COMBINING GRAZING AND HAY PRODUCTION FOR REMEDIATING SOIL P IN PASTURELAND OF THE SOUTHEAST U.S.

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INTRODUCTION

Confinement poultry and hog production are concentrated in the southeastern U.S.A., where most of the soils are marginal for crop production. Because much of the agricultural land is utilized for forage production, confinement animal production in the region is often combined with cattle grazing to diversify production and make use of poultry waste as a low-cost fertilizer for pastures. Application of 4.5 to 9 metric tons of broiler litter per ha effectively promotes grass growth (Hileman, 1967, 1973). Huneycutt el al. (1988) showed that litter applications of 13 Mg ha^{-1} increased dry matter yields of tall fescue (*Festuca arundinacea* L.) and bermudagrass (*Cynodon dactylon* [L.] Pers.) by 306 and 215 %, respectively. Animal waste therefore can be effectively utilized as a fertilizer source for boosting the growth of forages.

A problem with using animal waste as a fertilizer is that phosphorus (P) is often applied in quantities that are above plant requirements. Consequently, P can accumulate and increase concentrations of soluble phosphorous in runoff and cause eutrophication of surface waters (Sharpley et al., 1994). A direct linear relationship between runoff phosphorus and Mehlich-3 phosphorus has been observed (Pote et al., 1996). There apparently is potential for developing environmentally unsafe P levels in runoff as soil phosphorus increases.

Pastures and hay meadows with excessive soil P will require remediation through the development of forage systems that provide maximum growth distribution of productive forage species. Managing both cool- and warm-season grasses can maximize the annual distribution of growth and uptake of P in aboveground forage. Furthermore, the wide distribution of annual forage growth must be intensively utilized in a manner that results in movement of the accumulated P in forage growth out of the pasture or hay meadow for eventual transfer to lower-P soils.

Animal waste is often applied to bermudagrass and bahiagrass pastures and hay meadows because the two warm-season perennial grasses can effectively utilize the high nutrient concentrations of animal waste. Cool-season annual grasses (rye [*Secale cereale* L.], wheat [*Triticum aestivum* L.], or ryegrass [*Lolium multiflorum* L.]) can be notill planted into bermudagrass and bahiagrass to provide growth during dormancy of the two warm-season grasses (Ball et al., 1996). Although cool-season grasses increase the annual distribution of growth, hay production with these grasses is difficult because cool, moist weather conditions during most of the season prevent sufficient drying of hay. Production of silage or haylage is an option for utilizing cool-season herbage, but requires special equipment, long storage times increase spoilage, and the bulkiness of silage and haylage makes transporting difficult (Rotz and Muck, 1994). This option is most feasible for fields with severely high soil-P levels, requiring expeditious remediation of soil P. It is also possible to graze cool-season grasses to take advantage of the forage production and remove small quantities of P. Cattle grazing may be necessary for some farms because cattle production is the main source of income and available land is limited. The objective of this paper is to discuss forage systems that are developed for remediating soil P and combine intensive production of hay during the warm-season with cattle grazing during the cool-season.

DISCUSSION

Intensive Hay Production

Bermudagrass is most productive when growing in well-drained soils with moderate fertility (Burton and

Hanna, 1985), whereas bahiagrass grows on well- to poorly drained soils and can tolerate marginal fertility (Watson and Burson, 1985). The forage quality of bermudagrass is generally higher than that of bahiagrass (Ball et al., 1996). Although both grasses respond to fertilization with N (Wilkinson and Langsdale, 1974), hybrid bermudagrass typically yields 6 to 8 tons ha^{-1} and the yield potential of bahiagrass is between 3 and 5 tons ha^{-1} (Ball et al., 1996). Bermudagrass therefore has an advantage of producing higher yields and quality hay, but bahiagrass can persist and grow on marginal, poorly-drained soils and is more tolerant of poor management.

Intensive production of bermudagrass hay can potentially remove 60 kg P ha^{-1} (Ball et al., 1996; USDA-NRCS, 1998). Documentation with bahiagrass is lacking, but lower yields with bahiagrass suggest the potential to remove P in harvested forage is lower than for bermudagrass. A study by Pedersen and Brink (1999) showed that P uptake of harvested bermudagrass is improved if stem and leaf production is maximized and runner production is minimized. Tall cutting heights for bermudagrass promotes growth of leaves and stems and short cutting heights encourage lateral growth of runners (Aiken et al., 1995). Another recommendation is to routinely test the nutrient status for fields under intensive hay production so that nutrients, other than P, are not limiting yields. Producing high yields of hay will likely require additional applications of fertilizer N and K. (Rasnake et al., 1991; Evers, 1998).

