# The Effect of Implanting Synovex-C Once or Twice during Nursing on Calf Gain and Weaning Weight

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## Summary

Implanting nursing calves in mid-May with Synovex-C significantly increased calf weaning weight compared to the control. Re-implanting during the nursing phase in mid-July stimulated a further significant increase in weaning weight compared to single implanted calves or controls; therefore, implanting increased calf gross income by approximately $5 to $7 per implant.

## Introduction

It is well documented that growth-stimulating implants administered during the nursing phase result in increased calf weaning weight. Most commercial implant products have a length of benefit of 90 to 120 days and are administered at a calf age of 30 to 45 days. Most calves are not weaned prior to 170 to 210 days of age; thus, the majority would be eligible for a second implant. This study was conducted to determine the effect of re-implanting with Synovex-C during the nursing phase of growth on calf average daily gain and weaning weight.

## Procedures

A total of 134 steer calves born in the springs of 1994 and 1995 were used in this trial. Calves were individually identified by ear tag and tattoo, stratified into three groups based on birth date and age of dam, and randomly assigned by group to treatment (control, implant once, implant twice).

Calves allotted to the implant treatments initially received a single dose of Synovex-C (100 mg progesterone and 10 mg estradiol benzoate) in mid-May of each year. One half of the Synovex-C steers were re-implanted with a second dose of Synovex-C in mid-July of each year. Implants were administered subcutaneously in the middle third of the backside of the ear using aseptic techniques.

Individual calf weights were recorded at time of first implanting, second implanting, and at weaning. All calves were grazed with their dams on mixed grass-legume pastures until weaning on November 22, 1994, or October 30, 1995.

Data were statistically analyzed using the General Linear Model procedures of SAS. The statistical model included year, treatment, year-by-treatment interaction, and random error. Initial weight was used as a covariate.

## Results and Discussion

The dates of initial implanting, re-implanting, and weaning as well as the number of days in each period are shown in Table 1 for both the 1994 and 1995 seasons. Calves were weaned approximately three weeks earlier in 1995 than in 1994, resulting in fewer days in the re-implant period during 1995. No year-by-treatment interaction occurred. Year influenced average daily gain (ADG) and weaning weight (Table 2). Calves had greater ADG ($P < .01$) during the first implant period in 1994 compared to 1995. Conversely, gains for the second implant period were greater ($P < .01$) in 1995 than 1994; thus, year had no effect ($P > .10$) on ADG from first implanting to weaning or on calf weight per day of age. Weaning weight was increased ($P < .01$) for 1994 compared to 1995 because calves were older at weaning time. The effect of implanting on calf ADG during the nursing phase for the combined years is shown in Table 3. Implanting increased ($P < .10$) calf ADG during the first period. Both initial and re-implanting increased ($P < .10$) ADG during the second period. A single implant did not increase ($P > .10$) ADG of the combined periods, but re-implanting did increase ($P < .10$) calf ADG compared to calves implanted once or the control calves.

**Table 1.** Dates implanted and days in treatment periods by year.

| Year | 1994 | | 1995 | |
|---|---|---|---|---|
| | Date | Days | Date | Days |
| Initial implanting | May 23 | 89 | May 11 | 95 |
| Re-implanting | Aug 20 | 94 | Aug 14 | 77 |
| Weaning | Nov 22 | 183 | Oct 30 | 172 |

**Table 2.** Effect of year on ADG and weaning weight.

| Year | 1994 | 1995 | SEM |
|---|---|---|---|
| Period 1 ADG, lb[a] | 2.39 | 2.01 | .03 |
| Period 2 ADG, lb[a] | 1.66 | 1.93 | .03 |
| Total ADG, lb[b] | 2.02 | 1.97 | .03 |
| Weaning wt, lb[a] | 596 | 563 | 5.5 |
| Wt per day of age, lb[b] | 2.33 | 2.29 | .05 |

[a]Means in rows differ, $P<.01$; [b]Means in rows do not differ, $P>.10$.

**Table 3.** Effect of implanting on ADG and weaning weight.

| | Control | Implant | Re-Implant | SEM |
|---|---|---|---|---|
| Period 1 ADG, lb[a] | 2.12[b] | 2.23[c] | | .04 |
| Period 2 ADG, lb | 1.69[b] | 1.80[c] | 1.90[c] | .04 |
| Total ADG, lb | 1.91[b] | 1.99[b] | 2.09[c] | .03 |
| Weaning wt, lb | 564[b] | 579[c] | 595[d] | 6.7 |

[a]All implanted calves were pooled for comparison; [b, c, d]Means in rows with differing superscripts differ, $P \leq .10$.

The use of a single implant increased (P <.10) weaning weight by 15 lb compared to the control calves (Table 3). Re-implanting resulted in an additional 16-lb increase (P <.10) over calves receiving a single implant and a 31-lb increase over control calves.

The economics of implanting once or twice during nursing are shown in Table 4. A single implant increased gross income per calf by $6.93. Implanting twice during the nursing phase increased gross income per calf by $11.98 compared to the control calves and $5.05 compared to calves receiving the single implant.

**Table 4.** Economics of implanting[a].

| Treatment | Control | Implant Once | Implant Twice |
|---|---|---|---|
| Weaning wt, lb | 564 | 579 | 595 |
| Price, $/cwt | 69.35 | 68.75 | 67.75 |
| Value, $/hd | 391.13 | 398.06 | 403.11 |
| Difference from control, $ | ------- | 6.93 | 11.98 |

[a]Kentucky Market News Summary, Week of Oct 12, 1998.

# The Effect of Revalor-G, Synovex-S, or Ralgro on Gain of Grazing Steers

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## Summary

Implanting produced heavier-weight steers after either 98 or 130 days of grazing compared to non-implanted controls. Implanted calves gained faster than non-implanted calves during the first 98 days and for the entire grazing period. Ralgro and Synovex-S did not maintain their gain-stimulating effects during the last 32 days of grazing in this trial. Revalor-G implanted steers were heavier at 130 days than steers from all other treatment groups because of greater gains during the last 32 days of grazing.

## Introduction

Grazing stocker cattle allows producers to market forages for which additional alternatives may not exist. Optimizing the utilization of available forage is necessary for grazing to be profitable. Both animal and grazing system management must be considered to optimize forage utilization. Growth-stimulating implants that increase rate and efficiency of gain are a valuable animal management tool for producer use. A new product, Revalor-G, has recently become available for use in stocker cattle. This study was conducted to determine and compare the effects of the growth-stimulating implants, Revalor-G, Synovex-S, and Ralgro, on gain of grazing steers.

## Procedures

Three hundred nineteen crossbred steers were purchased by a single-order buyer from area sale barns for this trial. All steers were treated using standard procedures for control of Bovine Respiratory Disease syndrome and internal parasites upon arrival at the farm. Booster vaccinations were given according to label directions. Strategic deworming was practiced by providing Safeguard7 containing mineral to the cattle on Days 28 and 56 following arrival.

Steers were individually identified by ear tag and tattoo, stratified by body weight, and randomly allocated within weight groups to implant treatments or a non-implanted control. Implant products were inserted subcutaneously in the middle third of the ear according to label instructions. The trial was initiated on 5/24/96 and terminated on 10/1/96. The initial average weight across treatments was 545 lb. Individual weights were taken on Days 1, 98, and 130 of the trial.

All steers were grazed as a single group. Pasture consisted of endophyte-infected Kentucky 31 (KY 31) fescue. Pasture divisions were made with temporary electric fencing, and the group was rotationally grazed so that forage available for grazing would not limit intake and growth.

Analyses of variance were calculated for Day 98 weight, final weight, early-season average daily gain, late-season average daily gain, and full-season average daily gain using the General Linear Models procedure of SAS. The model for each dependent variable included the effects of treatment (control, Revalor-G, Synovex-S, and Ralgro) and random error with initial weight included as a covariate.

## Results and Discussion

The effects of implanting on steer weights at 98 and 130 days are shown in Table 1. Regardless of product used, implanted calves were heavier (P <.10) than the non-implanted controls at both 98 and 130 days. There were no differences (P >.20) among implant treatments at 98 days. At 130 days, steers implanted with Revalor-G were heavier than steers implanted with Ralgro or Synovex-S (P <.10).

The effects of implanting on steer average daily gain at 98 days, from 98 to 130 days, and for the entire trial are shown in Table 1. Regardless of product, implanted calves gain faster for the first 98 days of the trial than the non-implanted control. During the last 32 days of the trial, steers implanted with Ralgro and Synovex-S did not gain differently (P >.20) than the non-implanted control. Steers implanted with Revalor-G gained faster than control, Ralgro-implanted, and Synovex-S implanted (P <.10) steers during the last 32 days of the trial. The gain-stimulating effects of both Ralgro and Synovex-S did not last for the entire 130 days of grazing.

Averaged across the entire grazing season, implanted steers gained faster than the non-implanted controls. Total period average daily gain for Revalor-G implanted steers was greater than the average daily gain for Ralgro-implanted or Synovex-S implanted steers (P <.10).

**Table 1.** Least square means for treatment effects of Revalor-G, Synovex-S and Ralgro on weight and ADG of grazing steers.

| Treatment | Control | Revalor-G | Synovex-S | Ralgro | SEM |
|---|---|---|---|---|---|
| 98-day wt, lb | 675[a] | 701[b] | 691[b] | 690[b] | 6.3 |
| Final wt, lb | 709[a] | 746[b] | 729[c] | 727[c] | 6.4 |
| 98-day ADG, lb | 1.33[a] | 1.59[b] | 1.49[b] | 1.48[b] | .06 |
| Final 32-day ADG, lb | 1.03[a] | 1.40[b] | 1.18[a] | 1.16[a] | .08 |
| Total ADG, lb | 1.25[a] | 1.54[b] | 1.41[c] | 1.40[c] | .04 |

[a,b,c]Means in the same row with differing superscripts differ, P<.10.

# A Molasses-Based Liquid Supplementation Program for Beef Cows Grazing Endophyte-Infected Tall Fescue

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## Summary

A three-year study at the Eden Shale Farm, Owenton, Kentucky, showed cows grazing endophyte-infected KY 31 tall fescue and receiving a molasses-based supplement gained more weight and maintained higher body condition scores than unsupplemented cows. Most of this difference occurred between May 4 and October 28. Seventy-six percent of the difference between May 4 and October 28 cow weights was accounted for during the period when a 20% CP molasses-based supplement was consumed (May 4 to July 29) as opposed to the 32% supplement fed the remainder of the year. Calf gains from May 4 to October 28 were also higher in the molasses-supplemented group, but 68% of the difference between non-supplemented and supplemented groups occurred from July 29 to October 28. This may be explained by consumption of the 32% CP supplement by the calves.

Overall mineral intake was 17% less when the molasses-based supplement was consumed. However, winter hay intake tended to be higher in the molasses-supplemented group. Pregnancy rates were low and varied among years, and the consumption of the molasses-based supplement had no effect on reproductive performance. Although the molasses-based supplement evaluated in this study increased cow and calf performance when grazing endophyte-infected KY 31 tall fescue, the increased performance was not large enough to be economically feasible.

## Introduction

Tall fescue is grown extensively in the United States. Although this grass has many desirable agronomic traits, grazing endophyte-infected tall fescue pastures during late spring, summer, and early fall has been shown to reduce reproductive performance of cows and weaning weights of calves. As a result, a supplementation program that nutritionally counteracts some of the toxic effects encountered with endophyte-infected tall fescue could be economically beneficial to the beef cow-calf producer. Use of a molasses-based supplement provided ad libitum in lick tanks might accomplish this objective in a labor-efficient manner. Therefore, the objective of this study was to evaluate the potential of a molasses-based supplement to increase beef cow and calf performance when grazing endophyte-infected KY 31 tall fescue.

## Procedures

Performance of 276 cow-calf pairs (grade Aberdeen Angus and 2 Aberdeen Angus 2 Beefmaster mature cows and 2-year-old heifers bred to Aberdeen Angus or Beefmaster bulls) was measured over three consecutive years at the University of Kentucky Eden Shale Farm at Owenton. The original allotment to KY 31 tall fescue pastures (> 95% endophyte infected) took place after calving in March and April of Year 8 pastures (7.2 to 10.4 ha; .8 ha/cow-calf pair) were randomly assigned each year, after calving, to either unsupplemented (C) or molasses-supplemented (M) groups so three pastures of each treatment contained mature cows and one pasture of each treatment contained 2-year-old heifers. Open cows were removed from the study at weaning each year. After weaning, C and M pregnant cows were maintained in two separate herds so molasses supplementation could continue from weaning until the beginning of the next grazing season on May 14. Heifers were randomly allotted to pastures as they calved each February and March. All cows had ad libitum access to rolled bales of KY 31 tall fescue hay (> 95% endophyte infected) in winter. A loose, salt-trace mineral mix was available throughout each year.

All cows were weighed and body condition scored (BCS; 1 = emaciated, 10 = obese) on February 8 of years 2 and 3 and at approximately 28-d intervals during the grazing season that extended from May 4 to October 28 each year. Jugular blood samples were collected from cows at each weighing during the grazing season and analyzed for urea nitrogen (BUN). Molasses and mineral intakes were monitored for each weigh period.

Calves were weighed the same day as cows from May 4 to October 28. Twenty-four-hour milk consumption estimates were determined by the weigh-suckle-weigh method after a 4- to 5-h separation of calves from cows. Weaning weights were adjusted for birth date, calf sex, and cow age.

Random forage samples were taken on each weigh day of the grazing season by hand clipping. Samples were analyzed for dry matter (DM), crude protein (CP), and neutral detergent fiber (NDF). All eight pastures were fertilized with urea (170 kg/ha) in mid-March and ammonium nitrate (170 kg/ha) on approximately July 20 each year.

