A SECOND YEAR REPORT ON THE USE OF DAIRY MANURE EFFLUENT IN A RHIZOMA (PERENNIAL) PEANUT BASED CROPPING SYSTEM FOR NUTRIENT RECOVERY AND WATER QUALITY ENHANCEMENT[1]

by

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Introduction

Importance

A by-product of a dairy operation is an abundant quantity of nutrients, viewed by many as an animal waste product, but used properly can be a benefit to the feed production program of a dairy. Management of nutrients derived from dairy effluent through sprayfield crop production systems can be an important component to the business of producing animal feed while contributing to the overall scheme of protecting ground and surface water from elevated levels of nitrogen and phosphorous. Uptake of nutrients by crops sequenced over time is an effective, economical, and environmentally sound means of nutrient management.

Development of appropriate crop management programs for dairy effluent sprayfields is needed to efficiently use the available nutrients and avoid possible ground water contamination. The most desirable design for any cropping system is one that meets environmental demands by maximizing nutrient uptake by the crops while meeting the needs of dairy producers. Several cropping systems using traditional crops have been suggested for use under sprayfields. Rhizoma (perennial) peanut (*Arachis glabrata* Benth.), a relatively new crop to

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Florida, is currently being examined for use in effluent sprayfields. Perennial peanut is a legume that produces a high quality forage which can be used in a dairy cow ration as a source of protein, fiber, and other nutrients. A perennial peanut sod based system in a dairy effluent sprayfield may also have the potential of continuous nutrient recovery over an entire year in addition to the production of a high quality forage. Being a legume, perennial peanut is normally grown with no applied nitrogen fertilizer, but when nitrogen is made available perennial peanut will up-take it from the soil and manure effluent. Perennial peanut produces a dense underground rhizome/root system which can intercept applied nutrients.

Perennial Peanut: Description

Perennial peanut has been identified as the only persistent, high-quality, warm season forage legume available to producers in Florida today. Perennial peanut can be produced in Florida and southern portions of the Gulf coast states, and Georgia. Perennial peanut has been produced in small plots as far north as the southern most extreme of South Carolina. Perennial peanut has no economically significant insect or disease pests and is resistant to nematodes. Because it has no pest problems there is no need for pesticides, making perennial peanut an environmentally sound crop to produce and/or provide a pest-free sod into which other crops can be seeded. In quality, perennial peanut is similar to alfalfa which is imported into the state of Florida at a cost to dairymen that ranges from $150 to $185 per ton of hay.

Perennial Peanut vs. Grass

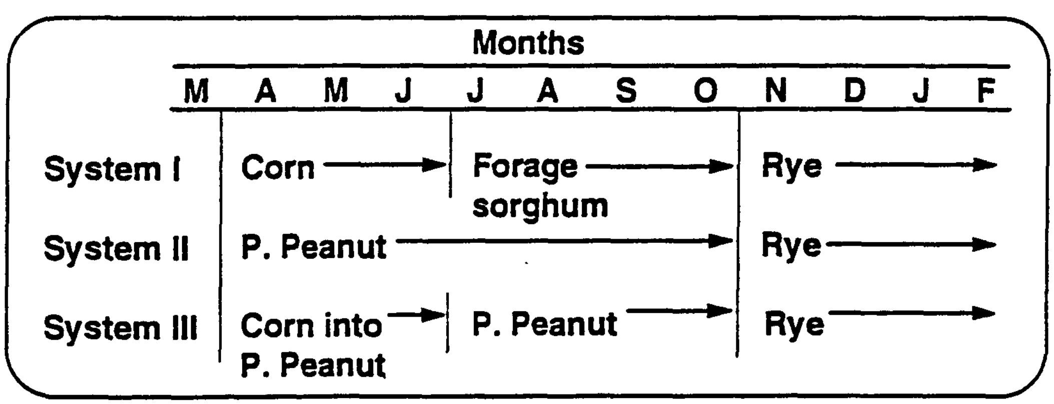
In contrast to a legume sod based system, such as one using perennial peanut, a grass sod based system may require additional nitrogen to produce quality forage under an effluent disposal system. For the production of quality grass hay under the condition of abundant summer rainfall and the continuous application of manure effluent, added nitrogen fertilizer may be required due to the dilute form of nitrogen being applied and the potential loss of nitrogen from the soil due to leaching. The condition described is ideal for point source pollution of ground water.

