Effects of harvest management on bermudagrass yield and nutrient utilization in a swine-effluent spray field

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Swine waste management plans often include the use of lagoon effluent for the production of bermudagrass [*Cynodon dactylon* (L.) Pers.], the predominant warm-season forage in the southeastern USA. Producing bermudagrass hay from fields receiving swine effluent provides both high quality forage for ruminant livestock and a means of exporting manure nutrients to reduce potential surface and ground water impairment. The objective of this study was to determine harvest management effects on annual forage yield and uptake of N and P by common bermudagrass. Research was conducted in 2001-2003 in a swine-effluent spray field on a commercial farm in northeast Mississippi on a Prentiss sandy loam. Small plots (2 x 4 m) were irrigated with 15 cm ha^{-1} effluent from April–October, which provided about 520 kg ha^{-1} N and 110 kg ha^{-1} P during the growing season. After an initial harvest of all plots in early May, summer growth was harvested at 4, 6, 8, 10, and 12 week intervals and at 3- and 9-cm cutting heights using a sickle-bar mower. The year x harvest interval interaction effect was significant ($P<0.001$) for P uptake because maximum values were obtained at the 10-wk interval 2001 and at the 6-wk interval in 2002 and 2003. This interaction may be explained by seasonal changes in plant maturity, effluent nutrient concentration, irrigation rate or the combined effect of these factors. The year x height interaction effect also was significant ($P<0.05$); however, harvesting at 3-cm height consistently increased P uptake by about 18% in 2001, 28% in 2002, and 29% in 2004, as compared to 9-cm cutting height. These results provide information to producers and land managers on methods to enhance the uptake of manure nutrients by bermudagrass, and thereby decrease potential losses of N and P from hay fields receiving swine effluent. If the goal is to produce a high quality forage, bermudagrass should be cut frequently (< 5-wk interval) and as tall as practical in order to harvest more leaf tissue. If the goal is maximum utilization of manure nutrients in the effluent, bermudagrass should be cut at 6-10 wk intervals as close to the ground as possible in order to maximize annual forage yield.

Keywords: Agriculture, Ecology, Irrigation, Wastewater

Introduction

The manure produced on swine farms in Mississippi is typically washed into lagoons to facilitate anaerobic digestion. In Mississippi, this waste-water effluent is often used to irrigate summer hay crops in nearby fields. Nitrogen, P, and K are the most agronomically important nutrients of the multiple nutrients in swine effluent, while excess N and P also pose an environmental hazard Adeli and Varco (2001) reported that summer forage grasses responded very similarly when fertilized with conventional fertilizer and when fertilized with swine effluent. These results suggest nutrient management plans do not have to be modified for swine waste, which improves the potential for expanded use of swine lagoon waste as a fertilizer.

Bermudagrass, the predominant warm-season forage in the region, is a recommended grass species for manure disposal due to a high annual N requirement (200 kg ha^{-1} or greater) and the potential to remove large amounts of nutrients with multiple hay harvests and off-site removal of the products. Nevertheless, a concern regarding repeated and/or heavy applications of swine effluent to bermudagrass is the difference in nutrients applied vs. crop nutrient requirements may result in a build up of not only soil P, but also total N (King et al., 1985). Water quality problems can occur if P enters the surface water in runoff, and processes of nitrate (NO_3-N) leaching loss are of concern for both economic reasons and impact on ground water quality.

Because land application rates are dependent on plant uptake rates of P, our research has addressed maximizing P uptake by forages so that less land is potentially affected by excessive nutrients. Results indicate forage species and management affect P removal rate. Annual uptake by bermudagrass is about 50 kg P ha^{-1}, with the largest amounts coming from high growth potential in summer (31 kg P ha^{-1}), as compared to harvesting in spring (25 kg P ha^{-1}) (Brink et al., 2005). The distribution of forage yield during the growing season can be affected by the harvest interval. Harvesting every 28 days beginning June 1 resulted in a typical single peak yield curve or "hump." Shortening the harvest interval to 21 days tended to flatten out the curve, but reduced total yield. As with any forage, stage of growth also affects bermudagrass nutrient content. The more mature the forage, the lower the quality. With bermudagrass, the protein level can decrease significantly if cutting is delayed. Additionally, frequent close cutting promotes shallow rooting, a trait that may increase the uptake of P, because unlike N, P is immobile in and tends to concentrate in the surface soil.