Grazing Cool-Season Grasses

A large portion of P in the forage grazed by cattle is recycled back to the soil (Fig. 1). Cattle digest approximately 64% of the total P in forages (TCORN, 1991); therefore, approximately 36% of the consumed P is excreted in feces. The proportion of digested P that is metabolized and retained in body tissues will depend on the P concentration of consumed forage. Estimated values (NRC, 1996; Fig. 1) for growing calves indicate there is a three-fold increase in the percentage P in excreted urine as P concentration of forage increases from 2.5 to 4.5 g P kg-1 DM. Therefore, higher P concentration in forages results in higher amounts of soluble P being recycled back to the soil in manure and urine. Mature bulls and non-lactating and non-pregnant cows are on maintenance diets and contribute substantially to the recycling of P (Table 1). Amounts of P used for maintenance will be approximately equal to amounts secreted in digestive juices or in sloughed cells of the GI tract, (i.e., fecal endogenous P; NRC, 1996). Pregnant cows retain P in fetal growth and lactating cows retain P in milk and a certain percentage of milk P will be retained in tissues of suckling calves. Growing calves are the only class of cattle that can retain P, even though it is in small amounts. Cow-calf production can therefore reduce soil P, but this is inefficient because a high proportion of body weight on the pasture will be with mature cows that retain little P in their tissues. Stocker calf production is a more efficient approach, because the pastures can be stocked totally with growing cattle.

Management strategies must be imposed for cool-season pastures to maximize utilization of forage and reduce soil P. One strategy is to graze high-P pastures with cows and/or calves for short periods of time (2 to 4 hrs. daily) and move them to low-P pastures. Consumed P from the high-P can be transferred to the low-P pasture via manure and urine. Another strategy is to initiate grazing with stocker calves in the fall following establishment of a cool-season grass. Stockpiling of fall growth prior to grazing is preferred to conserve forage during the winter months and not feed supplemental grains and hay. Grazing could be terminated in late April to middle March to allow for rapid growth following an application of N. Hay could be cut when temperatures are high enough to facilitate drying and the warm-season perennial is breaking dormancy. Neither the grazing or single hay cutting alone can remove an abundance of P, but together soil P can be reduced 15 to 20 lbs, depending on stocking rate and hay yield.

Retention of P is highly dependent on average daily weight gain (Fig. 2; ADG). Extrapolations from NRC (1996) values indicate that quantities of P retained in tissues will increase between .6 and 1.0 kg d^{-1}, but a higher ADG of 1.3 kg d^{-1} showed reduced P retention. This is likely due to higher fat deposition with extremely high weight gains.

Average daily gain typically declines linearly as stocking rate (SR) increases (ADG = a - b SR;

Jones and Jones, 1974; Bransby et al., 1988). Assuming this relationship is correct, Sandland and Jones (1974) derived that the relationship between gain per unit land area (GAIN) and stocking rate is quadratic (GAIN = a SR - b SR^2). To evaluate these relationships for P retention in stocker calf tissues, extrapolations were done with ADG data measured for steers grazing a 'Maton' rye-'TAM 90' ryegrass mixture in a stocking rate study that was conducted at the Texas A&M University Research and Extension Center in Overton (Fig. 3). Phosphorus retained in weight gains decreased linearly as stocking rate increased (P = 5.3 - 0.7 SR). The relationship between retained P per ha and stocking rate showed that retained P increases (P ha^{-1} = 5.3 SR - 0.7 SR^2) as stocking rate increases to approximately 3.8 steers ha-1 and decreases with higher stocking rates. For this example, a maximum of 10 kg P ha^{-1} was retained in calf weight gains. These relationships parallel those calculated for weight gains; therefore, setting stocking rates to achieve maximum weight gains can provide the highest retention of P per unit of land area.

CONCLUSIONS

Bermudagrass and bahiagrass can be utilized for intensive hay production to effectively reduce soil P levels. Cool-season grasses should be planted to increase the annual distribution of forage growth, but utilization of these forages to reduce soil P can be challenging. Producing silage or haylage from harvested cool-season grasses is the most promising method to intensively utilize these forages, but economic considerations may require that these grasses be grazed for at least part of the season. Cool-season grasses can be grazed and then cut for hay in the late-growing season to produce quality hay and improve the uptake and removal of P. Grazing followed with a late-season hay harvest can potentially reduce soil P 15 to 20 kg ha^{-1}, depending on stocking rate and yield of hay. Intensive hay production with bermudagrass or bahiagrass combined with grazing and hay production with cool-season annual grasses can annually reduce soil P between 60 and 90 kg ha^{-1}. Success of meeting ambitious quotas will depend heavily on weather patterns and using best management practices.

