# MAXIMIZING NUTRIENT UPTAKE THROUGH FORAGE CROP SELECTION

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## INTRODUCTION

The long-term application of animal manure to agricultural land has increased the potential for nutrients, particularly phosphorus, to enter and impact surface and ground water (Daniel et al., 1998). The growth of the confined swine feeding and broiler industry in the southeastern USA has resulted in greater manure application to forages. Nutrient uptake and export through forages may serve as a component of nutrient management planning.

Hybrid bermudagrass responds readily to increasing nitrogen rates from either inorganic or organic sources (Overman et al., 1993). When swine effluent was applied to 'Russell' hybrid bermudagrass to provide 560, 1120, and 2240 kg N $ha^{-1}$ per year, a yield response similar to that for inorganic N was observed, but efficiency of N and P recovery declined quickly with increasing effluent rate (Liu et al., 1997). Applying effluent at the two higher rates resulted in large additions of N and P that were not recovered in the forage and were potential contributors to ground and surface water pollution. In North Carolina, Burns et al. (1985) reported that 'Coastal' hybrid bermudagrass receiving 670 kg N $ha^{-1}$ and 153 kg P $ha^{-1}$ from swine effluent removed an average of 382 kg N $ha^{-1}$ and 43 kg P $ha^{-1}$ per year. Nutrient uptake by common bermudagrass, prevalent throughout much of the Southeast, has not been compared with that of hybrids.

Temperate forage species, which include annual ryegrass, annual clovers, small grains, and some perennial species, are an integral component of many forage-livestock systems in the region. These forages are planted in late summer or early fall in a prepared seedbed or oversown on a perennial grass sod, and grazed during the winter and spring (Bagley et al., 1988). They provide high quality forage during a period when cool temperatures limit tropical grass growth. Poor drying conditions often limit producers' ability to make hay from these forages until late spring. Annual ryegrass is the primary temperate species utilized due to its adaptability to a broad range of soil and climatic conditions, ease of establishment, late maturity compared with small grains, excellent forage quality (Balasko et al., 1995), and tolerance of close, continuous stocking (Ball et al., 1991).

The Southeast is also the primary producer of broiler chickens in the United States. Approximately 70% of the broiler chickens produced nationally in 1998 were produced in Texas, Arkansas, Tennessee, Mississippi, Alabama, Georgia, South Carolina, and North Carolina (NASS, 1998). A large proportion of the litter (a mixture of manure, wasted feed, feathers, and wood shavings or other crop residue) is applied to hay fields and pastures. Application may occur anytime during the year, depending on when a flock is removed from the house. If litter is applied to a dormant tropical grass hay field or pasture during the winter and spring, the presence of an oversown temperate forage will reduce the potential for nutrient loss through runoff, largely by reducing sediment movement (Sharpley, 1994), and leaching (Brandi-Dohrn et al., 1997; Shipley et al., 1992). Nutrients will also be taken up by the temperate species if it is harvested for hay in the spring (Brink and Rowe, 1999). Temperate forage species can thus serve in both a feed and nutrient management role in hay and pasture systems receiving broiler litter as a fertilizer source.

Because phosphorus concentration tends to fluctuate little relative to other nutrients, P uptake is generally a function of herbage yield, which may vary greatly depending on management, soil type, weather, quantity of nutrients applied, and cultivar (Robinson, 1996). In this paper, we report results from several investigations to determine the nutrient uptake of diverse perennial and annual forages receiving swine effluent and broiler litter.

## MATERIALS AND METHODS

Alicia, Brazos, Coastal, Russell, Tifton 44, and Tifton 85 hybrid bermudagrass and common bermudagrass were established in 2 x 6 m plots in a randomized complete block design with four replicates on a Brooksville silty clay loam (fine, smectitic, thermic Aquic Hapludert) near Crawford, MS and on a Ruston fine sandy loam (fine-loamy, siliceous, semiactive, thermic Typic Paleudult) near Mize, MS. Both soils had P levels in excess of 600 kg $ha^{-1}$ when the experiment began. The hybrid cultivars are representative of those which are available to producers in the Southeast. Swine effluent was applied to the Brooksville soil by center-pivot irrigation system from May to October at an annual rate of 98 mm $ha^{-1}$ to provide 403 kg N $ha^{-1}$ and 75 kg P $ha^{-1}$. Broiler litter was broadcast on the Ruston soil in early May and late July at an annual rate of 18 Mg $ha^{-1}$ to provide 540 kg N $ha^{-1}$ and 360 kg P $ha^{-1}$. Bermudagrass plots were harvested four times each year with a 6-wk interval. A 1 x 6 m swath was cut to a 5-cm stubble from the center of each plot with a sickle-bar mower and a 800-1000 gm subsample was taken for dry matter and nutrient analysis. Cultivar means for DM yield and nutrient uptake were separated by LSD ($P \leq 0.05$).