Summer rains also create an unpredictable hay making schedule. Quality of the hay crop left in the field beyond its optimum stage for cutting deteriorates rapidly. The mat of grass stems that results from an extended period between mowings makes hay mowing difficult. In contrast, once perennial peanut reaches a mowing height of approximately 12 inches it can be left in the field for 2 to 4 weeks more without a drastic reduction in quality and does not form a mat of long runners on the ground as does grass.

Cropping Systems

Considering the advantages and potential inherent to perennial peanut, research was designed and conducted to examine perennial peanut as a component in cropping systems managed in a dairy effluent sprayfield setting as compared to a conventional crop rotation of corn-sorghum-rye. Three 12-month cropping rotations were compared for their yield potential of high quality forage and ability to prevent groundwater contamination (Fig. 1). The year-round systems consisted of (1) corn, forage sorghum, and winter rye; C-FS-R, (2) perennial peanut and rye; PP-R, and (3) corn (planted directly into a perennial peanut sod), perennial peanut, and rye; C-PP-R.

Fig 1. Year-round cropping systems that utilize plant nutrients contained in dairy waste irrigation effluent.



Corn and forage sorghum harvested for silage while the rye and perennial peanut are harvested as hay or silage.

Before the initiation of this study, the nitrogen uptake was estimated to be 440 lbs per acre per year for the C-FS-R system, 428 lbs for the PP-R, and 440 for the C-PP-R. These estimates were based on previously reported dry matter yields and forage N percentages of the individual crops grown in North-Central Florida.

EXPERIMENTAL METHODS

A waste effluent-cropping systems study was conducted at the University of Florida's Dairy Research Unit near Hague, Florida.. All annual crops were planted using no-tillage equipment. Rye was planted on all plots in December, 1992. The study began in March, 1993 with the corn planting, continued through two 12-month cycles, and ended with rye harvest in late March, 1995.

In the C-FS-R system, corn was no-till planted into rye stubble and harvested in July. Forage sorghum was then no-till planted into existing corn stubble. Following sorghum harvest, rye was planted for the winter season using a no-till grain drill. For the C-PP-R rotation, corn was no-till planted into an established perennial peanut sod in March. At that time, the growth of perennial peanut is somewhat slow due to cool night temperatures, which allows corn a slight head start. After the corn canopy develops overhead, growth of

Table 1. Nitrogen applied to all cropping systems during corn, forage sorghum, and rye growing cycles at the Dairy Research Unit near Hague, Florida during 1993-94.

Crop	N treatment	N applied (lb/acre)
Corn	Control (effl. only)	195
	Low N	195+130=325
	High N	195+230=425
Forage sorghum	Control (effl. only)	70
	Low N	70+60=130
	High N	70+120=190
Winter rye	Control (effl. only)	95
	Low N	95+40=135
	High N	95+80=175
Total N	Control (effl. only)	360
	Low N	590
	High N	790

the perennial peanut is suppressed. After corn harvest, the p.peanut recovers and its growth phase begins. After it was harvested in late fall, rye was overseeded with a no-till grain drill. For the PP-R system, the perennial peanut was harvested three times during the warm-growing season. Rye was overseeded into the peanut sod in late fall for the cool season crop.

