 1993. Neutron probe access tubes were installed in all 0-N and 400-N plots in both forage systems (16 plots) and in two replications receiving 100 lbs N/acre annually (4 plots). Soil moisture was monitored weekly at 6-, 12-, 24-, and 36-in. soil depths via neutron probe.

Manure applications on 17 June and 31 August of 1992 provided rates of 0, 80, 160, and 320 lb N/acre. Three applications in 1993 (3 March, 18 May, and 29 June) were the equivalent of 0, 101, 202, and 404 lb N/acre. These rates were based on manure as it was sampled at the time of application and were not adjusted for N volatilization loss. Deviation from planned N application rates resulted from estimation of manure N content before application and laboratory analysis.

Soil samples were taken initially in May 1992 in 6 in. increments to a depth of 42 in. Cores were taken from the 0-6 and 6-12 in. depths in all plots on 26 April 1993 to monitor changes in soil test values, particularly N, P, pH, and salt.

'Wintex' winter wheat was seeded into Coastal bermudagrass sod on 20 October 1992 after the grass was clipped to 2-in. height and yield data were taken. Seeding rate was 85 lb/acre in 10-in. drill rows.

Nitrogen loss resulting from surface application of manure was determined in a separate study conducted at the time of manure applications made on 31 August 1992 and 3 March, 18 May, and 28 June 1993. Weighed amounts of manure (approximately 150g) were placed onto paper plates and placed on a bermudagrass sod. Four replications were arranged in a completely randomized design. Exposure times were 0, 0.5, 1, 2, 3, 6, 12, 24, 48, and 96 hr. After completion of each exposure time one-half of each sample was weighed, oven-dried at 131°F and reweighed to determine dry matter (DM) percentage. The second half of each sample was sealed in a plastic bag and frozen for analysis.

Bermudagrass was harvested 21 July, 21 August, and 16 Oct. 1992 and 1 June, 28 June, and 6 Oct. 1993. Residual bermudagrass (from bermudagrass-only plots of the previous year) was harvested on 5 April 1993 to better determine N recovery. Wheat was cut at early anthesis on 23 April 1993. A sickle mower was used to cut a 2.83 by 20-ft swath from the center of each plot. Samples for DM determination were hand-clipped to avoid contamination with manure.
Manure and soil were analyzed by the Texas A&M Soil Testing Laboratory. Bermudagrass N content was determined by Near Infrared Reflectance (NIR) procedures. Wheat forage N content was determined by a modified Kjeldahl procedure using a block digester and colorimetric measurement (Baethgen and Alley, 1989). Soil water NO_3 was analyzed by a cadmium reduction method (U.S. Environmental Protection Agency, 1974). Statistical analysis utilized PC-SAS (SAS, 1988).

Results and Discussion

Dry matter yield increased linearly each year as manure-supplied N increased. Yield increased only 716 lb/acre in 1992 as manure N increased from 0 to 320 lb N/acre, possibly because of limited mineralization of organic N (Fig. 1). Yields in 1993 were more than doubled in each system as N application rate increased from 0 to 404 lb N/acre (Fig. 2). There was a strong relationship between manure-supplied N and dry matter yield for each forage system. Yield response for the bermudagrass-only system was greater per unit of N than was the response for the bermudagrass-wheat system. Dry matter yield of winter wheat forage cut 23 April was about the same as bermudagrass yield on 1 June 1993 (Table 1). However, yields of bermudagrass following the wheat harvest were significantly less than the bermudagrass-only system for both the 1 June and 28 June harvests resulting in equivalent total annual yields for each system. Reduced yield of bermudagrass in the bermudagrass-wheat system may have occurred because the wheat canopy delayed early bermudagrass growth through light interception or other competition. The reduction was not the result of differences in soil water content (Fig. 4). Bermudagrass yields at all N rates were lower than those for comparable rates of commercial fertilizer N under similar management (Sanderson et al., 1991). This may be due in part to loss of N after application, slow mineralization, or other factors.

