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# Integrated Crop/Cattle Production Systems Present Unique Opportunities for Gastrointestinal Parasite Control and Enhanced Cattle Performance

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## Abstract

We have been examining the ability of forage crops and pasture to restore soil quality of degraded cropland. This report describes parasite-free land maintainance by anthelmintic treatment of animals prior to placing them on pastures. The site for this experiment was previously cropped and conventionally cultivated for several decades prior to sprigging of Coastal bermudagrass [*Cynodon dactylon* (L.) Pers.] in 1991. It can be assumed that cropland with no exposure to cattle for several years would have few infective nematode larvae. From 1994 to1998, yearling Angus steers grazed the paddocks for 140 days from mid-May until early October each year. Anthelmintic treatment included pour-on ivermectin on day –21, albendazole on day –7, and injectable ivermectin 48 hours prior to stocking of pastures, with the cattle remaining in drylot during the 48-hour period prior to being placed on the experimental paddocks. All steers received only one series of treatments during any given year.

During the 5-year period, examination of rectal fecal samples revealed that the mean worm eggs per gram of feces (epg) gradually increased from 0 (following treatment) to a mean of 2.2 (range from 0.7 to 3.0) by the end of the grazing season (the last sampling date) in October. Although the epg were not zero, they were below threshold levels that would allow development of a parasite burden in cattle. Consequently, pastures were maintained in a parasite-free condition for at least five years by simply therapeutically treating animals prior to placing them on the parasite-free pastures. The therapeutic treatment prevented transport of larvae to the pastures, thus preventing pasture contamination and re-infection.

Producers who use crop/pasture rotation systems can use this concept to maintain their pastures parasite-free and prevent parasites from negatively influencing cattle performance and production. In reality, many producers probably have not considered the concept of maintaining pastures parasite free, and have allowed cattle that are infected with parasites to move to parasite-free land, i.e., land that has been in crop production, and thereby contaminate the area. By using anthelmintic treatments in a prophylactic

manner in combination with parasite-free pastures, we have demonstrated that parasite-free grazing of cattle is achievable. This approach reduces the number of anthelmintic treatments that are required, while enhancing animal productivity.

**Keywords:** Gastrointestinal Parasites; Cattle; Bermudagrass; Nematodes; Pasture; Crop/pasture Rotation.

## Introduction

Gastrointestinal parasites are a major constraint to health and productivity in grazing livestock production systems (Fox, 1997). People have generally assumed that parasite infections are inevitable in grazing animals; therefore treatment and control programs have been aimed simply at reducing rather than eliminating the effect of parasites. However, this assumption may not be true. Reviews on the epidemiology of gastrointestinal nematodes (Thomas 1982; Williams, 1986a), show that cropland with no exposure to cattle for several years would have relatively few infective nematode larvae. If these croplands were converted to pasture, and cattle were treated with anthelmintics prior to being placed on these pastures, it should be theoretically possible to maintain pastures parasite-free or below threshold levels indefinitely. This concept is similar to that of the "safe pasture" preventative control system that combines anthelmintic treatment with management (Michael, 1976; Brunsdon, 1980; Morley and Donald, 1980; Williams, 1986b). In the Southern Piedmont region there has been a trend of conversion of cropland to managed pasture (Census of Agriculture, 1992; 1997). Although to a lesser extent, the same trend has been occurring in the Southern Coastal Plain region (Census of Agriculture, 1992; 1997). This trend provides an excellent opportunity to integrate anthelmintic treatment with management to provide and maintain parasite-free pastures.

An experiment was designed to broadly examine the ability of forage crops and pasture to restore soil quality of degraded cropland. This report describes a portion of the experiment to determine if parasite-free land could be maintained by anthelmintic treatment of animals prior to placing them on pastures.

## Material and Methods

### Site characteristics

A 37-acre upland field (33° 22'N, 83° 24'W) in the Greenbrier Creek subwatershed of the Oconee River watershed near Farmington, GA had previously been conventionally cultivated with cotton (*Gossypium hirsutum* L.), sorghum [*Sorghum bicolor* (L.) Moench], soybean [*Glycine max* (L.) Merr.], and wheat (*Triticum aestivum* L.) for several decades prior to grassland establishment by sprigging of Coastal bermudagrass [*Cynodon dactylon* (L.) Pers.] in 1991. Mean annual temperature is 61.7°F, rainfall is 49.2 in, and potential evaporation is 61.4 in, and elevation is 673 to 706 ft above sea level.