## Results and Discussion

Composition of the molasses-based supplement, a commercial product formerly manufactured by Cargill Molasses Liquid Products, is shown in Table 1. This supplement is currently manufactured by Westway Trading Corporation and is marketed as Fes-Q-Foe by Southern States Cooperative Inc. The base product contained 32% CP and was fed to M cows from July 29 until May 4 of the following year. A 20% CP product was fed from May 4 to July 29 each year. Approximately 70% of the CP nitrogen was in a non-protein form. About 14% was estimated to be undegradable in the rumen (pork blood meal and feather meal in a 1:1 combination), while 86% was ruminally available.

Cow weights and BCS, taken periodically through the three-year study, are presented in Table 2. Winter weights, taken on February 8 before the calving season began in years 2 and 3, were not different, but BCS of M cows tended to be higher than C. Cows in the M treatment tended to weigh less than C on May 4 (beginning of the grazing season). Weights of the two groups were similar on June 1, June 29, and July 29, although molasses supplementation tended to increase BCS. Even though M cows weighed 13 kg less on May 4, molasses consumption caused them to be 9.7 kg heavier on October 28. Consumption of the molasses supplement also caused M cows to remain in a higher body condition from June 1 to October 28.

Cow weight and BCS changes for different periods are summarized in Table 3. As expected, extensive weight and BCS loss occurred in both treatments during the calving season and until May 4. However, M cows gained more weight and body condition than C cows from May 4 to July 29. This period included the breeding season for all cows (May 20 to July 29). Gain and improvement in BCS continued through October 28, but no differences were found between C and M. The C cows gained more than M during the last trimester of pregnancy (October 28 to February 8), but no differences were found for BCS change. Still, BCS tended to be higher for M cows on February 8.

Annual molasses (kg/hd/d) and mineral (g/hd/d) intakes are shown in Table 4. Molasses intake was fairly constant, at about 1.2 kg/hd/d throughout the year except from May 4 to July 29 (breeding season when the 20% CP product was offered). This was also the time frame when cows gained more weight and increased more in BCS (Table 3). Mineral intake was consistently lower in the M treatment than in C. Based on the mineral content of the molasses-based supplement (Table 1), this was expected. Greatest differences between C and M were found from May 4 to July 29, the period when the 20% CP product was offered.

Daily hay intake during the winter is summarized in Table 5. The low intake for both treatment groups from March 26 to May 4 of Year 1 was a result of increasing availability of pasture forage from March 26 (initiation of this study), allowing all cows to stop consuming hay in April. Much greater intakes occurred in Year 2, from February 8 (before calving season) until April 14 (when cows stopped consuming hay because of pasture forage availability). Hay intakes from November and December to

**Table 1.** Composition of molasses-based supplement (Fes-Q-Foe).

| Component | As-Fed |
|---|---|
| **DM, %** | **64.0** |
| CP, % of DM | 32.0 (20.0)[a] |
| Undegradable intake protein,% of CP | 14.4 |
| Rumen-degradable intake protein, % of CP | 85.6 |
| **Proportion of DM** | |
| Nonstructural carbohydrates,% | 43.0 |
| TDN, % | 45.0 |
| Phosphorus, % | 1.0 |
| Calcium, % | .4 |
| Sulfur, % | .7 |
| Magnesium, % | .2 |
| Potassium, % | 2.6 |
| Cobalt, ppm | 1.9 |
| Copper, ppm | 93.4 |
| Iodine, ppm | 3.7 |
| Iron, ppm | 213.9 |
| Manganese, ppm | 88.2 |
| Zinc, ppm | 205.2 |
| Vitamin A, IU/kg | 40,000 |
| Vitamin D, IU/kg | 10,000 |
| Vitamin E, IU/kg | 50 |
| Thiamine, g/kg | .7 |
| Niacin, mg/kg | 1.1 |

[a]32% CP product fed from July 29 to May 4 of following year; 20% CP product fed from May 4 to July 29 each year.

**Table 2.** Weights (lb) and body condition scores (BCS) of nonsupplemented (C) and molasses-supplemented (M) cows on specific dates during three-year KY 31 tall fescue grazing study.

| | Weight | | BCS[a] | |
|---|---|---|---|---|
| | C | M | C | M |
| **Date** | | | | |
| Feb 8[b] | 1111 | 1093 | 5.6[e] | 5.9[f] |
| May 4[c] | 1023 | 994 | 5.0 | 5.2 |
| June 1 | 1034 | 1041 | 5.1[e] | 5.4[f] |
| June 29 | 1036 | 1045 | 5.2[e] | 5.5[f] |
| July 29 | 1016 | 1027 | 5.1[g] | 5.5[h] |
| Sept 2 | 1052 | 1071 | 5.2[g] | 5.7[h] |
| Oct 5 | 1087 | 1102 | 5.3[g] | 5.8[h] |
| Oct 28[d] | 1076 | 1096 | 5.5[e] | 5.8[f] |

[a]BCS (1 = emaciated; 10 = obese).
[b]Average wt in Year 2 and 3 prior to calving season.
[c]Average initial wt for grazing season in three consecutive years.
[d]Average final wt for grazing season in three consecutive years.
[e,f]Treatment difference ($P < .10$).
[g,h]Treatment difference ($P < .01$).

**Table 3.** Weight (lb) and body condition score (BCS) change of nonsupplemented (C) and molasses-supplemented (M) cows grazing KY 31 tall fescue for three consecutive years

| | Weight Change | | BCS Change | |
|---|---|---|---|---|
| | C | M[a] | C | M[a] |
| **Period** | | | | |
| Feb 8 to May 4 | -88 | -99 | -.6 | -.7 |
| May 4 to July 29 | -7[b] | 33[c] | .1[b] | .3[c] |
| July 29 to Oct 28 | 59 | 68 | .4 | .3 |
| Oct 28 to Feb 8 | 35[b] | -2[c] | .1 | .1 |

[a]32% CP molasses-based supplement provided ad libitum from July 29 to May 4; 20% CP supplement fed from May 4 to July 29.

[b,c]Treatment difference ($P < .05$).

**Table 4.** Daily molasses and mineral intake of nonsupplemented (C) and molasses-supplemented (M) cows grazing KY 31 tall fescue for three consecutive years.

| | Molasses, lb/d | Mineral, lb/d | |
|---|---|---|---|
| | M | C | M |
| **Period** | | | |
| Feb 8 to May 4 | 2.4 | .29 | .26 |
| May 4 to June 1 | 2.9 | .27 | .23 |
| June 1 to June 29 | 3.5 | .26 | .21 |
| June 29 to July 29 | 4.4 | .23 | .17 |
| July 29 to Sept 2 | 2.4 | .22 | .21 |
| Sept 2 to Oct 5 | 2.6 | .24 | .22 |
| Oct 5 to Oct 28 | 2.6 | .26 | .22 |
| Oct 28 to Feb 8 | 2.6 | .14 | .10 |

**Table 5.** Daily hay intake (lb/hd) of nonsupplemented (C) and molasses-supplemented (M) cows.

| | C | M |
|---|---|---|
| **Period** | | |
| Year 1, March 26 to May 4 | 9.2 | 9.9 |
| Year 1, Nov 4 to Feb 8 | 19.6 | 21.1 |
| Year 2, Feb 8 to April 14 | 28.2 | 25.1 |
| Year 2, Dec 15 to March 28 | 21.1 | 23.1 |

February and March of Years 1 and 2, respectively, were higher for M cows than for C. These were periods when M cows were consuming 1.2 kg/hd/d of the molasses supplement (Table 4). Hay intake was not measured in Year 3 because the study was completed on October 28 of that year.

The CP and NDF composition of the forage available to cows and calves in C and M pastures during the experimental grazing season is shown in Table 6. High CP and lower NDF percentages are indicative of high quality forage. The high CP and low NDF values found on May 4 are a result of the nitrogen fertilization in March and the spring flush of cool-season grass growth. In contrast, lower CP and higher NDF levels were found in June. The decrease in forage quality in late May, through June, and into July coincided with the breeding season for cows in this study (May 20 to July 29). Therefore, supplementing with a protein and energy source during these months might prove beneficial from the standpoint of cow weight gains, BCS, conception rate, milk production, and calf gains. Even though forage quality decreased in May, June, and July (Table 6), this was the period when M cows gained more weight and increased their BCS more than C (Table 3), evidently because of the daily molasses intake of 1.3 to 2.0 kg/hd/d (Table 4).

An increase in CP and decrease in NDF concentration of the forage sampled on July 29 was the result of ammonium nitrate fertilization on approximately July 20. This fertilization, plus clipping all pastures shortly afterwards, kept the forage in a relatively high-quality state through August, September, and into October.

Normally, tall fescue pasture quality is lowest in July and August. Therefore, the 32% CP molasses-based supplement was fed from July 29 through October 28. Daily intake of this product averaged about 1.2 kg/hd/d. The C cows gained 27 kg and .4 BCS units, while M cows gained 31 kg and .3 BCS units during this period (Table 3). Although providing the 20% CP supplement from May 4 to July 29 appeared beneficial, consumption of the 32% CP product from July 29 to October 28 was not beneficial in terms of increasing cow gain or BCS.

Some research indicates high BUN concentrations (>19 to 20 mg/100 ml) may be related to lower conception rates in beef cows. Conversely, if BUN concentrations are too low (<5 to 6 mg/100 ml), normal ruminal digestion of feedstuffs may be inhibited. Table 7 shows BUN concentrations were approaching the critical high on May 4. These high levels probably resulted from the mid-March urea fertilization and, within the M treatment, consumption of the 32% CP molasses-based supplement. However, BUN concentrations were not different between C and M on May 4. Levels in both treatments were lower on June 1 and 29, probably a function of lower CP content of the fescue (Table 6). The cows in the M treatment had higher concentrations on these dates than did C cows. This difference may be attributed to the relatively high consumption rate of the 20% CP supplement (Table 4).

Cows in both treatments exhibited relatively high BUN concentrations on July 29 (C = 21.7; M = 21.8 mg/100 ml). These levels may be attributed to the increased CP concentration of the forage the cows consumed (Table 6) after it was fertilized and clipped on approximately July 20. Thereafter, BUN concentrations decreased through October 28, but M cows tended to have numerically higher levels.

Percentage of cows that were pregnant, determined by palpation on October 5, was low (Table 7). However, these percentages may not be unrealistic for beef cows grazing endophyte-infected KY 31 tall fescue year-round in Kentucky. Overall, the three-year averages (C = 79%; M = 76%) were not different for the C and M treatments.

Weights of calves born on March 20 (average) each year are presented in Table 8. No differences were found between C and M calf weights until the September 2 weighing. Although M calves were physically large enough by June 1 to consume the molasses supplement, it is doubtful they consumed significant amounts before the July 29 weighing. Therefore, any difference

**Table 6.** Crude protein (CP) and neutral detergent fiber (NDF) composition of KY 31 tall fescue forage in pastures grazed by nonsupplemented (C) and molasses-supplemented (M) cows for three consecutive years.

| | CP, % of DM [a] | | NDF, % of DM [a] | |
|---|---|---|---|---|
| | C | M | C | M |
| **Date** | | | | |
| May 4 | 15.5 | 15.7 | 57.2 | 57.0 |
| June 1 | 8.4 | 8.9 | 68.3 | 65.6 |
| June 29 | 8.9 | 9.1 | 69.7 | 69.8 |
| July 29 | 14.8 | 13.9 | 63.5 | 61.1 |
| Sept 2 | 13.5 | 13.4 | 63.1 | 59.0 |
| Oct 5 | 13.2 | 13.1 | 61.7 | 61.5 |

[a]DM = dry matter.

**Table 7.** Blood urea nitrogen (BUN) and pregnancy status of nonsupplemented (C) and molasses-supplemented (M) cows grazing KY 31 tall fescue for three consecutive years.

| Item | C | M |
|---|---|---|
| **BUN, mg/100ml** | | |
| May 4 | 18.2 | 19.4 |
| June 1 | 14.0[a] | 16.1[b] |
| June 29 | 15.7[a] | 18.4[b] |
| July 29 | 21.7 | 21.8 |
| Sept 2 | 14.3 | 15.0 |
| Oct 5 | 13.0 | 14.5 |
| Oct 28 | 13.3 | 14.1 |
| **Pregnancy status, %** | | |
| Year 1 | 77 | 69 |
| Year 2 | 74 | 79 |
| Year 3 | 87 | 81 |

[a,b]Treatment difference ($P < .05$).

in calf performance from birth to July 29 between C and M would have been attributed to the molasses consumption and, subsequently, greater milk production by the cow. Although M calves tended to be numerically heavier than C at all weighings prior to July 29, these differences were not significant. Milk consumption estimates (kg/hd/d), taken on May 4, June 1, June 29, and July 29 were 13.2, 12.9; 12.7, 12.0; 9.5, 10.7; and 9.8, 9.6 for C and M, respectively. None of these differences were significant. Therefore, any effect of supplementing with the 20% CP product from May 4 to July 29 was expressed through increased cow weight and BCS (Table 3).

Calves in the M treatment weighed more than C calves on September 2, October 5, and October 28. Because milk consumption estimates were similar for C and M on September 2 and October 5 (6.9, 7.6 and 5.9, 5.5 kg/hd/d) and forage quality was similar on these same dates (Table 6), calf weight differences may be a result of their consumption of the 32% CP molasses-based supplement. This conclusion is supported by the fact that 68% of the difference in total gain from May 4 to October 28 accrued from July 29 to October 28.

**Table 8.** Weights (lb) of calves born to unsupplemented (C) and molasses-supplemented (M) cows grazing KY 31 tall fescue for three consecutive years.

| Item | C | M |
|---|---|---|
| Average birth date | 3/20 | 3/20 |
| Average birth wt | 85.4 | 83.4 |
| **Period** | | |
| May 4 | 178 | 178 |
| June 1 | 232 | 234 |
| June 29 | 286 | 291 |
| July 29 | 348 | 354 |
| Sept 2 | 420[a] | 432[b] |
| Oct 5 | 484[c] | 499[d] |
| Oct 28 | 512[a] | 530[b] |
| Total gain, May 4 to Oct 28 | 334[a] | 352[b] |

[a,b]Treatment difference ($P < .05$).

[c,d]Treatment difference ($P < .10$).