Studies have shown that unimproved, common bermudagrass has higher leaf N concentration and its leaves constitute a larger fraction of the herbage, as compared to either [Coastal' or 'Tifton 85' hybrids [Pederson and Brink, 1998 (unpublished); Pederson et al., 2002; Brink et al., 2003; Brink et al., 2004]. These studies also found herbage N:P ratio was relatively low in common bermudagrass, ranging from 6.2 to 7.3 across harvest dates, and common had a greater P concentration than the two hybrids in both the stem (2.2 vs 1.8 g kg^{-1}) and leaf (2.1 vs 1.8 g kg^{-1}) fractions. Given these results, we hypothesized that increasing the leaf:stem ratio in herbage should increase P removal by common bermudagrass fertilized with swine effluent. The present study determined if harvesting high quality (i.e, leafier) bermudagrass hay removes more nutrients than low quality hay, and thereby provide both forage for ruminant animals and a means to increase the removal rate of P, and other nutrients, from the field.

Materials and Methods

The site was a common bermudagrass hay meadow on Prentiss sandy loam at a private hog farm near Pheba, MS. Small plots (2x5 m) were fertilized using anaerobic swine effluent applications of 7.5 cm-ha between April and October each year that provided about 520 kg ha^{-1} N and 90 kg ha^{-1} P. Irrigations were under the control of the farm manager and were provided by a centerpivot system. The different harvest management treatments were two cutting heights of 3 and 9 cm (from the soil surface), and four harvest intervals of 4, 6, 8, 10, and 12 weeks (Table 1). All plots were initially harvested in early May, prior to spring greenup. Samples were collected at each harvest for determination of forage dry matter (DM) yield and the concentration of N and P in the herbage DM. Plots were evaluated in 2001, 2002, and 2003 and the different treatments were re-randomized each year. Experimental design was a randomized complete block with four replicates. Adjacent plots were separated by a 1-m alley and adjacent blocks were separated by a 2-m alley. Apparent N and P uptake (kg ha^{-1}) were calculated as the product of DM yield and forage nutrient concentration at each harvest date, and total nutrient uptake was determined by summing average values across harvest dates.

Results

The interval x year interaction effect was highly significant (Table 2). Maximum forage DM in 2001, 2002, and 2003 occurred at 10, 8, and 12-week intervals, respectively (Table 3). This result was probably influenced by different in rainfall, as well as timing of an effluent application relative to harvest date. With regard to P uptake, maximum values occurred with 10-wk interval in 2001, and with 6-wk interval in 2002 and 2003 (Table 4).

A significant height x year interaction effect was detected for P uptake, but not DM yield (Table 2). Results indicated that a cutting height of 3 cm consistently increased DM yield and nutrient uptake, as compared to 9-cm height. The percentage increase differed across the different years, with the largest increases observed in 2003 of 27% for DM yield and 39% for P uptake(Table 5). Because the N:P concentration ratio in herbage did not differ between cutting heights in 2003, the observed increase in P uptake resulted largely from increased DM yield at 3-cm height rather than increased P concentration (Table 6). Increased N:P ratio observed in 2003 was largely due to increased nutrient concentration in the second harvest of 12-week harvest interval treatment. This generally occurs because nutrient supply exceeds plant growth. Results for the preceeding harvests, week 4-20 were more similar across the three years of the study.

Conclusion

Results provide alternative management options to increase the rate of nutrient removal by common bermudagrass in swine-effluent spray fields. Cutting height of 3 cm consistently increased DM yield and nutrient uptake, as compared to 9 cm. If goal is to maximize nutrient uptake, harvest at 6-10 week interval and as close to the ground as possible to maximize biomass yield. For high quality hay, harvest at less than a 6-week interval and as tall as practical to improve leafiness. Other producer options to mitigate water quality impacts from swine effluent include overseeding bermudagrass with a cool-season annual forage, though the amount of excess N and P removed over winter varies with forage species and number of hay harvests in spring (McLaughlin et al., 2005).