**Experimental design**

The experimental design was a randomized complete block with treatments in a split plot arrangement in each of three blocks, which were delineated by landscape feature (i.e., slight, moderate, and severe erosion classes). Main plots were pasture fertilization treatments (n = 3) and split plots were grazing intensities (n = 2). Individual paddocks ranged from 1.6 to 1.9 ac. Paddock shape minimized runoff contamination among paddocks and an animal handling and service alley followed the top of the landscape. Each paddock contained a 10 x 13 ft shade, a mineral feeder, and a water trough placed in a 50 ft line near the top of the landscape.

Fertilizer treatments consisted of (a) inorganic or mineral only (~180 lb N $ac^{-1}$ $yr^{-1}$ as $NH_4NO_3$ broadcast in split applications in May and July), (b) crimson clover cover crop plus supplemental inorganic fertilizer (~180 lb N $ac^{-1}$ $yr^{-1}$ with one-half of the N assumed fixed by clover biomass and the other half as $NH_4NO_3$ broadcast in July), and (c) broiler litter (~180 lb N $ac^{-1}$ $yr^{-1}$ broadcast in split applications in May and July). Phosphorus and K applications varied among treatments because excess P and K were applied with broiler litter (111 +/- 36 lb P $ac^{-1}$ $yr^{-1}$ and 149 +/- 43 lb K $ac^{-1}$ $yr^{-1}$) to meet N requirements, while diammonium phosphate and potash were applied based on soil test recommendations (14 +/- 10 lb P $ac^{-1}$ $yr^{-1}$ and 46 +/- 37 lb K $ac^{-1}$ $yr^{-1}$ for inorganic fertilizer and 21 +/- 18 lb P $ac^{-1}$ $yr^{-1}$ and 50 +/- 67 lb K $ac^{-1}$ $yr^{-1}$ for crimson clover cover crop plus supplemental inorganic fertilizer). Crimson clover was directly drilled in clover treatments at 9 lb $ac^{-1}$ in October each year. All paddocks were mowed in late April and residue allowed to decompose [i.e., clover biomass in clover plus inorganic treatment and winter annual weeds in other treatments].

Harvest methods were (a) high forage mass or low grazing intensity (put-and-take system of grazing to maintain a target forage mass of 2700 lb $ac^{-1}$), and (b) low forage mass or high grazing pressure (put-and-take system of grazing to maintain a target forage mass of 1,350 lb $ac^{-1}$).

**Cattle**

Yearling Angus steers (*Bos taurus*) were managed in a put-and-take grazing system with three "tester" steers assigned to each paddock and "grazer" steers added or removed at 28-day intervals except during periods of rapid forage mass changes when steers were added or removed at 14-day intervals. Except on rare occasions, three tester steers grazed each of the paddocks. Mean initial steer weights of testers for each year are presented in Table 1.

Table 1. Initial Tester Steer Weights

| Year | N | Weight, lb | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 1994 | 51 | 575 | 32 | 500 | 631 |
| 1995 | 54 | 602 | 35 | 536 | 690 |
| 1996 | 54 | 569 | 30 | 500 | 631 |
| 1997 | 54 | 540 | 41 | 434 | 615 |
| 1998 | 54 | 545 | 28 | 481 | 600 |

Steers that were not grazing the 18 paddocks, were on an adjacent, parasite-free pasture until needed. Steers were randomly allotted to paddocks. The stocking density for a given paddock was computed by assuming that each steer would consume 2.2 % of body weight daily. The number of steers that could be supported on a given paddock was calculated by dividing the forage mass (lb $ac^{-1}$) by the estimated average daily intake and then dividing by 28 (the number of days in the grazing period). Estimates of forage mass were made prior to stocking the paddocks and at 28-day intervals except during those times when adjustments were made at 14-day intervals. Estimates of forage mass were made by clipping a 2.7 $ft^2$ area to ground level at 100 ft grid sites.