# Supplementing Steers Grazing Stockpiled Tall Fescue with Cracked Corn or Soyhulls

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## Summary

Supplementing steers grazing stockpiled endophyte-infected fescue with soyhulls (SH) vs cracked corn (CC) during the winter months appears to be beneficial to steer weight gain. The steer gains for this short trial were not sufficient to be economically viable in most situations, but are to be used to demonstrate the principle of supplementing with two different types of energy sources without sacrificing the digestibility of the forage.

Each steer consumed an average of 175 lb of supplement (SH or CC). In December 1996, the delivered cost of bulk soyhulls was $121/ton and the cost of bulk delivered cracked corn was $100/ton. The total cost of the supplement per steer for the trial was $10.60 for SH and $8.75 for CC, a $1.85/head higher cost for soybean hull-supplemented steers. The median Kentucky livestock market price for a 700- lb steer that week was $51/cwt. The 45-lb advantage in weight gained per steer because of supple-

menting SH was worth about an extra $21 ((45 lb x $.51/lb) - $1.85 extra SH cost) to the producer compared to supplementing cracked corn. The steers supplemented with soyhulls returned about an extra $2 ($21 extra return/$10.60 soyhull investment) per supplement dollar invested compared to feeding cracked corn.

Extra pastures were not available to include a grazing-without-supplementation treatment, thus the merit of supplementation was not evaluated. The level of soyhulls which can be fed without interfering with the digestibility of tall fescue needs more investigation. We will continue to investigate the role that by-products such as soyhulls might play in the grazing supplementation of growing beef cattle.

## Introduction

High quality cool-season grasses have adequate nutrient content available for young growing beef cattle to promote average daily gains of 1.5 to 2.5 lb per day while grazing without supplementation in temperate weather. However, energy supplementation may become necessary for grazing stockpiled cool-season grasses in the late fall and winter to promote these gains because of the increased energy requirements for maintaining body temperature. While most cool-season grasses quickly loose their nutrient content and become unpalatable in stockpiled situations, tall fescue is known for its ability to remain palatable and maintain good nutrient content despite freezing temperatures. Choosing an energy supplement which complements the predominantly fiber-digesting rumen microflora in a grazing animal may be important to maintaining rumen microbial efficiency and result in better animal performance. Typically, if any energy supplement is fed, corn is selected because of traditional use and high availability. However, the starch content of corn may cause a shift in the rumen microflora towards starch-digesting bacteria at the expense of fiber-utilizing bacteria. More recently, highly fermentable fiber by-product feedstuffs, such as soyhulls and wheat middlings, have become available to producers. These more fibrous energy sources may complement, rather than compete with, the bacteria which are breaking down the tall fescue grass. Therefore, the objective of this preliminary experiment was to compare the performance of growing steers supplemented with either cracked corn (CC) or soyhulls (SH) while grazing stockpiled fescue in the late fall and winter.

## Procedures

Forty-eight crossbred steer calves (651 lb, initial weight) were used in an 84-day growth trial. Steers were adapted to stockpiled tall fescue for two weeks, sorted and stratified by weight, and randomly allotted to four adjacent seven-acre pastures (12 steers/pasture) on December 18, 1996. The pastures on the Coldstream Farm were open (no constructed shelter) except for occasional trees. There was approximately 6,470 lb of endophyte-infected tall fescue available per acre of pasture at the initiation of the study.

The supplements were offered in wooden feed bunks at 4.5 lb per head per day (as-fed basis). The level of supplementation selected was approximately .6% of body weight (BW); the estimated amount of dry matter intake of a starch-based supplement before cool-season forage digestion is negatively affected, based on previous research. Steers were started on each supplement at a rate of 2 lb/hd/day and uniformly reached the full supplementation level within two weeks after the trial began. Table 1 shows the chemical composition of pasture supplement treatments: cracked corn, soyhulls, and the composition of the free choice pasture mineral mix. Six random ¼ $m^2$ samples were hand clipped from each pasture during each period as near to the weigh date as possible (Table 2). The steers were weighed at the beginning and end of the trial and at 28-day intervals. The experiment ended March 12, 1997.

**Table 1.** Chemical composition of pasture supplements.

| Item[a] | DM, % | CP, % | NDF, % | ADF, % | ADL, % | $NE_g$[b], Mcal/lb |
|---|---|---|---|---|---|---|
| | | DM basis | | | | |
| Soyhulls | 91 | 13.9 | 59.8 | 43.1 | 3.9 | .55 |
| Corn grain | 88 | 9.1 | 8.5 | 3.1 | 1.9 | .59 |

*Free-choice pasture mineral mix:*
68% Trace mineral salt + selenium (NaCl—95%, Zn—.35%, Fe—.34%, Mn—.20%, Cu—330 ppm, I—70 ppm, Co—50 ppm, Se—90 ppm);
23% monocalcium phosphate;
5% dried molasses;
4% Vitamin A, D, E premix (8,800 IU/g vitamin A; 1,760 IU/g vitamin D; and 1.1 IU/g vitamin E).

[a]DM—dry matter, CP—crude protein, NDF—neutral detergent fiber, ADF—acid detergent fiber, ADL—acid detergent lignin, $NE_g$—net energy for gain.

[b]Beef NRC, 1996.

**Table 2.** Chemical composition of clipped pasture samples[a].

| Pasture | Month[c] | Treatment | Forage DM[d], lb/ac | DM, % | %, DM basis[b] CP | NDF | ADF | ADL |
|---|---|---|---|---|---|---|---|---|
| 1 | Dec | Soyhulls | 8,470 | 25.0 | 9.4 | 71.4 | 35.8 | 5.2 |
| | Jan | | 4,802 | 30.3 | 10.8 | 71.4 | 40.5 | 5.0 |
| | March | | 2,813 | 63.9 | 10.4 | 72.5 | 38.5 | 5.7 |
| 2 | Dec | Corn | 5,734 | 28.7 | 10.0 | 71.1 | 43.1 | 7.6 |
| | Jan | | 4,617 | 26.9 | 10.7 | 70.3 | 37.1 | 5.4 |
| | March | | 2,148 | 62.3 | 10.3 | 72.0 | 44.1 | 4.4 |
| 3 | Dec | Corn | 6,332 | 21.5 | 12.0 | 71.2 | 37.8 | 5.4 |
| | Jan | | 3,756 | 23.1 | 12.2 | 70.5 | 40.0 | 6.9 |
| | March | | 1,326 | 61.3 | 11.9 | 69.2 | 42.1 | 5.5 |
| 4 | Dec | Soyhulls | 5,354 | 28.3 | 10.2 | 70.0 | 37.7 | 8.4 |
| | Jan | | 3,157 | 31.4 | 10.0 | 69.2 | 37.6 | 4.9 |
| | March | | 1,802 | 60.9 | 9.5 | 72.9 | 44.8 | 3.6 |

[a]All of the forage variables were similar (P > .1) between treatments, within each period (SEM and P values not shown).

[b]DM—dry matter, CP—crude protein, NDF—neutral detergent fiber, ADF—acid detergent fiber, ADL—acid detergent lignin.

[c]Feb samples not collected due to snow and rain conditions.

[d]Yields expressed as lb dry matter/ ac available on day of sampling.

The effects upon the studied variables exerted by the two types of supplements were analyzed using a General Linear Model, testing the effects of each treatment (SH or CC).

## Results and Discussion

All forage variables (Table 2) were similar (P > .1) between treatments (statistical analyses not shown). Initial steer weights were similar (P = .19) between treatments (Table 3). However, the steers which were supplemented with SH gained .71 lb more (P = .05) than those fed CC as a supplement (1.07 vs .35 lb/d, SH and CC, respectively). The SH-supplemented steer first-month weights were slightly higher (P = .07) than those fed CC (680 vs 662 lb for SH and CC). Since the nutrients provided by CC, SH, and the forages (Table 2) were not dramatically different, this may indicate that the steers fed supplemental SH required less ruminal adaptation and were more efficient in their use of nutrients than those fed CC.

In contrast to the first month of excellent early winter weather conditions, the second month of grazing was marked by colder temperatures, more frequent rainfall, and one significant accumulation of snow (each pasture was offered one large bale of fescue hay in a round-bale feeder at this time). Mean ADG for this period was negative, and while steers supplemented with SH lost .9 lb less (P = .28) weight per day, they weighed 42 lb more (P = .07) than steers fed CC (-.09 vs -.99 lb ADG and 677 vs 635 lb BW for SH vs CC, respectively). The efficiency of SH nutrient use appears to have continued from the first month through the inclement weather of the second month of grazing.

The weather during the third month of grazing was mild and dry. The trial was concluded at the end of the third month because availablilty of stockpiled tall fescue was reduced to an average of 2,022 lb/acre of dry, unpalatable forage. During this month, the steers supplemented with CC gained a similar (P = .98) amount of weight as those fed SH (1.28 vs 1.27 lb/d for SH and CC). Final weight was higher (P = .04) for those fed SH (713 vs 670 lb for SH and CC). The ADG for the total trial reflected the first two months' advantage of the SH-supplemented steers, gaining an overall .54 lb/d more (P =.05) than those supplemented with CC (.75 vs .21 lb/d for SH and CC).

**Table 3.** Effects of soyhulls or cracked corn as supplements for steers grazing stockpiled tall fescue.

| | Supplement (pasture #) | | | | | | | P value[b] |
|---|---|---|---|---|---|---|---|---|
| Item | Soyhulls (1) | Cracked Corn (2) | Cracked Corn (3) | Soyhulls (4) | SH, total | CC, total | SEM[a] | Trt |
| Initial wt, lb | 650 | 651 | 654 | 650 | 650 | 652 | 1 | .19 |
| Day 28 wt, lb | 676 | 659 | 665 | 684 | 680 | 662 | 4 | .07 |
| ADG, days 1-28, lb/d | .92 | .29 | .40 | 1.22 | 1.07 | .35 | .11 | .05 |
| Day 56 wt, lb | 683 | 646 | 624 | 672 | 677 | 635 | 9 | .07 |
| ADG, days 28-56, lb/d | .27 | -.49 | -1.48 | -.45 | -.09 | -.99 | .43 | .28 |
| Day 84 final wt, lb | 709 | 678 | 662 | 718 | 713 | 670 | 6 | .04 |
| ADG, days 56-84, lb/d | .92 | 1.16 | 1.39 | 1.64 | 1.28 | 1.27 | .27 | .98 |
| ADG, days 1-84, lb/d | .70 | .32 | .10 | .81 | .75 | .21 | .08 | .05 |

[a]Standard error of treatment mean, n = 4.

[b]P <, Trt—treatment.

# Beef Cattle Grazing Endophyte-Infected Tall Fescue Pastures Interseeded with Alfalfa

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## Summary

Forage dry matter availability and quality were not limiting factors for cattle grazing these closely managed pastures. Unless forage endophyte levels, ergot alkaloid content, dry matter intake, or nutrient digestibility are different, cattle performance differences would not be expected. Cow/calf pair gains did not appear to respond to interseeded alfalfa or high rotation grazing management of pastures. Pregnancy data will need more years of data and animal numbers before any definite statement can be made about effects of interseeded alfalfa or endophyte infection. Stocker steers benefited from inclusion of alfalfa in fescue pasture as measured by increased weight gain but did not respond to high rotation grazing. Pending analyses of a rumen-cannulated steer trial may clarify reasons for increased steer gain due to interseeded alfalfa. Yearly weather differences may have a large effect upon forage availability, plant species composition, temperature/endophyte-related fescue toxicoses stress and, therefore, efficiency of forage/cattle interaction. Addition of alfalfa to tall fescue pastures will improve forage quality by reducing neutral detergent fiber content but may not affect crude protein content at levels of interseeding of this experiment. Reductions in alfalfa as a percentage of available forage dry mat-

ter and reduced alfalfa plant counts indicate that alfalfa interseeded into tall fescue and grazed in a low rotation system will begin to die out by the end of the second year of grazing, despite recommended fertilization.

## Introduction

Forages are an under-utilized resource for the Kentucky beef industry. The beef cattle population, number of producers, and income could increase in the Commonwealth by optimum management of beef cattle nutrition relative to our forages. However, traditional management practices with endophyte-infected tall fescue may not improve forage quality or quantity, maintain adequate legume populations, or maximize efficient use of pasture nutrients by beef cattle.

Good beef cattle grazing management includes meeting nutrient needs for the desired level of performance and optimizing forage availability, quality, and forage species' persistence. Cattle producers may impact productivity and efficiency of grazing beef cattle by 1) altering the grazing system, 2) selecting optimum forage species and cultivars for particular nutritional needs, 3) managing available forage of a certain quality to an animal per unit of time, (4) controlling available forage per land area, and (5) by feeding supplements to beef cattle which complement forage nutrient content and availability.

The beef animal defines available forage quality by level of dry matter intake and digestibility. Improvements made in management of these factors should improve efficiency and/or productivity. However, much remains to be understood when balancing the beef animals' needs with the pasture's available nutrients. Forage analyses which are commonly used by nutritionists to estimate diet quality and potential impacts upon dry matter intake include neutral detergent fiber and crude protein. Published values of tall fescue nutrient content, especially at different maturities during the growing season, are limited and usually do not relate to grazed forage. Grazing research requires high investment in people, cattle, and land resources. Therefore, limited information is available to nutritionists and producers to optimize their grazing nutrition management. Grazing management can affect forage quality, and managing available forage influences animal performance through dry matter intake. When available forage is not limiting, digestibility is the primary factor influencing animal performance.

This report is a summary of the first two years of a multiyear study designed to evaluate grazing management of endophyte-infected tall fescue alone or with interseeded alfalfa. Response criteria include beef cow/calf and growing steer weight; efficiency of production per land area; pregnancy rate and days pregnant; and forage quality, availability, species persistence, and composition.

