DOUBLE CROPPING BERSEEM CLOVER AND GRAIN SORGHUM FOR NUTRIENT MANAGEMENT OF SWINE WASTE

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INTRODUCTION

The mission of the Waste Management and Forage Research Unit at Mississippi State centers on developing forage crops in management systems, which facilitate safe, sustained application of animal waste on agricultural lands in the South. Adapted summer and winter forage crops are tested in 12-month production systems for their abilities to capture and mine potentially polluting nutrients, especially nitrogen and phosphorus, derived from animal waste. The nutrients are removed as economically valuable hay, which may be used for animal feed at other locations. The utility of different management systems and forage species is determined for different soils and types of animal waste. Forage species are selected for persistence, dependability, and productivity in heavily manured fields. Economically reasonable management alternatives are tested for improvement in rates of nutrient removal. The goal of this research is development of guidelines, systems, and forages for sustained and safe use of fields for waste disposal.

A 12-month double cropping system, comprised of winter annual berseem clover, *Trifolium alexandrinum* L., and summer grain sorghum, *Sorghum bicolor* (L.) Moench, was tested for nutrient management in a black prairie field soil. The field was under heavy fertilization with swine lagoon effluent and was located on a privately owned hog farm in southwestern Lowndes County, Mississippi. Partial results from the first 2 years of an ongoing study, begun in October 1997, are reported here. The effects of bean yellow mosaic potyvirus (BYMV) infection in the berseem clover were also examined (McLaughlin and Fairbrother 1996).

MATERIALS AND METHODS

'Bigbee' berseem clover (Knight 1985) was seeded (broadcast in 1997; drilled in 18 cm rows in 1998) into 2x6m plots (minimally tilled in 1997; no tillage in 1998) in a grass hayfield in mid October. Four crop rotation treatments (BYMV-inoculated berseem clover, followed by grain sorghum; noninoculated berseem clover, followed by grain sorghum; grass followed by grain sorghum; and continuous grass) were imposed. Treatment plots, except for continuous grass plots, were cleared of natural grasses and other vegetation by use of herbicides at recommended rates. Roundup was used as a clover preplant in 1997 and as a sorghum preplant (except for grass/sorghum rotation treatment plots) in 1998. Clover plots were treated with Poast Plus for grass control in winter 1997 and 1998. All plots were treated with 2,4-DB for broadleaf weed control in late winter 1997 and 1998. Crop rotation treatments were replicated four times in a randomized complete block design, under a center pivot irrigation system, which operated from April through September. Virus inoculations were done in mid-April, 1 wk after the first spring harvest of berseem clover, to correspond with the annual spring peak in normal vector aphid flight activity (Ellsbury et al. 1988).

Clover was harvested for hay three times in 1997, in early April and at monthly intervals in early May and early June, and twice in 1998, in mid-April and late-May. All plot harvesting was done with a sicklebar mower at a cutting height of 10 cm. Fresh weight forage yields were measured for each plot at each harvest. Samples (1 kg fresh weight) from each plot and harvest were dried in a forced-air oven (150 C, 72-96 hr) and their dry weights determined and recorded for use in calculating plot yields.

Dried forage samples were ground to pass a 1-mm screen in a Wiley mill, then ground to pass a 0.5 mm screen in a Cyclotec mill (Plank 1992). Dried and ground samples were stored in sealed light-resistant plastic prescription bottles (amber, 40-dram, wide-mouth) at room temperature in the laboratory. Measured amounts of each ground sample were prepared for dry ashing, resuspended in acid, filtered and subsequently analyzed for mineral nutrients by plasma emission spectrometry (Jones et al. 1991). Measured phosphorus concentrations were recorded in g/kg on a dry weight basis and later converted to percentages for calculation of phosphorus content of harvested forage.

Soil samples were collected at 0-2.5, 2.5-5, 5-10, and 10-20 cm after the last clover harvest each spring and after the last harvest of summer sorghum or grass each fall. Four soil core subsamples were collected and combined for each measurement in each plot. A summer crop of 'Pioneer 8305 Hybrid' grain sorghum was no-till planted in 0.75 m (30-in) rows into each plot in early June. Grain and stover were harvested separately in early Oct., dried, and sampled for nutrient analyses. Continuous grass treatment plots were harvested in July and again at the time of sorghum harvest.