References

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Table 1. Harvest schedule and harvest interval treatments used in the analysis of variance.

Date	Week	Treatment Interval			
		weeks			
29 May	4	4			
12 June	6	6			
26 June	8	4	8		
10 Jul	10	10			
24 Jul	12	4	6	12	
21 Aug	16	4	8		
6 Sept	18	6			
18 Sept	20	4	10		
19 Oct	24	4	6	8	12

Table 2. Tests for significant statistical effects on hay yield and nutrient uptake with common bermudagrass harvested at two cutting heights and five harvest intervals in 2001, 2002, and 2003.

Effect	DM yield	P uptake	N uptake
Block			
Interval	**	**	**
Height	**	**	**
Year	**	**	**
Interval x Year	**	**	**
Height x Year	NS	*	*
Interval x Height			
2001	NS	NS	NS
2002	**	NS	**
2003	**	**	**
*, ** significant at P<0.05 and P<0.01, respectively, otherwise not significant (NS)			

Table 3. Effect of harvest interval on total annual forage dry matter yield averaged across two cutting heights of 3 and 9 cm.

Harvest Interval	Obs.	2001	2002	2003
weeks	n	Mg ha^{-1}		
4	6	13.9	13.4	11.3
6	4	14.9	17.1	14.5
8	3	18.5	17.7	13.2
10	2	20.0	16.6	12.7
12	2	16.1	17.4	16.1
5% LSD		1.0	0.8	1.1

Table 4. Effect of harvest interval on total annual P uptake by common bermudagrass averaged across two cutting heights of 3 and 9 cm.

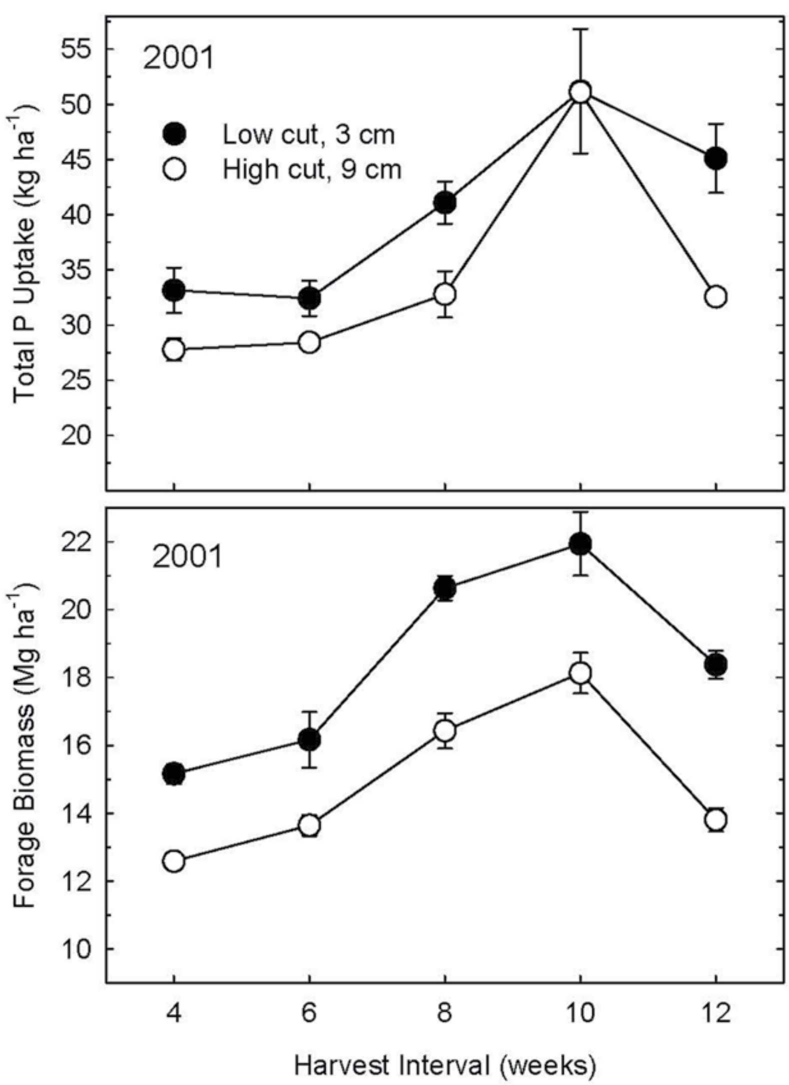
Harvest Interval	Obs.	2001	2002	2003
weeks	n	kg ha^{-1}		
4	6	30	41	32
6	4	30	47	39
8	3	37	45	27
10	2	51	44	30
12	2	30	42	28
5% LSD		5	3	3