## Procedures

Two plant species combinations, endophyte-infected tall fescue with or without alfalfa, and two grazing management systems were arranged in a randomized complete block design, with three pasture replications per treatment. Grazing systems included a two-paddock rotation referred to in this report as "low rotation" vs a six- to 12-paddock rotation called "high rotation." Each of 12 pastures consisted of 15 acres for a total of 180 acres. Fifteen acres would normally support a minimum of seven to eight cow/calf pairs in a continuous grazing system in this area of Kentucky. Pastures were blocked by soil type, topography (percentage slope), and soil tests for allotment to treatment (Table 1). Pasture treatment assignments were maintained for the duration of the experiment. All pastures were slightly rectangular. Harvested endophyte-infected tall fescue seed (KY 31, endophyte infection > 80%), was planted in late summer of 1994. Alfalfa (AlfaGraze™) was interseeded in dense, endophyte-infected tall fescue in spring of 1996 following a band-sprayed application of Gramoxone™. The goal of alfalfa interseeding was to provide 30% of forage dry matter as alfalfa in the initial year of grazing.

**Table 1.** Average soil tests[a] and pasture slopes.

| | Treatments[b] | | | |
|---|---|---|---|---|
| **Item** | **HRF** | **LRF** | **HRFA** | **LRFA** |
| pH | 6.5 | 6.7 | 6.7 | 6.7 |
| Phosphorus, lb/ac | 179 | 288 | 269 | 118 |
| Potassium, lb/ac | 495 | 565 | 462 | 342 |
| Percentage of area with 2- 6% slope | 68 | 65 | 65 | 65 |

[a]Falls of 1996, 1997, and 1998.

[b]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

Cow/calf and stocker systems were chosen for use in this experiment because of 1) the high number of these types of operations in Kentucky, 2) their high availability for research, and 3) ability to monitor reproductive, growth, and nutritional traits. Cows were blocked (variables included: cow breed and age, calf age and sex) and randomly allotted to treatments each year.

Seven to eight Angus cow/calf pairs, a minimum of six to eight stocker steers (during peak growing season), one rumen-fistulated steer, and one bull (during breeding season) were placed in each pasture (three pastures per treatment). Based upon visual observation of forage, pasture production history, and measurements of available forage, extra stocker steers were placed in pastures to equalize residual forage. A reserve group of cow/calf pairs was available to maintain stocking rates when it was necessary to remove any animal or pair from a treatment for health or other reasons.

Rumen-fistulated steers were surgically prepared for collection of diet samples and to determine digestibility of grazed forage. This was accomplished by total fecal collection, reticulorumen evacuation, and masticate sample collection, followed by replacement of reticulorumen contents. Steers were adapted for at least two weeks to pastures and other cattle and trained for collection routines prior to conduct of the trial.

Potash, boron, and lime were applied to each pasture as recommended in *1998-1999 Lime and Fertilizer Recommendations* (AGR-1) for the particular crop being grown. Fifty lb of actual nitrogen per acre was applied twice annually (March and June) to pastures which did not contain alfalfa. Pastures were drag-harrowed each spring to break up residual manure before grazing began. The deciding factor for cattle movement between paddocks was to graze half and leave half of original forage height; therefore, days per paddock varied with forage availability. Pastures were clipped once per season when fescue seed heads had emerged and stem elongation had occurred.

Extent of endophyte infection was evaluated annually by staining and microscopic analysis by the UK College of Agriculture's Division of Regulatory Services. The grazing season spanned the time from turnout in early April until weaning of calves in early October. A final uniform grazing of all pastures (4 - 6 inches height) was conducted after conclusion of each grazing season, after air temperature fell to between 20° and 24° F.

Paddock subdivision for high rotation groups within pasture halves was accomplished with electrified polytape. Automated waterers were located centrally within each pasture. A vitamin and mineral supplement was offered free choice in weather-protected, portable feeders. Daily weather conditions pertinent to study were recorded at an existing on-site (within 2 miles of all pastures) weather station. Portable shades were moved for each pasture as often as cattle in high rotation group were moved. All cattle grazed a common pasture prior to initial and final weights to minimize any rumen fill variation that could be caused by dry matter intake differences among pasture treatments. Monthly weights (full) were taken approximately every 28 days. Blood samples were collected from cows and stocker steers at beginning and end of their respective grazing seasons for measurement of serum prolactin concentration (fescue toxicosis indicator).

Animal/forage relationships were used for interpretation of this research. Animal units were used as a reference, where one animal unit equals 1,000 lb of animal body weight. Grazing pressure is normally calculated as mean animal unit/weight of forage dry matter during the grazing season. However, we used the inverse relationship to examine available forage dry matter/mean animal unit. Stocking rate is calculated as animal unit/acre over grazing season.

Forage availability of each treatment was determined monthly during grazing season by hand clipping. Randomized ¼ $m^2$ test quadrats (n = 12) were clipped throughout each pasture. These samples were collected to compare effects of season (maturity), species mix, and grazing rotation effects on forage quality and availability. In April and October, these quadrats were used to estimate alfalfa plant stand. Botanical composition (species profile) was determined each year during May (Table 2). These samples were separated into fescue, other grasses, alfalfa, clover, and weed portions. All samples were dried in a forced-air oven at 60° C to determine dry matter and ground (1-mm screen) in a Wiley mill and analyzed for crude protein and neutral detergent fiber content. Forage quality and availability for 1997 and 1998 grazing seasons are included in Table 3.

Data were analyzed using General Linear Model (GLM) procedure of SAS (1996). The grazing model included treatment, with pasture as experimental unit. Since differences due to year were highly significant, data is separated, analyzed, reported, and discussed by year. Weather patterns affect yearly grazing results. Therefore, this report includes weather data for each year to aid in interpretation (Table 4).

## Results and Discussion

Soils at the University of Kentucky Animal Research Center's Beef Research Pastures are primarily Maury silt loams, with lesser amounts of Loradale, Nolin, Hagerstown, and Lowell silt loams. Each grazing treatment had between 65 and 68% of soils consisting of 2 to 6% slopes (Table 1). All pastures had high-measured levels of phosphorus and potassium, above 60 and 300 lb/acre of phosphorus and potassium, respectively. Potassium levels in fescue/alfalfa treatments were maintained to benefit legumes. The pH levels were well above the recommended 6.4 for hay and pasture renovation of grass with legumes.

Hand-clipped forage samples from the month of May of each year were separated into five categories: fescue, other grasses, alfalfa, clover, and weeds (Table 2). The proportion of fescue, as anticipated, was greatest ($P = .02$) in high and low rotation fescue treatments, intermediate in low rotation fescue/alfalfa, and least in high rotation fescue/alfalfa pastures in 1997. Fescue dry matter proportions between all treatments were similar ($P > .10$) in 1998. Alfalfa interseeding was successful in promoting growth of alfalfa in an established stand of tall fescue. Although alfalfa was immature for the May sampling period, it made up more than 10% of available forage dry matter in 1997. The 1997 alfalfa dry matter availability and plants per $m^2$ in April and October were similar ($P > .10$) between high and low rotation fescue/alfalfa treatments. In April 1998, alfalfa plants per $m^2$ were similar ($P > .10$) between high and low rotation fescue/alfalfa treatments. The May 1998 clip sampling revealed lower ($P = .05$) alfalfa dry matter availability with low rotation compared to high rotation systems. October 1998 alfalfa plant counts were reduced ($P = .004$) for low rotation fescue/alfalfa pastures compared to those in high rotation fescue/alfalfa treatment. It appears that low rotation fescue/alfalfa management decreased ability of alfalfa plants to remain in the stand. Other invasive grass species, primarily bluegrass, were similar ($P > .10$) between treatments in 1997, but were lower ($P = .06$) in fescue/alfalfa pastures in 1998 compared to fescue pastures. Volunteer clover (white and red) was higher ($P = .03$) in high rotation fescue/alfalfa pastures in 1997 and higher ($P = .006$) in all fescue/alfalfa (low and high rotation) pastures in 1998. This may indicate that alfalfa fertilization strategy (potash and boron, but not nitrogen) encouraged growth of clover and suppressed grass growth and that rotational grazing influenced botanical composition. Weeds were not a major component of pastures in either year but appeared to be increasing slightly. Weed dry matter production was similar ($P > .10$) between treatments in both years. Total legume component of available forage dry matter was higher ($P = .001$) in fescue/alfalfa pastures than fescue pastures, as expected. High rotation fescue/alfalfa pastures contained higher proportions of available legume dry matter than low rotation fescue/alfalfa pastures in 1997 and tended to be higher ($P = .11$) in 1998. Total available other grass dry matter was higher ($P = .001$) in fescue vs fescue/alfalfa pastures in both years. Initially, the other grass proportion in high rotation fescue/alfalfa was lower ($P = .03$), but it was similar ($P > .10$) to low rotation fescue/alfalfa in 1998. The percentage of tall fescue plants infected with endophyte was lower ($P = .05$) in fes-

**Table 2.** Forage species composition in May for 1997 and **1998** grazing seasons.

| | Treatments[a] | | | | | Contrasts[b], P Values | | |
|---|---|---|---|---|---|---|---|---|
| **Item, % of Dry matter** | **HR F** | **LR F** | **HR FA** | **LR FA** | **SEM[c]** | **F vs FA** | **HRF vs LRF** | **HRFA vs LRFA** |
| Fescue | 76.5 | 88.0 | 60.7 | 73.1 | 5.1 | .02 | .15 | .12 |
| | **75.9** | **83.0** | **73.6** | **75.2** | **5.7** | **.40** | **.40** | **.85** |
| Alfalfa | 0 | 0 | 14.8 | 10.3 | 2.7 | | | .27 |
| | **0** | **0** | **9.4** | **5.0** | **1.4** | | | **.05** |
| Other grasses | 22.0 | 11.0 | 14.6 | 14.3 | 5.0 | .69 | .16 | .97 |
| | **21.2** | **14.9** | **8.5** | **10.5** | **3.9** | **.06** | **.29** | **.72** |
| Clovers | .9 | .2 | 8.3 | 1.4 | 1.6 | .03 | .76 | .02 |
| | **1.2** | **1.1** | **6.0** | **5.3** | **1.2** | **.006** | **.94** | **.68** |
| Weeds | .5 | .9 | 1.7 | .9 | .6 | .38 | .67 | .37 |
| | **1.7** | **1** | **2.5** | **4.0** | **1.4** | **.20** | **.74** | **.46** |
| Legumes | .9 | .2 | 23.1 | 11.7 | 3.0 | .001 | .87 | .03 |
| | **1.2** | **1.1** | **15.4** | **10.3** | **2.0** | **.001** | **.96** | **.11** |
| Grasses | 98.5 | 99.0 | 75.2 | 87.4 | 3.2 | .001 | .92 | .03 |
| | **97.1** | **97.9** | **82.1** | **85.7** | **2.6** | **.001** | **.83** | **.36** |
| Endophyte infection, % | 51 | 57 | 81 | 65 | 8 | .05 | .62 | .20 |
| | **54** | **64** | **88** | **60** | **14** | **.30** | **.62** | **.17** |
| Alfalfa plants/m$^2$, April | 0 | 0 | 15.9 | 16.6 | 2.1 | | | .83 |
| | **0** | **0** | **16.9** | **17.1** | **2.0** | | | **.95** |
| Alfalfa plants/m$^2$, Oct | 0 | 0 | 19.4 | 19.9 | 2.0 | | | .40 |
| | **0** | **0** | **14.7** | **9.6** | **.88** | | | **.004** |

[a]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

[b]Orthogonal contrasts of treatments.

[c]Standard error of mean, n=3/treatment.

**Table 3.** Forage quality and availability[a] for the 1997 and **1998** grazing seasons.

| | Treatments[b] | | | | | Contrasts[c], P Values | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **HR F** | **LR F** | **HR FA** | **LR FA** | **SEM[d]** | **F vs FA** | **HRF vs LRF** | **HRFA vs LRFA** |
| Dry matter, % | 34.0 | 35.8 | 31.5 | 33.2 | .9 | .03 | .23 | .24 |
| | **34.5** | **35.6** | **29.8** | **34.1** | **1.5** | **.07** | **.60** | **.08** |
| Forage available, lb dry matter/ac | 1582 | 1551 | 1736 | 1228 | 164 | .62 | .90 | .06 |
| | **1834** | **1710** | **1571** | **1,553** | **122** | **.12** | **.49** | **.92** |
| Neutral detergent fiber, % | 62.8 | 64 | 59.3 | 61.9 | .9 | .01 | .34 | .06 |
| | **62.0** | **63.1** | **59.1** | **61.0** | **.7** | **.007** | **.31** | **.10** |
| Available NDF[e], lb/ac | 996 | 1007 | 1055 | 774 | 104 | .43 | .94 | .09 |
| | **1152** | **1087** | **931** | **959** | **80** | **.06** | **.58** | **.81** |
| Crude protein, % | 13.5 | 12.4 | 13.9 | 12.4 | .7 | .75 | .30 | .15 |
| | **14.3** | **14.2** | **15.0** | **12.8** | **.6** | **.55** | **.96** | **.03** |
| Available crude protein, lb/ac | 212 | 193 | 236 | 149 | 25 | .70 | .61 | .04 |
| | **256** | **234** | **229** | **191** | **14** | **.04** | **.30** | **.09** |

[a]Forage availability and quality day of clip sampling.

[b]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

[c]Orthogonal contrasts of treatments.

[d]Standard error of mean, n=3/treatment.

[e]Neutral detergent fiber.