Steers grazed the paddocks for a 140-day period from mid-May until early October each year except during the first year of treatment implementation (1994) when grazing began in mid-July due to repairs to infrastructure following a tornado. Shrunk weights (16 h off water) were obtained initially and at 28-day intervals and when stocking rate adjustments were made at 14-day intervals.

**Anthelmintic treatment**

Anthelmintic treatment included pour-on ivermectin on day –21, albendazole on day –7, and injectable ivermectin 48 hours prior to stocking of pastures, with the cattle remaining in drylot during the 48-hour period. This treatment regimen would be expected to remove 99.9 % of all gastrointestinal nematodes infecting cattle. All steers received only one series of treatments during any given year.

**Fecal sampling and analyses**

Rectal fecal samples for worm egg counts were obtained on day 0 and at 28-day intervals thereafter. On all sampling days after day 0, samples were obtained only from tester animals. A modification of Stoll's flotation-centrifugation technique was used to determine the number of nematode eggs per gram of feces (epg) (Stoll, 1930).

**Statistical analyses**

Because fecal worm egg counts would presumably increase during the grazing season and were greatest at the last sampling date of each grazing season, data from only the October sampling were statistically analyzed for treatment differences. Fecal epg showed a heterogeneity of variance among treatments, so epg values were transformed by calculating base 10 logarithm(total epg +1). Paddock was considered the experimental unit so paddock epg averages were used. Data were analyzed as a randomized complete block design that included random and fixed effects with repeated measures (years). Block was considered as a random effect while year, nitrogen, and grazing intensity were fixed effects. Statistical analyses were calculated using the Mixed Procedure of SAS (Littell, et al., 1996). The best fitting model, as determined by Schwarz's Bayesian Criterion was with block specified as random, with year repeated, and using the AR (1) (first order autoregressive) error structure on the residuals. The AR (1) error structure allows for equal variances on the main diagonal (year). Covariance among years was reduced as measurements became further separated in time. The model included nitrogen and grazing intensity effects and their interaction. These were tested with the block*nitrogen*grazing intensity term. Year, and its interactions with nitrogen and grazing intensity were included and tested with residual error. The effect of block was not significant (P>.05) and was dropped from the analysis.

## Results and Discussion

### Steer performance

Average daily gain (ADG) of tester steers for each of the five years and overall are presented in Table 2. Among the pasture fertilization treatments, steers grazing the clover plus nitrogen treatment had higher (P<.05) ADG than those on either of the other treatments. There is no obvious explanation for these differences in ADG. There was very little clover available for consumption, other than some residue in the early part of the grazing season, because the clover was mowed approximately one month before grazing began each year. Steers grazing at the low forage mass (high intensity) had lower (P<.05) ADG than those grazing at the high forage mass (low intensity). This difference could be attributed to greater selection potential for steers grazing the high forage mass.

Table 2. Average Daily Gain (lb day$^{-1}$) of Tester Steers by Nitrogen Treatment and Grazing Intensity

| | Nitrogen Treatment | | | Grazing Intensity | |
|---|---|---|---|---|---|
| Year | Clover | Litter | Mineral | High | Low |
| 1994 | 2.4 | 1.9 | 1.9 | 1.6 | 2.5 |
| 1995 | 1.5 | 1.4 | 1.3 | 1.2 | 1.5 |
| 1996 | 1.9 | 1.4 | 1.7 | 1.6 | 1.7 |
| 1997 | 1.7 | 1.5 | 1.7 | 1.3 | 1.9 |
| 1998 | 1.9 | 1.8 | 1.9 | 1.7 | 2.0 |
| Mean | 1.9$^{a}$ | 1.6$^{b}$ | 1.7$^{b}$ | 1.5$^{c}$ | 1.9$^{d}$ |

$^{a,b}$ Values with different superscripts across nitrogen treatments differ, P<.05. Year*nitrogen treatment interaction was significant, P=.0203.
$^{c,d}$ Values with different superscripts across grazing intensity differ, P<.05. Year*grazing intensity interaction was significant, P<.0001.