Dry weight forage yields were calculated for each plot at each harvest. Phosphorus concentrations of forage samples were used to calculate amounts of phosphorus removed from each plot at each hay harvest. Forage dry weight yield (kg/plot), phosphorus concentration (%P), and phosphorus removed (kg/ha) were compiled for all harvests. When harvest data were combined for analysis of seasonal or annual yields, data for plot dry weights and amounts of phosphorus removed were added together, respectively, across the respective harvests and the percent phosphorus contents of each treatment in the combined harvests were calculated as weighted means (total phosphorus removed for each treatment replication divided by total dry weight removed for each respective treatment replication). Means for dry weight yields, percent phosphorus, and total phosphorus removed, were subjected to analysis of variance using a factorial analysis for a randomized complete block (SAS Institute 1997).

RESULTS AND DISCUSSION

A total of seven harvests were made in the two years of the study. Three "winter/spring crop" harvests and one "summer crop" harvest were made in 1998 and two winter/spring harvests and one summer harvest in 1999.

A preliminary summary of phosphorus removal by the berseem clover and grain sorghum double crop showed: little difference in dry weight production due to the clover virus disease in either the clover or the sorghum; a slight increase in phosphorus content of BYMV-infected clover; higher dry matter production of sorghum following clover than following grass; and combined phosphorus removal of the clover and sorghum double crop of 54 kg/ha/yr (48 lb/A/yr). Annual double crop component contributions toward phosphorus removal were: berseem clover hay (17 kg/ha); sorghum grain (13 kg/ha); and sorghum stover (24 kg/ha). Soil tests showed phosphorus levels: were consistently higher in the upper soil profile in all treatments; increased in all samples and treatments from June to Oct.; and were lower in clover and sorghum treatment plots than in continuous grass control plots.

The data were combined for years 1998 and 1999 and an analysis of dry weight, percent phosphorus, and total phosphorus removed was conducted with an ANOVA model which included blocks (replications), crop treatments, years, and treatment*year. This analysis showed a significant difference ($P=0.03$) in phosphorus removed due to an apparent treatment*year interaction. Subsequently, the data were divided further, with the four crop rotation treatments examined for four seasons (winter/spring in year 1, summer in year 1, winter/spring in year 2, summer in year 2) using an ANOVA model of blocks, crop rotation treatments, seasons, and crop rotation*season. This analysis suggested dry weight was influenced by crop rotation treatment ($P=0.08$, Table 1), season ($P=0.0001$, Table 4), and crop rotation*season interaction ($P=0.0001$, Figure 1); percent phosphorus was influenced by crop rotation treatment ($P=0.03$, Table 2), and season ($P=0.0001$, Table 5); and the amount of P removed was influenced by crop rotation treatment ($P=0.07$, Table 3), season ($P+0.0001$, Table 6), and crop rotation*season interaction ($P=0.0001$, Figure 2).

In summary, more dry weight was harvested with summer crops than with winter/spring crops (Table 4); sorghum rotations produced more dry matter than did continuous grass (Table 1); winter/spring crops, especially containing clover, had higher phosphorus concentrations than did summer crops and grass or grass/sorghum rotation treatments (Tables 2 and 5); crop rotations containing sorghum removed more phosphorus than the continuous grass treatment(Table 3); more phosphorus was removed in summer crops than in winter/spring crops (Table 6); crop rotations containing clover tended to remove more phosphorus than did the continuous grass treatment (Table 3, Figure 2); and phosphorus removal was highest in the virus-free berseem clover winter/spring rotation with summer sorghum in year 2.

These observations suggest that Bigbee berseem clover, despite its susceptibility to BYMV infection, could play an important role in mitigating soil phosphorus buildup, especially in crop rotations with a summer grass or hay or grain crop, such as sorghum. These data demonstrate that such crop rotations can remove about 55 kg phosphorus per hectare per year, thus providing farm managers with an alternative to continuous grass haying.

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TABLE 1. ANOVA T TESTS (LSD): FORAGE DRY WEIGHT (P= 0.08)

(Alpha= 0.05 df= 45 MSE= 2.798 Critical T= 2.01 LSD= 1.2)

CROP ROTATION	N	MEAN * (kg/plot)
GRASS/SORG	16	11.3 A
V-CLOV/SORG	16	11.1 A
V+CLOV/SORG	16	11.0 AB
CONT GRASS	16	9.8 B

* Means followed by the same letter are not significantly different.

TABLE 2. ANOVA T TESTS (LSD): PERCENT PHOSPHORUS (P= 0.03)

(Alpha= 0.05 df= 45 MSE= 0.001 Critical T= 2.01 LSD= 0.025)

CROP ROTATION	N	MEAN * (%)
V+CLOV/SORG	16	0.342 A
V-CLOV/SORG	16	0.331 AB
CONT GRASS	16	0.310 B
GRASS/SORG	16	0.309 B

* Means followed by the same letter are not significantly different.