**Table 4.** Weather data for 1997 and **1998** grazing seasons[a].

| Item | Maximum Air Temp, °F | Mininum Air Temp, °F | Rain Total, inches | Relative Humidity, maximum % | Relative Humidity, minimum % | 4" Soil Temp, maximum, °F | Solar Radiation, Langleys | Wind Speed, mph |
|---|---|---|---|---|---|---|---|---|
| April/May | 62 | 41 | 3.0 | 95 | 48 | 57 | 422 | 5 |
| | **65** | **47** | **6.0** | **98** | **63** | **58** | **326** | **6** |
| May/June | 69 | 54 | 7.5 | 97 | 69 | 67 | 346 | 5 |
| | **80** | **61** | **4.8** | **99** | **60** | **71** | **468** | **4** |
| June/July | 84 | 64 | 2.5 | 99 | 61 | 80 | 497 | 4 |
| | **82** | **65** | **6.5** | **100** | **69** | **78** | **456** | **6** |
| July/August | 86 | 66 | 2.6 | 97 | 54 | 83 | 467 | 3 |
| | **84** | **67** | **7.2** | **99** | **67** | **78** | **453** | **3** |
| August/September | 81 | 61 | 3.1 | 100 | 57 | 78 | 402 | 4 |
| | **86** | **63** | **.9** | **100** | **48** | **76** | **443** | **3** |
| September/October | 78 | 55 | .8 | 99 | 50 | 71 | 363 | 4 |
| | **81** | **61** | **3.9** | **96** | **54** | **72** | **315** | **4** |
| Grazing season | 76 | 57 | 19.6 | 98 | 56 | 72 | 418 | 4 |
| | **80** | **61** | **29.4** | **99** | **60** | **73** | **413** | **4** |

[a]University of Kentucky Weather Station, Woodford County.

cue pastures than fescue/alfalfa pastures in 1997. The 1998 infection levels were similar (P > .10) between treatments.

Yearly averages of forage quality and availability estimates are included in Table 3. The numerical percentage ranking of dry matter content was low rotation fescue > high rotation fescue > low rotation fescue/alfalfa > high rotation fescue/alfalfa for both 1997 and 1998. The percentage of dry matter content was higher in 1997 (P = .03) and 1998 (P = .07) for samples taken from fescue vs fescue/alfalfa pastures. The forage availability (lb dry matter/acre available on day of sampling) was similar (P > .10) between fescue vs fescue/alfalfa and high rotation fescue vs low rotation fescue treatments in 1997. However, forage availability in high rotation fescue/alfalfa pastures was higher (P = .06) than that for low rotation fescue/alfalfa pastures. Forage availability tended to be higher (P = .12) for fescue pastures vs fescue/alfalfa in 1998, while high rotation vs low rotation fescue and high rotation vs low rotation fescue/alfalfa were similar (P > .10). These forage availability differences may reflect annual growing conditions (Table 4) or a nitrogen fertilization response. The goal of this experiment in pasture management with extra stocker steers was to equalize forage availability. Neutral detergent fiber, crude protein, and forage availability estimates were similar (P > .10) between high rotation fescue and low rotation fescue in each year of the trial. Fescue pastures with alfalfa consistently (P < .01) had lower neutral detergent content than pastures with fescue only. Whether higher neutral detergent fiber content of fescue pastures reduced dry matter intake is unknown at this time. Surprisingly, crude protein content was similar (P > .10) between fescue vs fescue/alfalfa pastures each year. This indicates that well-managed tall fescue pastures can maintain excellent crude protein content. Crude protein content and forage availability differences (P < .10) between high rotation fescue/alfalfa and low rotation fescue/alfalfa may reflect reduced influence of legumes in low rotation fescue/alfalfa pastures. Higher (P < .10) availability of neutral detergent fiber and crude protein in 1998 for fescue vs fescue/alfalfa reflects higher forage availability in fescue pastures.

Weather differences between years affected growing forages and grazing animals (Table 4). During the 1998 growing season, average air temperatures were 4° F higher, rainfall was 10 inches greater, and minimum relative humidity was 4% higher than in 1997. Soil temperature and solar radiation were more similar between years. Rainfall and temperature patterns may have benefited tall fescue in 1998. High air temperatures may have adversely affected cattle performance, especially when grazing endophyte-infected tall fescue.

Cow/calf initial and final weights and average daily gains were similar (P > .10) among fescue vs fescue/alfalfa, and high rotation fescue vs low rotation fescue treatments for each grazing year (Tables 5 and 6). Calves grazing low rotation fescue/alfalfa pastures weighed 39 lb more (numerically) in 1997 and 37 lb more (P = .06) in 1998 than those in high rotation fescue/alfalfa pastures. Calves tended (P < .15) to gain more when grazing low rotation vs high rotation fescue/alfalfa in both years. These weight advantages may reflect increased diet quality (legume proportion) accomplished through selective grazing by calves in low-rotation pastures. Cow weight loss was numerically greater and calf gains were numerically lower in 1998 than 1997, resulting in lower final weights.

Each year, cows were rectally palpated for pregnancy diagnosis in September. The percentage of cows pregnant and number of days pregnant on day of palpation were similar (P >.10) between treatments each year. However, pregnancy percentage and days pregnant were numerically less in 1998 compared to 1997. Even though maximum possible days pregnant at palpation was 12 days less in 1998, the numerical differences of days pregnant remained between years. Although there was no difference (P > .10) between fescue vs fescue/alfalfa treatments in pregnancy percentage or days pregnant, numerical reductions

**Table 5.** Cows grazing endophyte-infected tall fescue—1997 and **1998**[a]

| | Treatments[b] | | | | | Contrasts[c], P Values | | |
|---|---|---|---|---|---|---|---|---|
| Item | HR F | LR F | HR FA | LR FA | SEM[d] | F vs FA | HRF vs LRF | HRFA vs LRFA |
| Initial wt, lb | 1361 | 1371 | 1360 | 1359 | 17 | .70 | .68 | .96 |
| | **1310** | **1366** | **1363** | **1367** | **19** | **.20** | **.08** | **.88** |
| Final wt, lb | 1329 | 1338 | 1348 | 1330 | 18 | .79 | .75 | .51 |
| | **1234** | **1268** | **1285** | **1295** | **23** | **.13** | **.32** | **.76** |
| Gain, lb/day | -.18 | -.19 | -.07 | -.17 | .10 | .51 | .95 | .51 |
| | **-.42** | **-.54** | **-.44** | **-.40** | **.11** | **.58** | **.47** | **.84** |
| Pregnancy, % | 92 | 92 | 92 | 96 | 4 | .63 | 1.00 | .50 |
| | **82** | **92** | **79** | **67** | **10** | **.22** | **.54** | **.42** |
| Days pregnant[e] | 87 | 87 | 82 | 81 | 5 | .32 | .96 | .93 |
| | **67** | **68** | **59** | **50** | **9** | **.16** | **.96** | **.46** |
| Prolactin 5/97, ng/mL | 78 | 76 | 172 | 113 | 23 | .02 | .96 | .11 |
| Prolactin 9/97, ng/mL | 10 | 34 | 23 | 27 | 7 | .73 | .03 | .69 |
| Prolactin,% reduction | 88 | 56 | 86 | 71 | 7 | .39 | .01 | .17 |

[a]24 cows per treatment in 1997 and **1998.**

[b]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

[c]Orthogonal contrasts of treatments.

[d]Standard error of mean, n=3/treatment.

[e]Days pregnant at time of palpation, 9/11/97 and **9/11/98;** maximum days pregnant 104 and **92**, 1997 and **1998**.

**Table 6.** Calves grazing endophyte-infected tall fescue with their dams—1997 and **1998**[a]

| | Treatments[b] | | | | | Contrasts[c], P Values | | |
|---|---|---|---|---|---|---|---|---|
| Item | HR F | LR F | HR FA | LR FA | SEM[d] | F vs FA | HRF vs LRF | HRFA vs LRFA |
| Initial wt, lb | 154 | 159 | 151 | 154 | 8 | .64 | .61 | .76 |
| | **144** | **148** | **137** | **146** | **5** | **.43** | **.57** | **.24** |
| Final wt, lb | 521 | 515 | 504 | 543 | 22 | .81 | .84 | .24 |
| | **459** | **464** | **448** | **485** | **12** | **.71** | **.79** | **.06** |
| Gain, lb/day | 2.09 | 2.02 | 2.00 | 2.20 | .09 | .58 | .59 | .15 |
| | **1.75** | **1.75** | **1.72** | **1.88** | **.06** | **.46** | **.99** | **.12** |

[a]21 and **24** calves per treatment, 1997 and **1998**.

[b]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

[c]Orthogonal contrasts of treatments.

[d]Standard error of mean, n=3/treatment.

in cows exposed to fescue/alfalfa treatment could be related to higher levels of soluble dietary protein, which is thought to negatively affect pregnancy when in excess. Because several factors surrounding breeding season were different between years (artificial insemination, synchronization, 12-day breeding delay, air temperature, etc.), identification of reasons for reduced pregnancy efficiency are elusive. Reduced pregnancy efficiency in the research herd should not be surprising, since cattle are purposely exposed to high levels of endophyte infection.

Reduced serum prolactin levels have been traditionally used as indicators of fescue toxicosis. Initial blood samples for measuring prolactin were taken from cows in May 1997, one month after being placed on treatment. Cows grazing fescue pastures had 54% lower ($P = .02$) circulating prolactin concentrations than those grazing fescue/alfalfa. Although no blood samples were taken prior to being placed on treatment in April, one could assume that initial prolactin levels were similar because cows were randomly placed in grazing treatments. Because May prolactin levels were different among treatments, reduction in prolactin from May to September was evaluated. Surprisingly, grazing of fescue vs fescue/alfalfa did not affect ($P > .10$) prolactin levels by September. This may have occurred because fescue/alfalfa pastures had high endophyte-infection rates and less alfalfa than desired to dilute effects of endophyte-infected fescue. Cows in high vs low rotation fescue treatments had a larger ($P = .01$) reduction in prolactin, and cows grazing high rotation fescue/alfalfa had numerically larger reductions of prolactin than those in low rotation fescue/alfalfa pastures. This may be due to less opportunity for diet selection in the high rotation system.

In 1997, initial weights of grazing steers in fescue/alfalfa pastures were lower than those in fescue treatments; therefore, initial weight was used as a covariate in analyses of final weight and average daily gain (Table 7). Steers grazing fescue/alfalfa gained more (P = .02) in 1997, tended (P = .11) to gain more in 1998, and tended (P = .11) to have higher final weights than steers on fescue pastures each year. During 1997, steers grazing high rotation fescue/alfalfa pastures gained more (P = .07) and had higher (P = .003) final weights than steers grazed on low rotation fescue/alfalfa pastures. This may be related to the greater proportion of legumes in high rotation fescue/alfalfa pastures. Steer initial and final weights and weight gains were similar (P > .10) between high vs low rotation fescue and high vs low rotation fescue/alfalfa in 1998.

Similar to cows in 1997, steers that had grazed fescue pastures until blood was collected in early May had lower (P = .08) serum prolactin concentrations than those grazing fescue/alfalfa pastures. However, when steers were removed from the experiment in late June, all prolactin levels were similar (P > .10). Interestingly, steers grazing fescue/alfalfa had a greater (P = .03) serum prolactin reduction during the experiment than those grazing only fescue. This may be due to higher endophyte infection rates of fescue plants in fescue/alfalfa pastures than in pure fescue pastures. Also, this greater prolactin reduction could have occurred due to higher dry matter intake (lower neutral detergent fiber, higher succulence of forage, more alfalfa) that would introduce higher levels of ergot alkaloids to circulation of steers that grazed fescue/alfalfa pastures.

Efficiency of forage use and forage availability for two grazing seasons is summarized in Table 8. As discussed earlier, forage availability was similar (P > .10) within fescue vs fescue/alfalfa and high vs low rotation fescue treatments for both years. However, fescue pastures tended (P = .12) to have more forage dry matter available in 1998. High rotation fescue/alfalfa pastures' forage dry matter availability was greater (P < .06) than that of low rotation fescue/alfalfa pastures in 1997. The decision to assign extra animal units as grazing steers to pastures was based on visual observation of forage height and density, pasture production history, and clip sample collections. Stocking rates (animal units/acre) were similar (P > .10) among high vs low rotation fescue and high vs low rotation fescue/alfalfa treatments in 1997. However, more (P < .03) animal units were assigned to fescue pastures than fescue/alfalfa. In 1998, animal units/acre were similar (P > .10) among fescue vs fescue/alfalfa and high vs low rotation fescue but lower (P < .01) for low vs high rotation fescue/alfalfa pastures. The goal of adjusting animal units/acre was to equalize forage availability per acre (available forage dry matter/animal unit). Fescue/alfalfa pastures supported more (P < .10) cattle gain/acre in 1997 than fescue pastures, while gain/acre was similar (P > .10) among high vs low rotation fescue and high vs low rotation fescue/alfalfa. In 1998, gain/acre was similar (P > .10) among all treatments. Because forage availability/animal unit and gain/acre were quite similar, it was no surprise that gain per available forage dry matter was similar (P > .10) among all treatments in both years. Interestingly, cattle grazing low rotation fescue/alfalfa in 1997 tended (P = .12) to gain more per available forage dry matter while forage dry matter available per animal unit was lower (P < .05) compared to high rotation fescue/alfalfa pastures. This may reflect that forage dry matter availability was not limiting intake in low rotation fescue/alfalfa pastures and that animals were able to select forages with sufficient nutrient content to perform adequately (selective grazing usually means that quality of ingesta is greater than quality of available clipped herbage). When efficiency is expressed as gain per animal unit, all treatments in both years were similar (P > .10) except in 1997 for fescue vs fescue/alfalfa. Since animal units/acre were slightly less and gain/acre was more for fescue/alfalfa vs fescue, the gain/animal unit was higher (P = .03) for animals grazing fescue/alfalfa compared to those on fescue pastures.

**Table 7.** Steers grazing endophyte-infected tall fescue —1997 and **1998**[a].

| | Treatments[b] | | | | | Contrasts[c], P Values | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **HR F** | **LR F** | **HR FA** | **LR FA** | **SEM[d]** | **F vs FA** | **HRF vs LRF** | **HRFA vs LRFA** |
| Initial wt, lb | 737 | 741 | 725 | 715 | 8 | .05 | .72 | .40 |
| | **714** | **715** | **714** | **714** | **1** | **.74** | **.46** | **.78** |
| Final wt, lb | 846 | 842 | 875 | 836 | 7 | .11 | .74 | .003 |
| | **790** | **784** | **797** | **811** | **9** | **.11** | **.67** | **.33** |
| Steer gain, lb/day | 1.80 | 1.67 | 2.47 | 1.96 | .17 | .02 | .60 | .07 |
| | **.73** | **.66** | **.79** | **.93** | **.09** | **.11** | **.63** | **.34** |
| Prolactin 5/97, ng/mL | 79 | 42 | 98 | 127 | 26 | .08 | .34 | .46 |
| Prolactin 7/97, ng/mL | 56 | 47 | 40 | 54 | 9 | .68 | .53 | .33 |
| Prolactin, % reduction | 19 | -12 | 56 | 46 | 19 | .03 | .28 | .72 |

[a]18 and **24** steers/treatment, 1997 and **1998**.