Within each cropping system there were three N treatments (Table 1). They consisted of a (1) control where plots received dairy waste effluent irrigation during a 12-month period at an annual input of 360 lb N per acre, (2) low N treatment where plots received waste effluent (same as control) and from ammonium nitrate, 130 lb N per acre during corn season, 60 lb N during forage sorghum, and 40 lb during rye, and (3) high N treatment where plots received effluent and 230 lb N per acre during corn, 120 during forage sorghum, and 80 during rye. The corn, forage sorghum, and rye received the nitrogen during early vegetative growth. For the aforementioned rates on corn and forage sorghum, N was split applied. Crops growing in the other two cropping systems were fertilized with ammonium nitrate at the same time and N rate as those in the C-FS-R system.

DRY MATTER YIELD

Perennial Peanut - Rye System

The dry matter (DM) yield (2-yr average) of perennial peanut in the control treatment of the PP-R rotation was 6.2 tons per acre (Table 2). Converting to 12% moisture forage, a hay yield of over 7 tons was obtained. This is one of the highest seasonal yield we have ever recorded for perennial peanut in north-central Florida. It appears that DM yield was suppressed slightly at the high N rate. The average DM yield of perennial peanut in the high N treatmentwas 8% lower from that of the control (effluent only). The overall average DM yield for the PP-R rotation was 7.9 tons per acre per year.

Corn-Perennial Peanut-Rye and Corn-Forage Sorghum-Rye Systems

Forage DM yield did not differ between the corn planted into rye stubble (C-FS-R) and that planted into perennial peanut sod (C-PP-R). Adding more N from ammonium nitrate to corn plots receiving effluent increased forage DM yield by 1.2 tons per acre or less (Tables 3 and 4). These results show that the corn was close to reaching its full production potential with effluent N only (Effluent N was applied at 195 lbs per acre during corn season).

Table 2. Dry matter yield (2 year average) of perennial peanut and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

	Perennial peanut					
	Harvest number					
Nitrogen treatment	1st	2nd	3rd	Sub total	Rye	Total yield
				ton/acre		
Control (Effl. only)	2.0	2.3	1.9	6.2	1.8	8.0
Low N (Effl+0.5 N)†	1.9	2.3	1.8	6.0	2.1	8.1
High N (Effl+full N)‡	1.7	2.2	1.8	5.7	2.0	7.7

† For Low-N treatment, 130 lbs N per acre was applied to these plots during the corn cycle, 60 lbs during the forage sorghum cycle, and 40 lbs during the rye phase in each 12-month period.

‡ For High-N treatment, 230 lbs N per acre was applied during the corn cycle, 120 lbs during the sorghum cycle, and 80 lbs during the rye in each 12-month period.

Table 3. Dry matter yield (2 year average) of corn, perennial peanut (following corn), and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

Nitrogen treatment	Corn	Perennial peanut	Rye	Total yield
		ton/acre		
Control (Effl. only)	7.7	2.2	1.8	11.7
Low N (Effl+0.5 N) †	8.7	2.1	2.0	12.8
High N (Effl+full N) ‡	8.5	1.9	2.0	12.4

† In the Low-N treatment ,130 lbs N per acre was applied to the corn, 60 lbs N to the perennial peanut (during forage sorghum cycle), and 40 lbs N to rye in each 12-month period.

‡ In the High-N treatment, 230 lbs N was applied to the corn, 120 lbs to the perennial peanut, and 80 lbs to rye in each 12-month period.

Table 4. Dry matter yield (2 year average) of corn, forage sorghum, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

Nitrogen treatment	Corn	Forage sorghum	Rye	Total yield
	ton/acre			
Control (Effl. only)	7.7	4.6	1.4	13.7
Low N (Effl+0.5 N) †	8.2	5.2	1.9	15.3
High N (Effl+full N) ‡	8.9	5.3	2.0	16.2

† In the Low-N treatment, 130 lbs per acre of N was applied to corn, 60 lbs to forage sorghum, and 40 lbs to rye during both 12-month cycles.