Soil test values of N, P, pH, and salinity did not differ between the bermudagrass and bermudagrass-wheat forage systems. As manure-N increased from 0 to 320 lb/acre, P increased from 10 to 25 lb/acre and pH increased from 5.9 to 6.2 in the surface 6 in. Salinity and NO_3-N did not change with increasing manure N rate. The decline in P level for both systems from 1992 to 1993 (Table 2) is inconsistent with an anticipated increase in P since manure P application (about 62% of the N rate) was high relative to normal plant uptake.

Loss of N (presumably ammonia volatilization) from sod-applied manure was significant for the four dates (Table 3). Nitrogen loss ranged from 11% to 36% following 96 hr of exposure. Factors which may affect N loss include original moisture and N content of the manure, pH of the manure, wind movement, and air temperature. Highest N loss occurred during a period in which both a lower maximum and a lower minimum air temperature were recorded. The mean N content of manure after varying exposure times for four dates shows that most of the N loss occurred within 6 hr of first exposure (Fig. 3).

Recovery of N through plant uptake was very low (Table 4). Where no manure was applied in 1992, N content of harvested bermudagrass forage totaled 34 lb/acre. At higher rates of manure-N, only slightly larger amounts of N were recovered. However, N application rates were not adjusted for volatilization losses, which averaged over 20% for four dates (Table 3). Nitrogen recovery by plant uptake in 1993 was greater for bermudagrass than for the bermudagrass-wheat forage system, and N recovery was higher in both forage systems than in 1992. The highest recovery of applied manure-N (41%) occurred for bermudagrass where 202 lb N/acre was applied.

Mean soil water content (0 to 36 in.) was similar for each system from 1 January through 27 July 1993 (Fig.4). Water content exceeded 0.3 in./in. of soil depth between 8 Dec. 1992 (DOY = 343) and 15 May 1993 (DOY = 135). Soil moisture for both systems declined soon after wheat harvest on 23 April. Wheat apparently did not use soil water necessary for subsequent bermudagrass growth or it was replenished by rainfall.

Nitrate-N content of soil water extracted from 18 and 36 in. soil depths during the period from 20 Nov. 1992 through 31 March 1993 was less than 1.0 ppm (data not shown). Higher manure application rates did not increase detectable NO_3 levels in soil water following three manure applications.

Literature Cited

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Table 1. Comparison of dry matter yields of bermudagrass and bermudagrass-wheat forage systems during 1993.

Harvest Dates	Forage System: Bermudagrass	Forage System: Bermudagrass-wheat
	---------------------lb/acre‡---------------------	
April 5, 23†	572**	1732
June 1	1929**	768
June 28	866*	688
October 6	1393^{NS}	1179
Total	4760^{NS}	4367

†Residual, dead bermudagrass was harvested April 5. Wheat was harvested April 23.
‡Mean yields for four manure-N rates.
*,**,^{NS}Significantly greater at the 0.05 and 0.01 probability levels or not significant, respectively.

Table 2. Mean soil test values for bermudagrass and bermudagrass-wheat forage systems before (May 1992) and after (April 1993) application of mature at four nitrogen levels.

Rates applied† N	Rates applied† P	Soil test‡ NO_3-N	Soil test‡ P	Soil test‡ Salinity	Soil test‡ pH
	lb/acre			µmhos/cm	
			May 1992		
		2	47	121	6.2
			April 26, 1993		
0	0	10^{NS}	10***	84	5.9*
79	50	12	15	82	6.0
159	99	13	21	84	6.1
319	199	15	25	90	6.2

†Manure applications were made 17 June 1992, 31 August 1992, and 3 March 1993.
‡Values for 0-6 inch soil depth.
*,****,^{NS}Significantly different at P≤0.05, 0.001, or not significant.

Table 3. Nitrogen loss from solid manure during 96 hours exposure.

Exposure period	N Loss†	Temperature High	Temperature Low	Wind Total‡	Pan evaporation
	%	°F		miles	in.
August 1992	11.2	93	63	229	1.06
March 1993	35.5	72	28	289	0.79
May 1993	21.2	84	57	294	1.10
June 1993	23.8	93	70	525	1.81

†Total Kjeldahl nitrogen loss as percent of initial N content.
‡Total miles of wind during 96 hours of manure exposure.

Table 4. Nitrogen recovered in bermudagrass and bermudagrass-wheat forage systems following applications of solid manure during two years.