[b]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.

[c]Orthogonal contrasts of treatments.

[d]Standard error of mean, n = 3/treatment.

**Table 8.** Forage availability[a] and efficiency of use for 1997 and **1998** grazing seasons[b].

| | Treatments[c] | | | | | Contrasts[d], P Values | | |
|---|---|---|---|---|---|---|---|---|
| Item | HR F | LR F | HR FA | LR FA | SEM[e] | F vs FA | HRF vs LRF | HRFA vs LRFA |
| Available forage, lb dry matter/ac | 1582 | 1551 | 1736 | 1228 | 164 | .62 | .9 | .06 |
| | **1834** | **1710** | **1571** | **1553** | **122** | **.12** | **.49** | **.92** |
| Animal units[f]/ac | 1.16 | 1.14 | 1.11 | 1.08 | .02 | .03 | .46 | .46 |
| | **1.37** | **1.41** | **1.47** | **1.21** | **.05** | **.36** | **.65** | **.01** |
| Forage available/animal unit, lb dry matter | 1358 | 1351 | 1568 | 1134 | 131 | .98 | .97 | .05 |
| | **1342** | **1232** | **1071** | **1283** | **122** | **.39** | **.54** | **.25** |
| Gain/ac, lb | 239 | 216 | 256 | 243 | 12 | .10 | .22 | .45 |
| | **238** | **219** | **244** | **214** | **21** | **.99** | **.54** | **.34** |
| Gain/available forage, lb gain/lb dry matter | .152 | .151 | .150 | .199 | .020 | .28 | .99 | .12 |
| | **.130** | **.129** | **.156** | **.143** | **.018** | **.29** | **.97** | **.60** |
| Gain/animal unit, lb | 205 | 190 | 232 | 224 | 11 | .03 | .38 | .67 |
| | **175** | **156** | **167** | **177** | **17** | **.72** | **.46** | **.68** |

[a]Forage availability expressed as lb dry matter/ac at day of sampling.
[b]All cow/calf pairs, steers and extra steers.
[c]HR—high rotation, LR—low rotation, F—fescue, FA—fescue/alfalfa.
[d]Orthogonal contrasts of treatments.
[e]Standard error of mean, n=3/treatment.
[f]Animal unit = 1,000 lb.

# Nutrient Ecosystem in Grazing Management Systems

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## Summary

A simulated study was conducted evaluating rotational grazing forage management effects upon pasture nitrogen and phosphorus. Forage management evaluated consisted of 1) overgrazing, 2) undergrazing, and 3) vegetative cover of 4- or 8-inch heights. Cattle presence was imposed by the application of either manure or manure + urine for three rotations of seven days grazing and 21 days of rest. Variables measured were soil, tall fescue, and runoff water content of nitrogen and phosphorus; tall fescue neutral detergent fiber content; and forage dry matter availability.

The application of waste as either manure or manure + urine did not affect any of the variables measured. Except for anticipated differences in forage dry matter availability, 4- vs 8-inch forage height did not affect variables measured. Soil in waste-treated plots contained more nitrogen and phosphorus than in non-treated plots. Soil organic matter was reduced by overgrazing. Waste application increased content of nitrogen and phosphorus in tall fescue and tended to reduce neutral detergent fiber content. Nitrogen and phosphorus in runoff from all pasture plots were very low and were lowest when optimal vegetative tall fescue growth occurred. Management of grazing to optimize vegetative tall fescue growth improves the nitrogen/phosphorus ecosystem and may improve the quality of available tall fescue. This research does not consider the behavior of cattle, which affects distribution of manure and urine on a pasture, especially near surface water.


## Introduction

Forages and beef cattle are vital to the future of Kentucky's agriculture. However, recent state and federal regulations concerning management of beef cattle grazing near streams, sinkholes, and drainageways may eliminate production in some locations. Perception is that grazing cattle near streams is a primary non-point source polluter of surface and ground water. Many Kentucky streams are considered impaired by high levels of nitrogen and phosphorus. These nutrients impact water quality because in high concentrations they may cause microbial enrichment conditions leading to eutrophication of surface waters. This results in reduction of oxygen levels in surface water by elevated biological oxygen demand.

Amounts of nutrients in runoff from animal waste may be small in comparison to total available for transport. Ohio research found that nitrogen and minerals in storm runoff were low in grazing situations and varied little from non-grazing land runoff. This emphasizes need for study of effects of grazing animals in proximity to surface water. Scant research has been directed toward tracking nutrient flow through the pasture ecosystem to thoroughly understand grazing effects on water quality. The objective of this research was to estimate nutrient balance in rotationally grazed pastures under three management ecosystems.

## Procedures

This research was conducted on 30 10 x 20-foot runoff plots at the rain simulation research facility at Maine Chance Farm. Each plot was defined by a 4-inch metal plot border to direct rain simulation runoff into a subgrade gutter, which emptied into a 12-inch PVC sump where the runoff was collected.

Steel pipe frame simulators were used to create rain events. A simulator (10 x 20 x 10 ft) was designed to accommodate an individual plot with a series of nozzles configured overhead. Rain intensity simulated 4-inches/hour, which was equivalent to a 10-year, 24 h rain. Each plot was covered with dense tall fescue sod and graded to a 3% slope. Soils within each plot were classified as Maury silt loam, Topic Paleudalf type.

Twenty-four plots were used to simulate rotational grazing, which consisted of eight treatments replicated three times, and six plots served as controls. Original treatments consisted of either a) manure or b) manure + urine (Table 1) randomly applied to simulated rotationally grazed pastures which were 1) overgrazed, 2) undergrazed, 3) 4-inch forage height, or 4) 8-inch forage height (Table 2). Forage heights of 4 and 8 inches are thought to be representative of grazing heights that have adequate photosynthetic surface to ensure active vegetative growth. Beef manure and urine were applied at respective rates of 50 and 30 lb/day/animal unit (AU = 1,000-lb body weight). Stocking density when rotationally grazed was 4.8 AU/acre; therefore, manure and urine application rates were 240 and 145 lb/day/acre. The waste treatment contributed 62 lb of nitrogen/acre (19 lb—manure, 43 lb—urine) which was available for plant uptake during the three-rotation, 86-day experiment. Furthermore, waste contributed 12 lb of phosphorus/acre, essentially all coming from manure. Rotational grazing was simulated by setting grazing residence time at seven days and resting the paddock for 21 days. Each experimental plot (.005 acre) received 1.2 lb of manure/plot/day during the grazing period, and none was applied during the rest period. Three 28-day grazing rotations were used during the study.

**Table 1.** Manure and urine nutrient content.

| **Waste, as applied** | **Nitrogen** | **Phosphorus** |
|---|---|---|
| | **Concentration** | |
| Manure, % | .38 | .24 |
| Urine, % | 1.42 | .005 |
| Manure, ppm | 3800 | 2400 |
| Urine, ppm | 14200 | 50 |
| | **Rate Applied, lb/ac** | |
| 145 lb urine/day | 2.06 | .01 |
| 240 lb manure/day | .91 | .58 |
| Total waste/day | 2.97 | .58 |
| 1,015 lb urine/7 days | 14.41 | .05 |
| 1,680 lb manure/7 days | 6.38 | 4.03 |
| Total waste/7 days | 20.80 | 4.08 |
| 3,045 lb urine/3 rotations | 43.24 | .15 |
| 5,040 lb manure/3 rotations | 19.15 | 12.22 |
| Total waste/3 rotations | 62.39 | 12.38 |

**Table 2.** Arrangement of treatments[ab] at rain simulation facility.

| **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
|---|---|---|---|---|---|---|---|---|
| | | | | **Grassed Walkways[c]** | | | | |
| X | Overgraze | 8-inch (Vegetative) | Control | | Undergraze | Undergraze | 8-inch (Vegetative) | X |
| | Manure/urine (Waste) | Manure (Waste) | | ↓ | Manure/urine (Waste) | Manure/ urine (Waste) | Manure/urine (Waste) | |
| X | 4-inch (Vegetative) | 4-inch (Vegetative) | Undergraze | ↓ | 8-inch (Vegetative) | Undergraze | Overgraze | X |
| | Manure/urine (Waste) | Manure (Waste) | Manure (Waste) | | Manure/urine (Waste) | Manure (Waste) | Manure (Waste) | |
| X | Control | Control | 4-inch (Vegetative) | | 8-inch (Vegetative) | 4-inch (Vegetative) | Control | X |
| | | | Manure (Waste) | ↓ | Manure (Waste) | Manure/urine (Waste) | | |
| X | Undergraze | Undergraze | Overgraze | ↓ | Overgraze | 8-inch (Vegetative) | Overgraze | X |
| | Manure/urine (Waste) | Manure (Waste) | Manure/urine (Waste) | | Manure (Waste) | Manure (Waste) | Manure/urine (Waste) | |
| X | Overgraze | 8-inch (Vegetative) | 4-inch (Vegetative) | ↓ | Control | Control | 4-inch (Vegetative) | X |
| | Manure (Waste) | Manure/ urine (Waste) | Manure (Waste) | | | | Manure/urine (Waste) | |

[a]Grazing management: overgrazed, undergrazed, 8-inch growth, and 4-inch growth = vegetative, X = border plots not used.

[b]Waste application: control, manure, and manure/urine = waste.

[c]Slope, 3% downward direction towards south indicated by ↓.

The 4-inch and 8-inch plots were mown to height with a 21-inch lawnmower following the 21-day rest period. Clippings were collected and removed from plots in an effort to simulate removal of forage. Overgrazed plots were mown 1 inch high, and undergrazed plots were not mown following the first application of manure.

Soil samples were collected for analysis prior to manure application, midstudy, and at end of study (Table 4). Plant quality clip samples were taken prior to first manure application and five times during the 21-day rest period for a total of 28 samples per plot. Plant clip samples were taken from a 4-inch$^2$ area, composited, and analyzed for neutral detergent fiber, nitrogen, and phosphorus.

Rain simulation followed each of three rotation cycles of seven-day manure application periods and 21-day rest periods (Table 3). Therefore, runoff water was collected for six rain simulations (RS1 through RS6). Rainfall duration was timed from start of simulated rain until runoff was discernible. At discernable runoff, one-liter samples were collected at 2-, 4-, 8-, 12-, 18-, 24-, and 30-minute intervals. Flow rate at each interval was used to compute dilution factors used to make a 1-liter composite sample. Incremental volume of runoff from each plot was computed to determine concentration of nutrients measured in composited samples. Incremental volume is average flow rate for any period of time during runoff. Statistical analysis was conducted for a model utilizing repeated measurements.

**Table 3.** Rain simulation schedule.

| Rain Simulation (RS) | Preceding Grazing Activity | Date of Rain |
|---|---|---|
| 1 | 7-day waste application | 07/07/97 |
| 2 | 21-day rest period | 07/29/97 |
| 3 | 7-day waste application | 08/06/97 |
| 4 | 21-day rest period | 08/26/97 |
| 5 | 7-day waste application | 09/11/97 |
| 6 | 21-day rest period | 10/01/97 |

**Table 4.** Soil nutrient content.

| | | Rain Simulation[a,b] | | |
|---|---|---|---|---|
| Variable | Treatment | Beginning RS1 | Middle RS4 | End RS6 |
| Total nitrogen, ppm | Control | 1,964 ± 7 | 2,081 ± 17 | 2,269$^{e}$ ± 17 |
| | Waste | 1,920 ± 5 | 2,043 ± 15 | 2,462$^{f}$ ± 49 |
| Ortho-phosphorus, ppm | Control | 38.4 ± .4 | 38.4 ± .4 | 38.4$^{e}$ ± .4 |
| | Waste | 38.4$^{x}$ ± .4 | 38.4$^{x}$ ± .4 | 48.6$^{fy}$ ± .4 |
| Organic matter, % | Control | 3.00 ± .15 | 3.10 ± .15 | 3.50$^{e}$ ± .15 |
| | Waste | 3.00 ± .01 | 3.10 ± .01 | 3.84$^{f}$ ± .09 |
| Organic matter, % | Vegetative | 2.95 ± .14 | 3.06 ± .14 | 3.80$^{e}$ ± .14 |
| | Overgrazed | 3.02$^{x}$ ± .11 | 2.99$^{x}$ ± .11 | 3.33$^{fy}$ ± .11 |
| | Undergrazed | 3.05 ± .11 | 3.12 ± .11 | 3.73$^{e}$ ± .11 |

[a]LS means ± standard error.

[b]Paired row values with different superscripts (x, y) differ (P < .05); column values with different superscripts (e, f) differ (P <.05).

## Results and Discussion

Main effects upon measured variables were not different (P > .05) for either waste treatments of manure vs manure/urine or for management of forage-grazing height at 4 inches vs 8 inches (data not shown). Therefore, data were combined where "manure" and "manure/urine" treatments are hereafter referred to as "waste" treatment when compared to "control." Forage heights of "4 inches" and "8 inches" are referred to as "vegetative" when compared to "overgrazing" and "undergrazing."

Soil nutrient concentrations of total nitrogen, ortho-phosphorus, and organic matter reflect sampling at the beginning (RS1), middle (RS4), and end (RS6) of the experiment (Table 4). Total nitrogen, organic matter, and ortho-phosphorous in waste-treated soil is greater (P < .05) than that of control plots at the end of the experiment, indicating an increase during growing season due to breakdown/mineralization of plant and waste. Soil organic matter increased (P < .05) during the experiment due to vegetative and undergrazed vs overgrazed pasture management treatments.