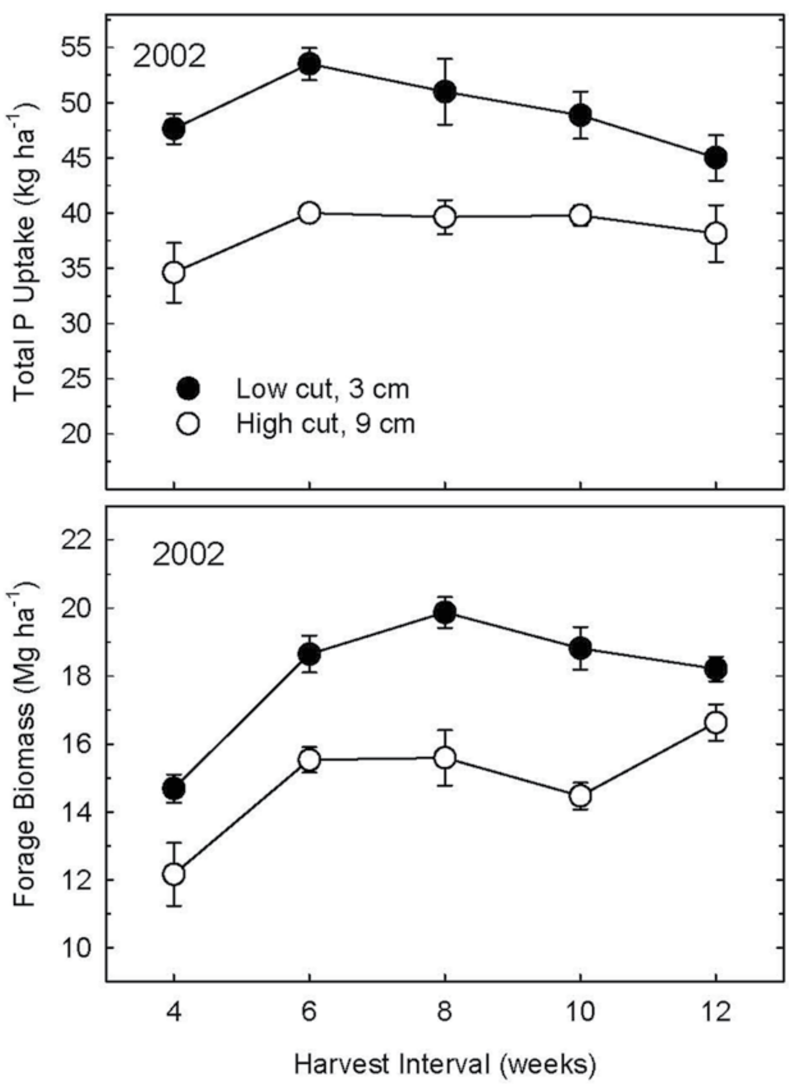
Table 5. Effects of two cutting heights on forage DM and P uptake by common bermudagrass averaged across five harvest intervals of 4, 6, 8, 10, and 12 weeks.