The steer ADG during this five-year period was excellent across all treatments. The ADG of the steers was equivalent to or greater than not only those gains reported for Coastal bermudagrass, but for some of the other hybrid bermudagrasses such as Tifton 44 (Conrad, et. al., 1981; Utley, et al., 1978). These results could partly by attributed to the fact that these pastures were free of nematode parasites. The impact of parasites on stocker-animal performance and production has not been fully documented. This is partly because the impact of parasites is influenced not only by the numbers and kinds of parasites present, but other factors such as season, abundance of feedstuffs, stocking rate, and age (Craig, 1988). The effect of anthelmintics on stocker performance has been investigated in many research studies (Reinemeyer and Linnabary, 1987; Williams, et al., 1989), but cattle have typically been released to parasite-contaminated pastures immediately following treatment. Consequently, it is difficult to attribute a specific improvement in ADG to the fact that the pastures were parasite free. Observations at our Research Center suggests that the improvement could be 0.2 to 0.5 lb per day.

**Fecal egg counts**

Fecal egg counts for the last sampling date in each year and a mean for the last sampling date across the five years are presented in Table 3. In each year, the epg were highest at the end of the grazing season (the last sampling date) in October. Although there were statistical treatment differences, the very low average epg (0.7 to 3.0) indicate that there were no biological differences among the fertilization and forage mass treatments.

Table 3. Average Fecal Egg Counts (eggs/gram) for October

| | Nitrogen Treatment | | | Grazing Intensity | |
|---|---|---|---|---|---|
| Year | Clover | Litter | Mineral | High | Low |
| 1994 | .7 | 4.1 | 6.1 | 2.6 | 4.7 |
| 1995 | 0 | .7 | .4 | .7 | .1 |
| 1996 | .9 | 4.2 | 4.0 | 3.1 | 3.0 |
| 1997 | .4 | 3.6 | 2.4 | .6 | .7 |
| 1998 | 1.3 | 2.6 | 1.7 | .8 | 2.9 |
| Mean | .7[a] | 3.0[b] | 2.9[b] | 1.6[c] | 2.9[d] |

[a,b] Values with different superscripts across nitrogen treatments differ, P<.05.
[c,d] Values with different superscripts across grazing intensity differ, P<.05. Year*grazing intensity interaction was significant, P<.0251.

Although the epg were not zero, they were below threshold levels that would allow development of a parasite burden in cattle. The threshold level that could allow for development of a parasite burden in steers is unknown for conditions of this experiment, but because epg did not increase between the years 1994 and 1998 we can say that they are below the threshold levels. A variety of factors including forage mass, cattle numbers and animal class could influence the threshold level necessary to allow development of a parasite burden in cattle. Consequently, we conclude that pastures were maintained in a parasite-free condition for at least five years by simply treating animals prior to placing them on the parasite-free pastures. The therapeutic treatment prevented transport of larvae to the pastures, thus preventing contamination.

The sensitivity of detection used for performing fecal egg counts in this study was much greater than that used for normal diagnostics. If the more usual methods had been used, every animal in this study during the 5-year period would have tested fecal-negative for parasites on every test date. During the 5-year period, mean epg at the end of the grazing period was 2.2; this level is approximately 2 orders of magnitude less than mean epg levels that one would expect under a more traditional management scheme. The treatment regimen used in this study was selected to ensure that cattle would enter the paddocks each spring in an essentially parasite-free state. Our more recent studies have demonstrated that this same effect can be achieved by a single dosing with two different anthelmintics given simultaneously 3 days before placing animals on pastures.

## Implications and conclusions

Results of this experiment illustrate that it is possible to maintain pastures in a parasite-free status in integrated crop/cattle production systems. By removing the effect of parasites, cattle can grow without the physiological constraints that gastrointestinal parasites place on appetite, digestion, nutrient utilization, and general well being. In traditional management systems, cattle graze parasite-contaminated pastures; therefore, parasites negatively impact growth and productivity throughout the entire grazing period. Periodic anthelmintic treatments simply give a temporary reprieve to those parasitic infections.

In reality, many producers probably have not considered the concept of maintaining pastures parasite free, and have allowed cattle that are infected with parasites to move to parasite-free land, i.e., land that has been in crop production, and thereby contaminate the area. By using anthelmintic treatments in a prophylactic manner in combination with parasite-free pastures, we have demonstrated that the goal of parasite-free grazing of cattle is achievable. This approach reduces the number of anthelmintic treatments that are required, while enhancing animal productivity.

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