Thirteen temperate legumes and four temperate grasses utilized for forage in the Southeast were evaluated on a Savannah fine sandy loam (fine-loamy, siliceous, semiactive, thermic Typic Fragiudult) near Collins, MS. The soil had a P level in excess of 360 kg $ha^{-1}$ when the experiment began. Broiler litter was applied at 9 Mg $ha^{-1}$ before seeding to supply 300 kg N $ha^{-1}$ and 160 kg P $ha^{-1}$. The 2 x 4 m plots were arranged in a randomized complete block design with four replicates. For comparison purposes, all species were treated as annuals and harvested once the following spring; legumes at full bloom and grasses when seed had reached the dough stage. Forage yields were determined by cutting a 1.0 $m^2$ quadrat from the center of each plot at a 2.5-cm stubble height. Dry weight, nutrient concentration, and nutrient uptake differences between ryegrass and the other species were determined by single degree of freedom contrasts ($P \leq 0.05$).

Harvested samples from all experiments were dried at 65 °C for 48 hr and then ground to pass a 1-mm screen. Forage P, Cu, and Zn concentration were measured by the following procedure: a 1-gm subsample was ashed at 500 °C for 4 hr and then 1.0 ml of a 1:1 hydrochloric acid:distilled water solution was added to the crucible. After one hr, 50 ml of a double acid solution (83 ml hydrochloric acid and 14 ml sulfuric acid brought to 20 l with distilled water) was added to the crucible, allowed to stand for another hr, and then filtered. Phosphorus, Cu, and Zn concentration of the filtrate were measured by emission spectroscopy on an inductively-coupled argon plasma spectrophotometer. Forage N concentration was determined by the kjeldahl procedure.

## RESULTS AND DISCUSSION

### Bermudagrass Evaluation

Annual DM yield by the seven bermudagrass entries fertilized with swine effluent ranged from 21.8 to 26.4 Mg $ha^{-1}$ in 1997 and 21.6 to 26.2 Mg $ha^{-1}$ in 1998 (Fig. 1). On the Brooksville soil, Tifton 44 yielded the least DM in both years. Yield differences among the remaining entries were small because in addition to the nutrients, irrigation also supplied water two to three times per week, removing any potential effects of drought on productivity of the entries. Although DM yield of all the hybrids is reported to be superior to that of common bermudagrass in traditional yield trials (Burton and Hanna, 1995), productivity of common bermudagrass was similar to Russell, Alicia, and Tifton 44 in 1997 and similar to or greater than all the hybrids in 1998. In addition, P uptake by common bermudagrass was similar to or greater than that of the hybrids in both years (Fig. 2).

Bermudagrass fertilized with broiler litter produced less annual DM than that fertilized with effluent (range of 10.1 to 20.3 Mg $ha^{-1}$ in 1998 and 8.7 to 18.2 Mg $ha^{-1}$ in 1999; Fig. 3). Common bermudagrass was generally less productive than the hybrids, particularly in 1999, when precipitation was approximately 30% below normal. When P uptake is considered however, common bermudagrass was similar to the hybrids in 1998, when precipitation was near normal, but ranked last in the dry year of 1999 (Fig. 4).

### Temperate Forage Evaluation

Dry matter yield of annual ryegrass was greater than all other species except ball clover in 1997 and oats in 1998 (Table 1), which supports previous reports of its superior productivity compared with other fall-sown, temperate species (Edwards et al., 1996). The clovers were more productive in 1997 than in 1998 because above-average precipitation and favorable temperatures contributed to the development of Sclerotinia crown and stem rot (*Sclerotinia trifoliorum* Erikss.) infestation in January, 1998 that reduced plant density and vigor. The potential for this disease to develop is greater when swards remain uncut through the winter (Pratt, 1991), and thus represents a disadvantage of these species when grown under a conservation management system. Compared with the annual legumes and grasses, a single-cut harvest system also placed the perennial legumes, particularly red clover and alfalfa, at a disadvantage because they continue growing into late spring and early summer. However, like many annual clovers, their use in typical southeastern forage-livestock systems is limited by such factors as high seed cost, inconsistent establishment in warm-season grass sods, and susceptibility to insects and diseases.

Phosphorus uptake by annual ryegrass was greater than most of the other temperate species in both years (Table 1); only crimson clover contained as much P as ryegrass. Phosphorus uptake was highly correlated with dry weight across all species ($r = 0.95$ and 0.89 in 1997 and 1998, respectively). Superior P uptake by ryegrass can be attributed to this positive association between dry weight and P uptake.

## CONCLUSIONS

Many of the productivity and nutrient uptake differences observed among bermudagrasses, including common, will likely be obscured when evaluations are made under swine effluent irrigation because of abundant nutrients and moisture. The cost of replacing common bermudagrass with a hybrid would therefore not be justified. Where broiler litter was the fertilizer source, however, the superior productivity of hybrids relative to common bermudagrass became more evident. Nutrient uptake from soils routinely receiving manure can be increased by an additional 20 to 30 kg $ha^{-1}$ by harvesting annual ryegrass as a hay crop.