Application Rate: Manure‡	Application Rate: N	Nitrogen Recovered†: Bermudagrass	Nitrogen Recovered†: Bermudagrass-wheat
lb/acre	lb/acre		
	1992		
0	0	34	--
3197	79	34	--
6394	159	37	--
12788	319	45	--
	1993		
0	0	52	42
7635	101	68	62
15297	202	134	75
30612	404	129	96

†Total Kjeldahl nitrogen.
‡Dry matter basis.

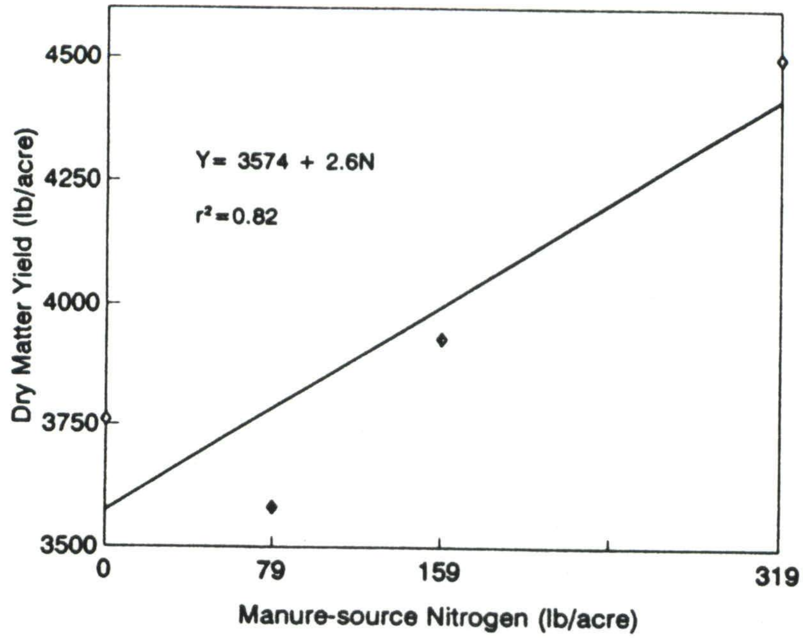

Figure 1. Effect of manure-source nitrogen on dry matter yield of Coastal bermudagrass during 1992.

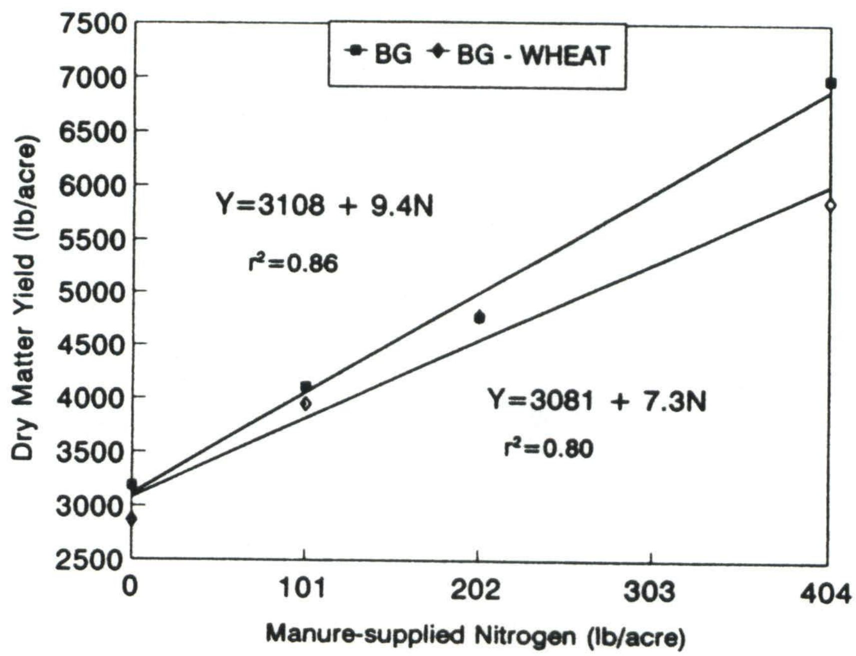

Figure 2. Effect of manure-source nitrogen on dry matter yield of Coastal bermudagrass and bermudagrass-wheat forage systems during 1993.