‡ In the High-N treatment, 230 lbs per acre of N was applied to corn, 120 lbs to forage sorghum, and 80 lbs to rye during both 12-month cycles.

Perennial peanut forage between corn rows in the C-PP-R system was harvested at the same time as the corn. Mean DM yield was only 0.5 ton per acre in 1993 and 0.7 ton in 1994 (not shown). Forage yield tended to be slightly higher in control plots compared to low N and high N plots, likely due to more shading at the higher N rates. The perennial peanut forage between corn rows will be difficult for the producer to harvest and because of the light yield, may not be feasible. Perhaps the best practice would be to mow the p. peanut and existing corn stubble as low as possible, thus allowing a new peanut crop to emerge uniformly. Following the corn, p. peanut produced an average DM yield of over 2 tons per acre, equivalent to a single cutting of p. peanut in the PP-R system.

Across all N treatments, the annual DM yield was greater in the C-FS-R system than the C-PP-R rotation. The main difference being the higher DM yield of the forage sorghum which was more than double that of the p. peanut. The annual DM yield of the C-PP-R system was 77 to 85% of the yield of the C-FS-R system while the DM production of the PP-R rotation was 48 to 58% of the C-FS-R.

NITROGEN REMOVAL

Perennial Peanut - Rye System

Mean N removal in 1993 from the three harvests of p. peanut was 326 lbs per acre for the control treatment (Table 5). Nitrogen removal increased by less than 20 lbs per acre with additional fertilizer N, a very small increase considering that during the growth cycle of the peanut in 1993, an additional 350 lbs N per acre was applied to the high N plots. This small increment is a result of a slight increase in N percentage in forage with the higher N rates and not a yield increase. The rye following p. peanut removed an average of 52 lbs per acre of N for the control. Removal increased to 81 lb for the high N treatment, due mainly to an increase in yield.

Table 5. Annual nitrogen removal by perennial peanut and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

	Perennial peanut					
	Harvest number					
Nitrogen † treatment	1st	2nd	3rd	Sub total	Rye	Total
	lb N/acre					
Control (Effl. only)	125	116	85	326	52	378
Low N (Effl+0.5 N)	126	130	87	343	71	414
High N (Effl+full N)	120	133	92	345	81	426

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1.

Corn-Perennial Peanut-Rye and Corn-Forage Sorghum-Rye Systems

No substantial differences in N removal occurred between the corn planted into rye compared to perennial peanut sod (Tables 6 and 7). As with the PP-R system, large increases in N removal did not occur with additional fertilizer N being applied. Nitrogen removal increased less than 40 lbs in high

N plots, although an additional 230 lbs of fertilizer N was applied during the corn season.

Table 6. Annual nitrogen removal by corn, perennial peanut, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 .

Nitrogen † treatment	Corn	Perennial peanut	Rye	Total
	lb N/acre			
Control (Effl. only)	186	100	57	343
Low N (Effl+0.5 N)	205	98	77	380
High N (Effl+full N)	212	86	91	389

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1.

Table 7. Annual nitrogen removal by corn, forage sorghum, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

Nitrogen † treatment	Corn	Forage sorghum	Rye	Total
	lb N/acre			
Control (Effl. only)	178	80	29	287
Low N (Effl+0.5 N)	198	111	44	353
High N (Effl+full N)	214	129	61	404

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1.

If the p. peanut forage between corn rows could be removed, then approximately 30 lbs of N could be added to each of the total means in Table 6, making a significant advantage in the C-PP-R system over C-FS-R. Nitrogen removal by the p. peanut following corn decreased slightly over N treatments, due mostly to a small yield decline, while removal by forage sorghum (following corn) increased, due mainly to increase in N percentage in forage in 1993. Nitrogen percentage in forage sorghum was 1.0 for the control, 1.1 for the low N and 1.3 for the high N. In the C-FS-R and C-PP-R systems, N removal by the rye increased across N treatments, due mainly to increased DM yield.