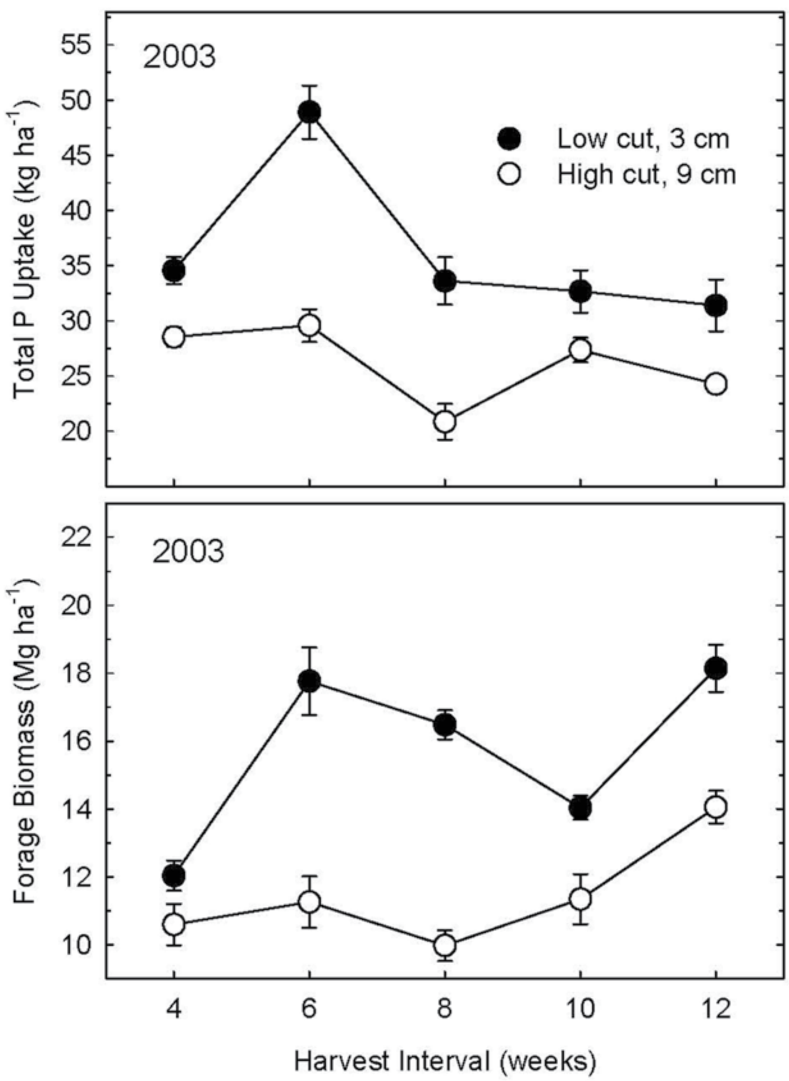
Variable and Cutting Height	2001	2002	2003
DM Yield, Mg ha^{-1}			
3 cm	18.4	18.0	15.7
9 cm	14.9	14.9	11.4
% increase	23	21	27
P Uptake, kg ha^{-1}			
3 cm	40	49	36
9 cm	34	38	26
% increase	18	28	39

Table 6. Effects of two cutting heights on herbage N:P concentration ratio averaged across five harvest intervals of 4, 6, 8, 10, and 12 weeks.

Cutting Height	2001	2002	2003	2003
				wk 4-20
3 cm	7.5	7.3	8.4	7.5
9 cm	7.8	7.6	8.4	7.8
Note: Results from harvests on week 4-20 only show lower N:P, due to apparent low growth on week-24 that concentrated nutrients in the herbage.				




2002
Total P Uptake (kg ha-1)
55
50
45
40
35
30
25
20
Low cut, 3 cm
High cut, 9 cm
2002
Forage Biomass (Mg ha-1)
22
20
18
16
14
12
10
4
6
8
10
12
Harvest Interval (weeks)


2003
Total P Uptake (kg ha^{-1})
55
50
45
40
35
30
25
20
Low cut, 3 cm
High cut, 9 cm
2003
Forage Biomass (Mg ha^{-1})
22
20
18
16
14
12
10
4
6
8
10
12
Harvest Interval (weeks)