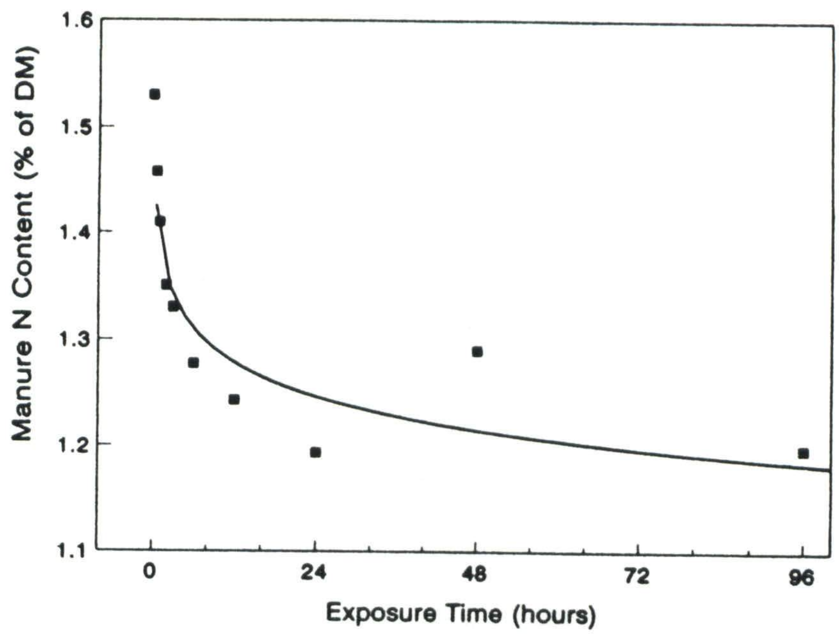

Figure 3. Mean nitrogen loss during four dates for sod-applied manure.

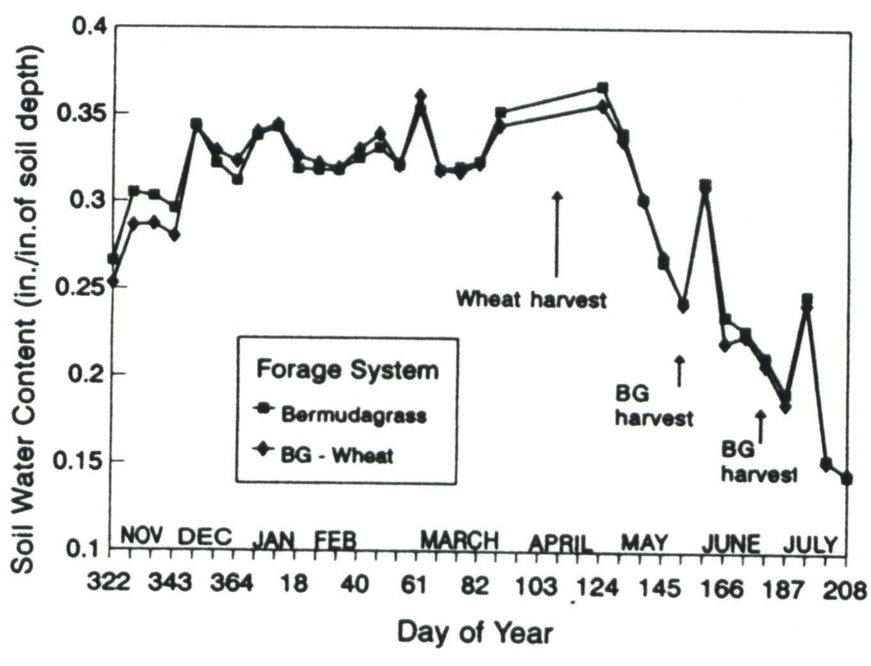

Figure 4. Mean water content of the upper thirty-six inches of soil profile for bermudagrass and bermudagrass-wheat forage systems for the period 17 November 1992 (day of year = 322) through 27 July 1993 (day of year = 208).