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Table 1. Approximate retention of P in tissues of various classes of cattle (NRC, 1996).

Class	Retention
Bulls	Maintenance[1]
Dry cows	Maintenance
Pregnant cows	7.6 g P/kg fetal development[2]
Lactating cows	0.95 g P/kg milk produced
Growing calves	3.9 g P/100 g protein gain[3]

[1] 16 mg P/kg body weight

[2] Last three months of pregnancy and a 35 kg birth weight

[3] Ellenberger (1950)

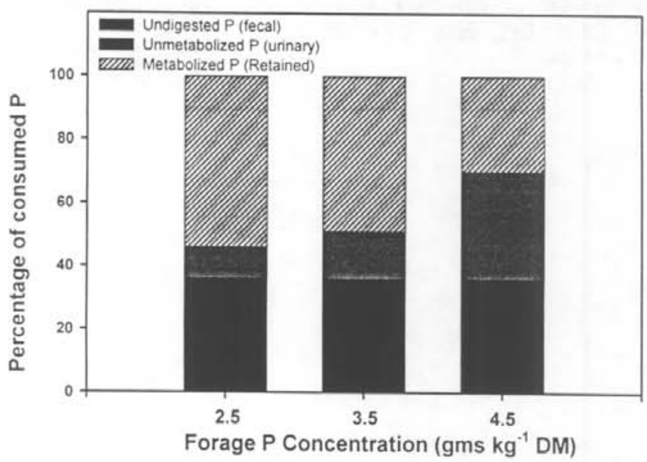

Fig. 1. Approximate retention and excretion of P for three forage P concentrations. Values are based on a feeder calf weighing 200 kg and gaining 1 kg day^{-1} (NRC, 1995).

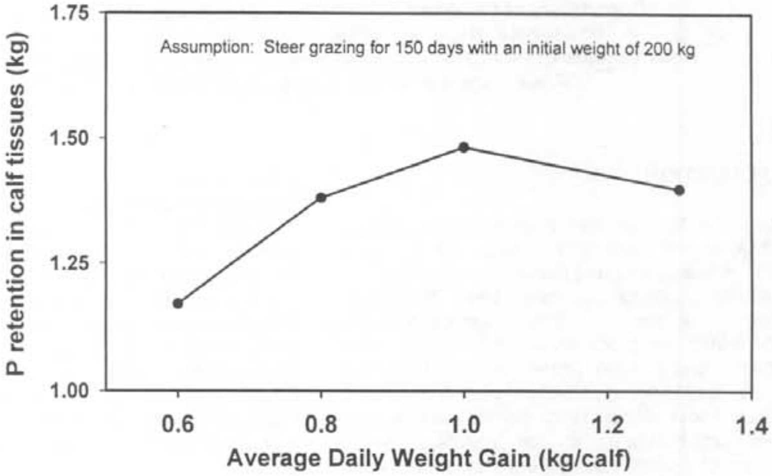

Fig. 2. Trend of P retention in calf tissues as average daily weight gain increases (NRC, 1995).

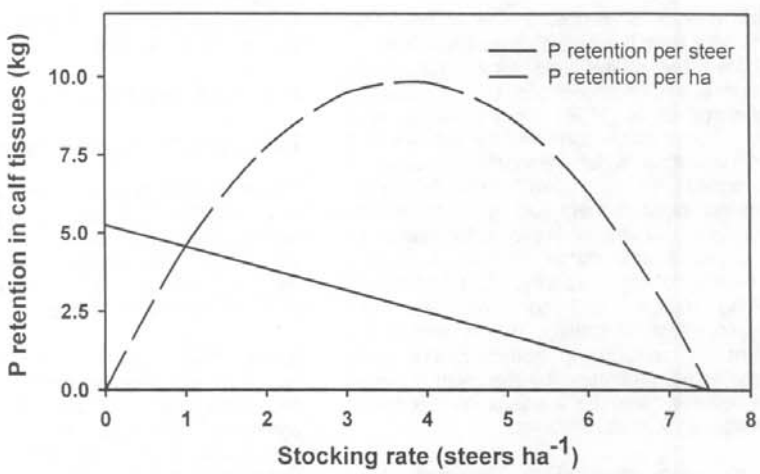

Fig. 3. Estimated changes in amounts of P retained in tissues of steers with increases of stocking rate. Animal data was provided by Texas A&M University (F. M. Rouquette, Jr.) and retained P calculated using NRC (1995) values.