Nitrogen and phosphorus in tall fescue are increased (P < .05) by waste application (Table 5). Nitrogen content in tall fescue exhibited an early seasonal reduction for the control (non-waste) treatment; however, the waste-treated tall fescue nitrogen content remained relatively constant. Phosphorus content in tall fescue increased (P < .05) during the experiment for both control and waste treatments. Concentration of phosphorus in waste-treated tall fescue was greater (P < .05) than that of control treatment. Organic matter from animal waste releases nutrients at a slow rate determined by soil microorganism growth conditions. In general, 60% of available nutrients will be released from beef manure during the first year of application, with reduced amounts available in years two and three. High levels of nitrogen and significant and stable levels of phosphorus in tall fescue samples may confirm presence of mineralized soluble phosphorus being made available to fescue plant (Table 5).

A slight reduction (P < .05) of neutral detergent fiber due to waste treatment was first observed at midexperiment (RS3) and remained lower during the remainder of the experiment (Table 6). Neutral detergent fiber content was mainly unaffected by waste treatment or grazing management in this experiment.

Nitrogen and phosphorus concentrations in runoff from pastures were very low whether treatment was waste or control (Table 7). Environmental Protection Agency limits for stream contamination are at 10 ppm and 1 ppm for nitrogen and phosphorus. Nitrate nitrogen concentrations were low in runoff water; the first two rain periods were higher (P < .05) than the last four periods. The average difference between waste and control for the experiment was .007 ppm.

**Table 5.** Nutrient content of tall fescue.

| | | Rain Simulation[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **Treatment** | **RS1** | **RS2** | **RS3** | **RS4** | **RS5** | **RS6** | **SE[b]** |
| Nitrogen, ppm | Control | $38,400^{ex}$ | $15,400^{ey}$ | $13,000^{ey}$ | $13,000^{ey}$ | $13,000^{ey}$ | $13,000^{ey}$ | 2,300 |
| | Waste | $36,500^{f}$ | $31,500^{f}$ | $30,900^{f}$ | $30,000^{f}$ | $30,000^{f}$ | $30,000^{f}$ | 1,600 |
| Phosphorus, ppm | Control | $3,500^{x}$ | $1,900^{ey}$ | $1,900^{ey}$ | $1,970^{ey}$ | $2,020^{ey}$ | $2,080^{ey}$ | 296 |
| | Waste | 3740 | $3,400^{f}$ | $3,740^{f}$ | $3,900^{f}$ | $3,820^{f}$ | $4,050^{f}$ | 205 |

[a]LS means, paired row values with different superscripts (x, y) differ (P < .05); column values with different superscripts (e, f) differ (P < .05).

[b]Standard error.

**Table 6.** Neutral detergent fiber content (%) of tall fescue.

| | Rain Simulation[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatment** | **RS1** | **RS2** | **RS3** | **RS4** | **RS5** | **RS6** | **SE[b]** |
| Control | $68^{x}$ | $71^{x}$ | $68^{ex}$ | $61^{y}$ | $66^{x}$ | $64^{y}$ | 1 |
| Waste | $68^{x}$ | $70^{x}$ | $65^{f\ y}$ | $61^{y}$ | $64^{y}$ | $62^{y}$ | |
| Vegetative | $69^{x}$ | $72^{x}$ | $67^{x}$ | $60^{y}$ | $64^{y}$ | $61^{ey}$ | 1 |
| Overgrazed | $68^{x}$ | $69^{x}$ | $64^{x}$ | $59^{y}$ | $66^{x}$ | $62^{ey}$ | |
| Undergrazed | $68^{x}$ | $69^{x}$ | $67^{x}$ | $59^{y}$ | $64^{y}$ | $65^{fy}$ | |

[a]LS means, paired row values with different superscripts (x, y) differ (P < .05); column values with different superscripts (e, f) differ (P < .05).

[b]Standard error.

**Table 7.** Nutrient content of runoff water.

| | | Rain Simulation[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable, ppm** | **Treatment** | **RS1** | **RS2** | **RS3** | **RS4** | **RS5** | **RS6** | **SE[b]** |
| Nitrate nitrogen | Control | $.0048^{x}$ | $.0042^{x}$ | $.0013^{y}$ | $.0006^{y}$ | $.0006^{y}$ | $.0007^{y}$ | .0017 |
| | Waste | .0049 | .0042 | .0031 | .0030 | .0025 | .0016 | .0012 |
| Ammonia nitrogen | Control | $.0036^{e}$ | .0034 | .0012 | .0020 | .0012 | .0014 | .0020 |
| | Waste | $.0066^{f}$ | .0032 | .0029 | .0038 | .0031 | .0012 | .0014 |
| Total nitrogen | Control | .0094 | $.0063^{e}$ | $.0004^{e}$ | $.0001^{e}$ | $-.0004^{e}$ | $-.0002^{e}$ | .0129 |
| | Waste | .0089 | $.0098^{f}$ | $.0089^{f}$ | $.0059^{f}$ | $.0079^{f}$ | $.0045^{f}$ | .0091 |
| Ortho-phosphorus | Control | $.0028^{e}$ | .0026 | .0003 | .0001 | .0003 | .0003 | .0042 |
| | Waste | $.0084^{fx}$ | $.0041^{y}$ | $.0035^{y}$ | $.0027^{y}$ | $.0026^{y}$ | $.0022^{y}$ | .0041 |
| Total phosphorus | Control | $.0022^{e}$ | .0022 | .0005 | .0002 | .0001 | .0001 | .0060 |
| | Waste | $.0113^{fx}$ | $.0047^{y}$ | $.0041^{y}$ | $.0032^{y}$ | $.0039^{y}$ | $.0026^{y}$ | .0042 |

[a]LS means, paired row values with different superscripts (x, y) differ (P < .05); column values with different superscripts (e, f) differ (P < .05).

[b]Standard error.

Concentrations of ammonia nitrogen, ortho-phosphorus, and total phosphorus in runoff were higher (P < .05) for waste treatment vs control at the beginning and decreased over time. At the same time, nitrogen and phosphorus were made available because of soil mineralization and accumulated in the plant as nutrients rather than runoff pollutants. Similarly, ortho-phosphorus and total phosphorus in control runoff water was numerically lower for the remainder of the experiment, but not different (P > .05) from waste treatment plots. Average concentration in waste plot runoff was .017 and .024 ppm higher for ortho-phosphorus and total phosphorus than control plots.

Nutrient recycling in a pasture system is possible only if organic matter mineralization takes place. This process occurs with help of heterotrophic microorganisms, adequate soil moisture, 2% oxygen, and soil temperatures of 41° F or greater. In addition, a carbon-to-nitrogen ratio of less than 20:1 is needed for a net accumulation of free nitrate nitrogen. Nitrate nitrogen can be immobilized by ratios for carbon to nitrogen higher than 30:1 and by soil organic matter and/or soil microorganisms. Growing conditions (soil temperature, moisture, and aeration) were nearly ideal for microbial mineralization of nitrogen compounds (RS1 and 2 in July/August, RS5 and 6 in September/October, Table 3). In this study, we can assume that waste and carbon content of waste plots are at a ratio of 20:1 or less. Tall fescue and runoff water total nitrogen content remained almost constant for the remainder of the experiment.

Rain simulation periods 1, 3, and 5 (after waste application) indicated higher levels of total phosphorus, and mineralization of ortho-phosphorus was higher for these periods by at least .002 ppm over RS2, 4, and 6 (followed 21-day rest periods). Organic and mineral components of waste treatment enhanced mineralization and subsequent availability of phosphorus. Net accumulation of soil ortho-phosphorus (3.39 ppm) and fescue total phosphorus (1,547 ppm) in waste treatment over control verifies that this pasture system recycled phosphorus effectively. Furthermore, nutrient recycling through grazed plants results in fewer losses of nutrients in pasture runoff water.

The various grazing/forage management treatments were successful in maintaining differences in available forage dry matter (Table 8). The ranking of undergraze > 8-inch > 4- inch > overgraze was consistent ($P < .05$) throughout the experiment. Waste-treated plots show a numerical advantage in available forage dry matter compared to the control (non-waste treated) from RS2 through RS6, but these differences were not statistically different ($P > .05$) because of high variability in estimates. The estimates of available forage dry matter in Table 8 do not reflect yield of forage during the experiment, but standing forage at the time of sampling.

**Table 8.** Tall fescue dry matter availability, lb/ac.

| | Rain Simulation[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatment** | **RS1** | **RS2** | **RS3** | **RS4** | **RS5** | **RS6** | **SE[b]** |
| Control | 1648 | 1009 | 1148 | 2806 | 3307 | 3048 | 1585 |
| Waste | 1680 | 1482 | 2680 | 4162 | 5550 | 4328 | |
| Overgrazed | $788^{ex}$ | $894^{ex}$ | $650^{ex}$ | $2660^{ey}$ | $2246^{ey}$ | $3190^{efy}$ | 263 |
| 4-inch | $1410^{efx}$ | $849^{ex}$ | $1326^{ex}$ | $3320^{efy}$ | $3134^{fy}$ | $2792^{ey}$ | |
| 8-inch | $2034^{fgx}$ | $1733^{fx}$ | $2874^{fy}$ | $3994^{fz}$ | $6151^{gz}$ | $3842^{fz}$ | |
| Undergrazed | $2572^{gx}$ | $2071^{fx}$ | $4710^{gy}$ | $5663^{gz}$ | $8854^{hz}$ | $5468^{gz}$ | |

[a]LS means, paired row values with different superscripts (x, y, z) differ ($P < .05$); column values with different superscripts (e, f, g, h) differ ($P < .05$).

[b]Standard error.

# Effects of Shade on Body Temperatures and Production of Grazing Beef Cows

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## Summary

The effects of shade upon beef cow body temperature and productivity were evaluated. Portable, pipe-constructed frames were draped with shade cloth in pastures with cow/calf pairs and stocker steers. Cows were equipped with data loggers, which simultaneously accumulated ambient temperature and body temperature. Body temperature was measured by ear probes at the tympanic membrane. Cattle were weighed at 28-day intervals.

The body temperature data, although not statistically significant, indicates that body temperatures of cows may be lowered slightly (.5° to 1.4° F) through the use of shade. Cows, calves, and growing steers tended to gain more weight per day with access to shade compared to those without access to shade. Numerical advantages in daily weight gains for cattle given shade over those not offered shade were 1.25 lb for cows, .41 lb for calves, and .89 lb for steers.

## Introduction

Cattle attempt to maintain a constant body temperature of about 101.3° F. This is accomplished by balancing internal heat production and external heat gain with external heat loss. When ambient air temperatures exceed some critical level, which varies from animal to animal, the total heat gained by the animal exceeds its heat loss capabilities, causing core body temperature to increase. Extended periods of extreme heat or cold or abrupt changes from one to the other without acclimatization can negatively affect cattle productivity, health, and well-being. A complete understanding of the interaction between an animal and its environment requires understanding the interaction between a number of dynamic, ambient conditions. Dry bulb air temperature is a principal thermal measure but alone cannot represent the thermal environment experienced by cattle. Factors such as humidity, solar radiation, and wind velocity interact with ambient air temperature to affect the animals' ability to maintain stable body temperatures.

Fescue toxicosis presents a significant challenge for cattle production in the southeastern and midwestern regions of the United States. Tall fescue is a cool-season grass that is grown on 26-31 million acres in the United States. A large proportion of this fescue is infected with the endophytic fungus *Neotyphodium coenophialum*. The ergot alkaloids produced by tall fescue and *N. coenophialum* are potent vasoconstrictors that hinder the animals' ability to dissipate heat. These ergots cause several problems for cattle; the most common condition is known as fescue toxicosis, or summer syndrome. The effects of fescue toxicosis may be generalized by reduced performance, impaired health status, and reduced comfort of the animal. These effects are similar to those caused by heat stress; however, the ergot alkaloids increase the severity of heat stress for the animal.

Modification of the animals' environment may be required to maintain acceptable cattle production during heat stress periods. Methods to alter the animals' microenvironment include shade cooling, misting, evaporative cooling, and air conditioning. Shading, by adding shade structures, is the most economical means of reducing heat stress in grazing animals. Shade structures decrease the radiant heat load on an animal by removing the portion of the total heat load associated with solar radiation. This research investigates the use of shade for relieving the problems associated with heat stress in beef cows. Tympanic (tympanic membrane within the ear) temperatures and production characteristics are measured to estimate the need for shade and eventually determine the proper placement of shade structures within the pastures. The results of this study may prove useful to beef producers throughout this region of the United States.

## Procedures

The University of Kentucky's Animal Research Center (Woodford County) is evaluating grazing management and legume interseeding in endophyte-infected tall fescue pastures. There are 12 15-acre pastures included in the study. All pastures were originally seeded with tall fescue (KY 31), which is infected with the endophytic fungus, *Neotyphodium coenophialum*. Six of these pastures are grazed in a two-paddock rotation and referred to as "low rotation," and six are grazed in a six-to-12 paddock rotation known as "high rotation." Six of these pastures have been interseeded with Alfa-Graze™ alfalfa. Each pasture has a centrally located, one-ball automatic insulated waterer. There are no trees or other permanent shade producing structures in any of the 12 pastures. Pasture terrain is classified as gently rolling and consists of predominantly Maury, Dunning, and Nolin soils. The existing project has four treatments, which include the following management practices: low rotation fescue, high rotation fescue, low rotation fescue/alfalfa, and high rotation fescue/alfalfa. Each treatment has three pasture replications. Two of the three pastures in each treatment have been assigned to either a shade or a no-shade treatment. The two test pastures were chosen based on the previous year's forage production/availability, endophyte infection levels, and slope. The two pastures which were most similar within treatment in the above characteristics were assigned to this project, and the shade or no-shade treatments were randomly assigned.

There were 96 Angus or Angus-crossbred cow/calf pairs grazing the 12 pastures. Eight cow/calf pairs were randomly assigned to each of the 12 pastures. Three of the eight cows, in both the shade and no-shade pastures of each treatment, were randomly chosen for temperature instrumentation.