In all cropping systems, N removal increased only slightly with increased loading rate of N (Table 8). These results indicate that the crops in the control plots of all systems were close to their maximum potential and efficiency for removing N from the soil. The largest increase of N removal across N treatments occurred in the C-FS-R system (117 lb N per acre). The highest N removal within all three N loading rates occurred with the PP-R rotation. This result seems inconsistent because it had the lowest annual DM yield. The reason for the higher values of the PP-R plots is because the N percentages of the p. peanut forage [crude protein (CP) as well] were 250% higher than those of the corn and forage sorghum (Table 9). The range of N percentages of p. peanut was 2.4 to 3.5 (15 to 22% CP) compared to 0.9 to 1.4 (6 to 9% CP) for

Table 8. Annual nitrogen removed by three year-round cropping systems conducted under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

Nitrogen treatment	Cropping systems: Corn F.sorghum Rye	Corn P.peanut Rye	P.peanut (3 harvests) Rye	Annual nitrogen applied
	lb N/acre			
Control (Effl. only)	287	343	378	360
Low N (Effl+0.5 N)	353	380	414	590
High N (Effl+full N)	404	389	426	790

corn and forage sorghum. The high N percentages in p. peanut forage not only compensated for the lower DM yields but resulted in the highest N removal.

Table 9. Range of crude protein, nitrogen, and phosphorus percentages of dry matter in forage crops grown under dairy waste effluent irrigation at the Dairy Research Unit near Hague, Florida during 1993-94.

Crop	Crude protein	Nitrogen	Phosphorus
		%	
Corn	6-8	1.0-1.3	0.18-0.27
Forage sorghum	6-9	0.9-1.4	0.16-0.28
Perennial peanut	15-22	2.4-3.5	0.24-0.36
Rye	12-19	1.9-3.0	----

PHOSPHORUS REMOVAL

Phosphorus removal did not follow the same trend as N (Table 10). Although P levels were generally higher in p. peanut forage (0.24 to 0.36%) than corn and forage sorghum (0.16 to 0.28%), they were not high enough to offset the much lower DM yield of the peanut. Therefore, higher P removal averages were recorded for the corn and forage sorghum (50 to 59 lb) and corn and p. peanut (56 lb). Average annual P removed by the p. peanut was 36 lbs per acre.

Table 10. Total phosphorus removed by corn and forage sorghum, corn and perennial peanut, and perennial peanut grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993.

Nitrogen treatment†	Corn F.sorghum	Corn P.peanut	P.peanut (3 harvests)
		lb P/acre	
Control (Effl. only)	59	56	36
Low N (Effl+0.5 N)	55	56	36
High N (Effl+full N)	50	56	35

† The only source of applied phosphorus on all plots during the study period was dairy waste effluent.

SUMMARY

Most of the forage production potential and nitrogen removal capacity of the three cropping systems was achieved with the control (effluent) N loading rate of 360 lbs N per acre per year. Substantial increases in either component did not occur with the low N rate (effluent plus 230 lbs per acre of fertilizer N) being applied. The optimum annual loading N rate in terms of DM yield and N removal is likely a level between the control and low N rate.

The lowest annual DM yield was obtained from the PP-R system. Since the forage N percentage (and crude protein as well) was about 250% greater in p. peanut than in corn and forage sorghum; however, the PP-R system attained the higher N removal values. The C-FS-R and C-PP-R systems were superior to the PP-R rotation in phosphorus removal. Though P levels in p. peanut forage were generally higher than those in corn and forage sorghum, they were not high enough to compensate for the much lower annual DM yields of the PP-R system. Therefore, these results suggest that if N pollution is the major concern in a particular area, then the PP-R would be a good choice since it performed as well or better than the C-FS-R and C-PP-R systems. However, if phosphorus is the major concern, the C-FS-R and C-PP-R systems would be better choices.