TABLE 3. ANOVA T TESTS (LSD): PHOSPHORUS MINED (P= 0.07)

(Alpha= 0.05 df= 45 MSE= 21.143 Critical T= 2.01 LSD= 3.3)

CROP ROTATION	N	MEAN * (kg/ha)
V+CLOV/SORG	16	29.0 A
V-CLOV/SORG	16	28.4 A
GRASS/SORG	16	28.2 AB
CONT GRASS	16	25.0 B

* Means followed by the same letter are not significantly different.

TABLE 4. ANOVA T TESTS (LSD): FORAGE DRY WEIGHT (P= 0.0001)

(Alpha= 0.05 df= 45 MSE= 2.798 Critical T= 2.01 LSD= 1.2)

CROP SEASON	N	MEAN * (kg/plot)
SUMMER2	16	15.8 A
SUMMER1	16	12.2 B
WINTER/SPR 2	16	8.7 C
WINTER/SPR 1	16	6.5 D

* Means followed by the same letter are not significantly different.

TABLE 5. ANOVA T TESTS (LSD): % PHOSPHORUS (P= 0.0001)

(Alpha= 0.05 df= 45 MSE= 0.001 Critical T= 2.01 LSD= 0.025)

CROP SEASON	N	MEAN * (%)
WINTER/SPR 1	16	0.359 A
WINTER/SPR 2	16	0.354 A
SUMMER1	16	0.309 B
SUMMER2	16	0.271 C

* Means followed by the same letter are not significantly different.

TABLE 6. ANOVA T TESTS (LSD): PHOSPHORUS MINED (P= 0.0001)

(Alpha= 0.05 df= 45 MSE= 21.143 Critical T= 2.01 LSD= 3.3)

CROP SEASON	N	MEAN * (kg/ha)
SUMMER2	16	35.2 A
SUMMER1	16	31.2 B
WINTER/SPR 2	16	24.9 C
WINTER/SPR 1	16	19.3 D

* Means followed by the same letter are not significantly different.

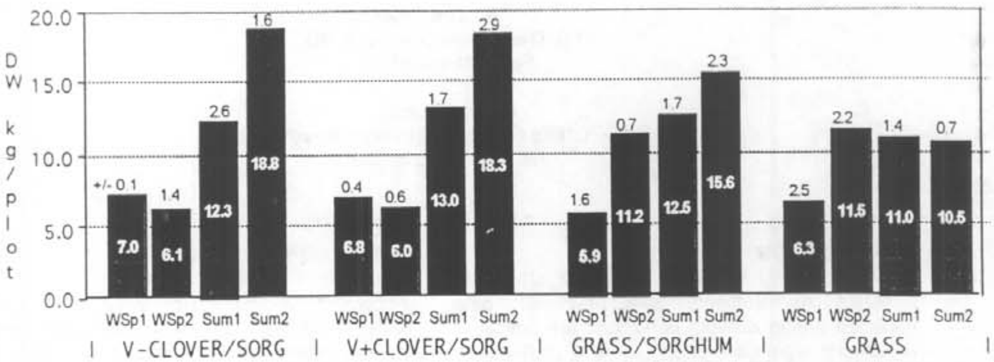

Figure 1. Crop x Season Interaction (P=0.0001) Means for Dry Weight, 1998-99.

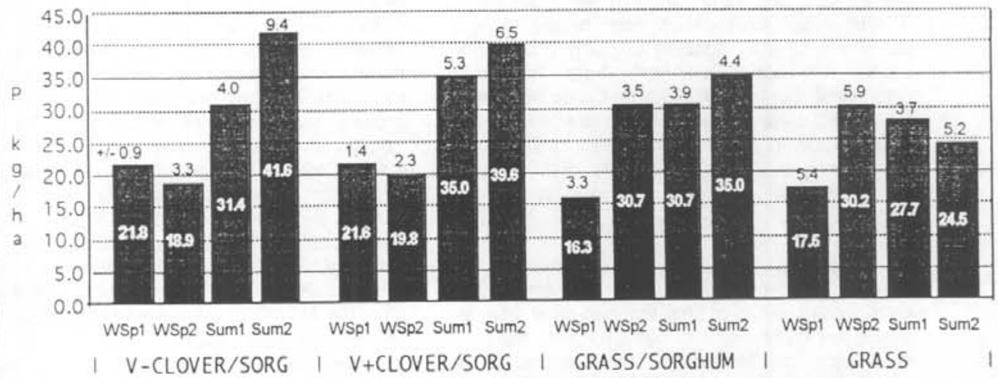

Figure 2. Crop x Season Interaction (P=0.0001) Means for P Mined, 1998-99.