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Table 1. Forage dry matter (DM) yield and P uptake by various temperate grasses and legumes.

| | DM yield | | P uptake | |
|---|---|---|---|---|
| | 1997 | 1998 | 1997 | 1998 |
| | ---Mg ha$^{-1}$--- | | ---kg ha$^{-1}$--- | |
| ryegrass | 12.40 | 10.00 | 28.1 | 18.7 |
| **Small grains** | | | | |
| oats | 3.95* | 9.42 | 12.8* | 21.1 |
| rye | 3.44* | 6.18* | 11.4* | 14.4* |
| wheat | 2.88* | 6.00* | 9.6* | 14.4* |
| **Clovers** | | | | |
| arrowleaf | 6.26* | 5.24* | 15.2* | 12.1* |
| ball | 11.04 | 4.40* | 29.5 | 13.5* |
| berseem | 4.72* | 0.87* | 12.4* | 1.8* |
| crimson | 9.72* | 5.38* | 27.9 | 16.2 |
| persian | 1.90* | 0.80* | 4.4* | 2.4* |
| red | 9.19* | 5.04* | 26.0 | 12.4* |
| rose | 5.10* | 3.62* | 13.9* | 10.2* |
| subterranean | 2.46* | 3.65* | 8.4* | 12.7* |
| white | 2.74* | 1.48* | 9.2* | 6.0* |
| **Other legumes** | | | | |
| alfalfa | 1.63* | 1.42* | 3.4* | 4.1* |
| caley pea | 1.94* | 2.69* | 5.8* | 9.0* |
| winter pea | 2.64* | 3.42* | 7.1* | 12.8* |
| hairy vetch | 5.48* | 5.58* | 19.2* | 18.3 |

* Significantly different from ryegrass at $P \leq 0.05$.

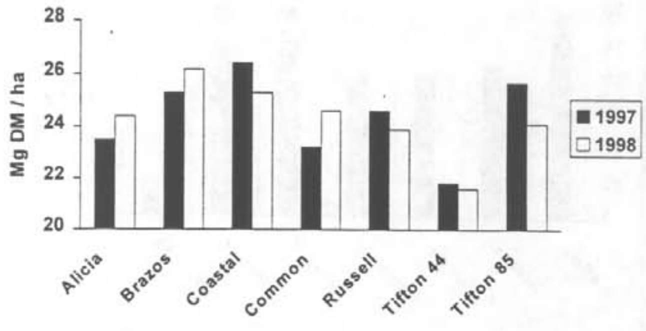


**Figure 1.** Annual dry matter (DM) yield of bermudagrass receiving swine effluent; LSD (0.05) = 2.0 in both years.

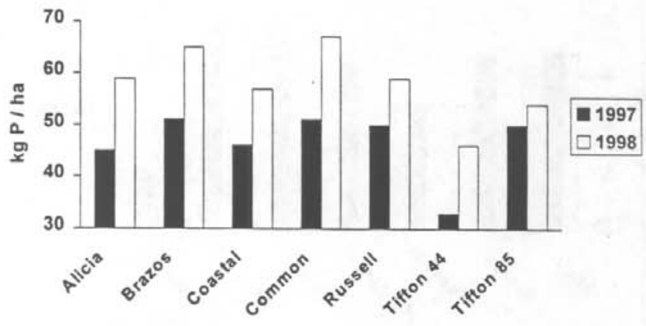


**Figure 2.** Annual P uptake by bermudagrass receiving swine effluent; LSD (0.05) = 6 in 1997 and 4 in 1998.

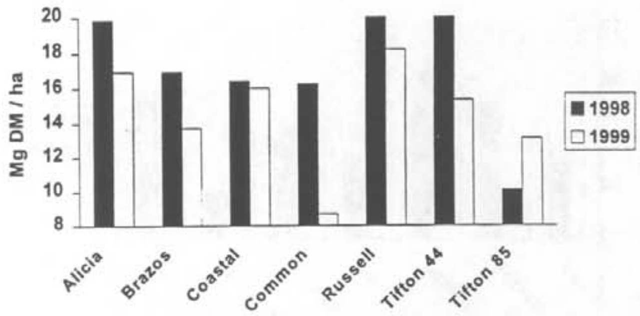


**Figure 3.** Annual dry matter (DM) yield of bermudagrass receiving broiler litter; LSD (0.05) = 3.0 in both years.

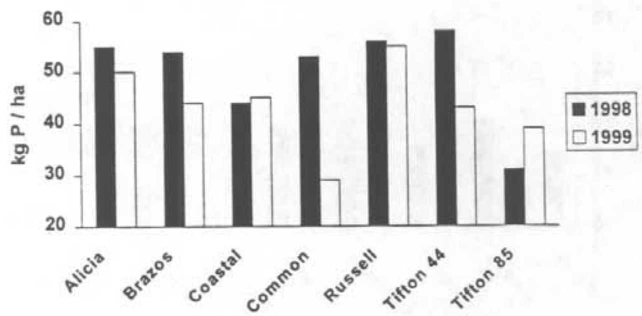


**Figure 4.** Annual P uptake by bermudagrass receiving broiler litter; LSD (0.05) = 11 in 1998 and 8 in 1999.