Tympanic temperatures were measured by inserting the probe approximately 6 inches into the ear canal. Measurements were made at two-minute intervals using custom data loggers (Stowaway XTI108C+36+46) with a 24-inch external thermistor (TMC2-1T, Onset Computer Corporation). Onset Computer Corporation makes a variety of one-channel loggers with different memory sizes and temperature ranges. The best accuracy achieved with standard commercial Stowaway models is ± .7° F. The diurnal variation in body temperature of cattle varies from .9° to 2.2° F in thermoneutral conditions. For this reason, improved accuracy is needed and can be achieved by narrowing the temperature range of the data logger. The custom data logger has a temperature range of +96.8° to +114.8° F and an accuracy of ± .2° F.

The cow/calf pairs were initially placed in the pastures on April 9, 1998. The first data collection period took place during the week of May 7–May 14, 1998. This data set was taken in an attempt to obtain body temperature records in "thermoneutral" conditions. A second data collection occurred the week of July 1–8, 1998. Although somewhat cooler than normal, this period should provide data that is representative of an average summer in Kentucky. The third and final collection period took place from August 18–24, 1998, in an attempt to catch a small heat wave that came through central Kentucky.

The artificial shade structures used for this experiment are made of 80% shade cloth. The structures are 12 x 24 ft, providing a total shade area of 288 $ft^2$. The shade cloth is 10 ft in height. Placement of the shade changes in all pastures as often as the high-rotation pastures' shades are moved. Shade placement is ultimately determined by the grazing patterns of the cattle.

Temperature data from this trial were analyzed on the basis of average body temperature, maximum body temperature, and the diurnal range of body temperature using the SAS computer program.

## Results and Discussion

The maximum ambient temperature of approximately 84.2° F occurred on May 13 (Figure 1). Despite this relatively low maximum ambient air temperature, the average and maximum body temperatures were approaching 104° F and 106° F, respectively. There are two factors that likely caused these unusually high body temperatures. This was the first heat wave that came through the area. Prior to May 13, the maximum ambient air temperature was well below 77° F. Over the course of 48 hours, the maximum ambient temperature rose nearly 15° F, giving the animals no time for acclimatization. A second explanation may be that the animals' forage dry matter intake is relatively high at this time of year when forage quality and ergot alkaloid content is high. Consuming high amounts of endophyte-infected tall fescue increases the amount of ingested ergot toxins. Because the toxins are concentration-dependent, the animals'susceptibility to heat stress increases. Although overt fescue toxicosis symptoms are generally associated with higher ambient temperatures of midsummer, unusual early-to-midspring warm fronts can cause dangerous hyperthermic conditions to develop.

From Table 1 and Figures 3 through 11, it can be seen that body temperatures of animals with access to shade were most often lower than body temperatures of animals without access to shade. These differences, however, did not prove to be significant ($P > .05$). There were no differences in measured performance traits due to the grazing management or pasture composition (P > .05).

Weight gains for cows, calves, and steers during the month prior to shade installation were similar among all pastures (P > .05). After a month of shade vs no-shade treatment, animals with access to shades had higher (cows P < .001, calves P < .05, and steers P < .005) weight gains for the period (Table 2).

Data for the third month of the trial is currently being analyzed. A detailed analysis of the weight gain data should be similar to that of the temperature data, with the only difference being that the measured data will be weight gains rather than body temperatures.

**Table 1.** Tympanic temperatures of beef cows grazing endophyte-infected tall fescue.

| Rotation | Forage | Shade | Average | Maximum | Range |
|---|---|---|---|---|---|
| | | | ° F, ± standard deviation [a] | | |
| Low | Fescue | Yes | 101.5 ± .5 | 104.4 ± .4 | 2.3 ± .5 |
| Low | Fescue | No | 101.5 ± .1 | 105.1 ± .3 | 2.9 ± .7 |
| High | Fescue | Yes | 101.1 ± 0 | 104.9 ± .6 | 3.1 ± 1.1 |
| High | Fescue | No | 101.7 ± .9 | 106.2 ± .9 | 3.2 ± 0 |
| Low | Fescue/alfalfa | Yes | 101.3 ± 0 | 104.0 ± 0 | 2.2 ± 0 |
| Low | Fescue/alfalfa | No | 101.7 ± 0 | 105.1 ± 0 | 2.7 ± 0 |
| High | Fescue/alfalfa | Yes | 101.7 ± 0 | 105.3 ± 0 | 2.5 ± 0 |
| High | Fescue/alfalfa | No | 102.7 ± .9 | 106.3 ± 1.1 | 2.7 ± .4 |
| Total | Fescue and fescue/alfalfa | Yes | 101.5 ± .4 | 104.7 ± .4 | 2.5 ± .8 |
| Total | Fescue and fescue/alfalfa | No | 101.8 ± 1.0 | 105.6 ± .8 | 2.9 ± .7 |

[a]Standard deviation listed as ± 0 indicates one observation per treatment.

**Table 2.** Weight gain/loss/head/day for beef cows, calves, and stocker steers grazing endophyte-infected tall fescue, month before and **month after** shades installed[a].

| Rotation | Forage | Shade | Cows | Calves | Steers |
|---|---|---|---|---|---|
| | | | lb, ± standard deviation | | |
| Low | Fescue | Yes | 2.20 ± 1.41 | 2.25 ± 1.43 | 3.70 ± 2.20 |
| | | | **-.24** ± 4.3 | **2.03** ± 1.37 | **1.41** ± .51 |
| Low | Fescue | No | 1.83 ± 2.51 | 2.36 ± 1.57 | 2.93 ± 3.46 |
| | | | **-.42** ± 1.79 | **1.46** ± 1.34 | **.60** ± 1.41 |
| High | Fescue | Yes | 3.00 ± 1.85 | 2.20 ± .97 | 5.31 ± 1.98 |
| | | | **-.07** ± .79 | **1.79** ± .77 | **.68** ± 1.83 |
| High | Fescue | No | 2.49 ± .66 | 2.51 ± .77 | 2.91 ± 2.45 |
| | | | **-.60** ± 3.86 | **1.41** ± 1.32 | **1.48** ± 1.21 |
| Low | Fescue/alfalfa | Yes | 1.17 ± 2.47 | 2.23 ± 1.10 | 2.12 ± 5.27 |
| | | | **1.74** ± 1.63 | **1.92** ± 1.06 | **3.20** ± 1.28 |
| Low | Fescue/alfalfa | No | 2.87 ± 2.56 | 2.25 ± .77 | 3.77 ± 4.85 |
| | | | **-.79** ± 3.15 | **1.57** ± 2.43 | **1.21** ± 2.27 |
| High | Fescue/alfalfa | Yes | 2.23 ± 1.52 | 2.20 ± 1.41 | 2.76 ± 8.11 |
| | | | **-1.04** ± 1.12 | **1.74** ± .46 | **1.37** ± 1.54 |
| High | Fescue/alfalfa | No | 2.34 ± 1.48 | 2.54 ± 1.26 | 4.78 ± 1.72 |
| | | | **-2.25** ± 2.18 | **1.43** ± 1.04 | **-.13** ± 2.47 |
| Total | Fescue and fescue/alfalfa | Yes | 2.12 ± 3.42 | 2.23 ± 1.43 | 3.48 ± 8.84 |
| | | | **.24** ± 4.78 | **1.87** ± 1.21 | **1.68** ± 2.82 |
| Total | Fescue and fescue/alfalfa | No | 2.38 ± 3.06 | 2.40 ± 1.61 | 3.59 ± 4.67 |
| | | | **-1.01** ± 3.44 | **1.46** ± 2.31 | **.79** ± 3.40 |

[a]4/9 to 5/7 and **5/7 to 6/2-3.**

**Figure 1.** Ambient temperature and relative humidity over the last week of the trial.

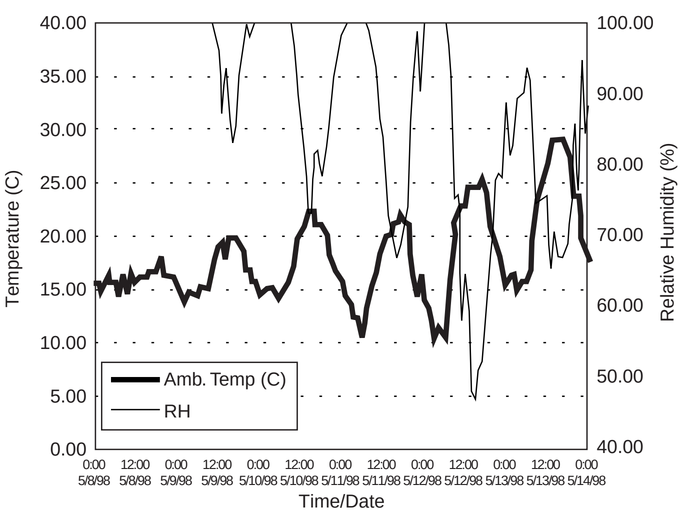


**Figure 2.** Deep body temperature for cow # C137.

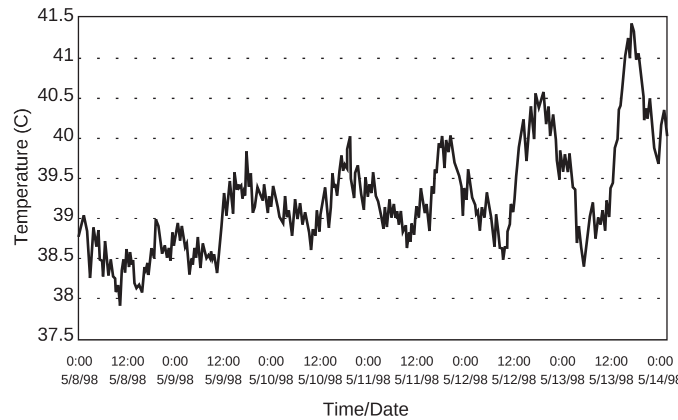


**Figure 3.** Average and maximum body temperature for cows on low rotation fescue/alfalfa pastures.

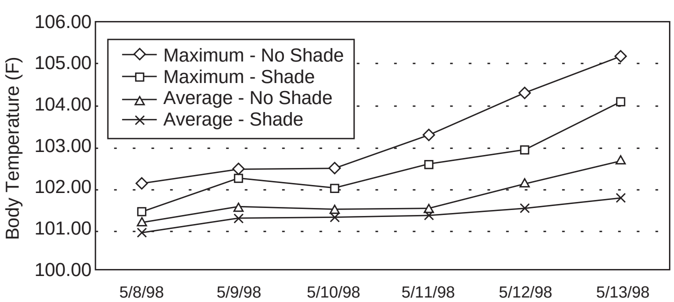


**Figure 4.** Average and maximum body temperature for cows on low rotation fescue pastures.

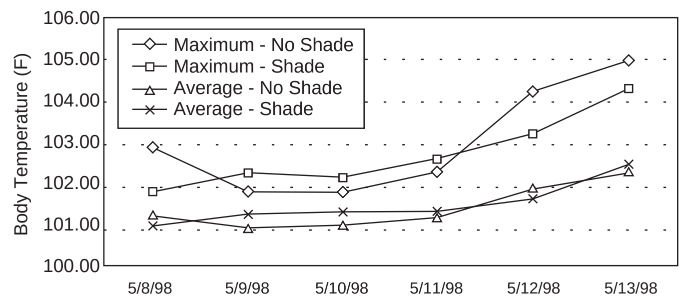


**Figure 5.** Average and maximum body temperature for cows on high rotation fescue/alfalfa pastures.

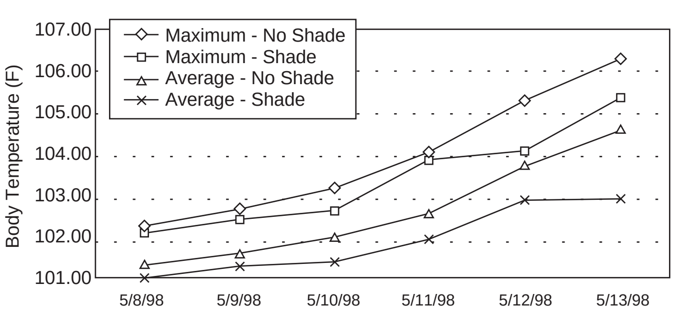


**Figure 6.** Average and maximum body temperature for cows on high rotation fescue pastures.

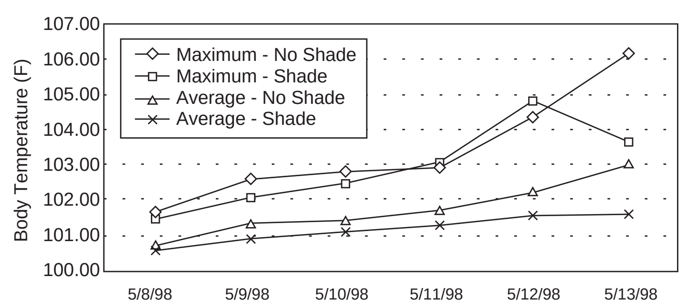

**Figure 7.** Diurnal range of body temperature for cows on low rotation fescue/alfalfa pastures.

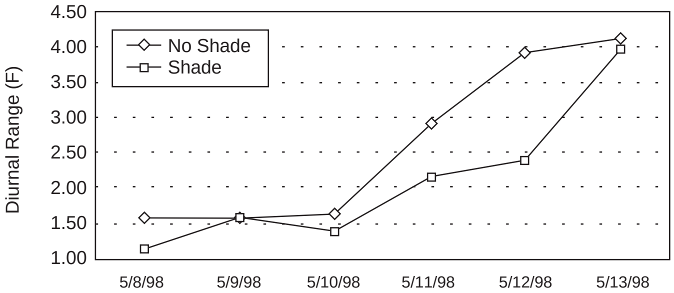


**Figure 8.** Diurnal range of body temperature for cows on low rotation fescue pastures.

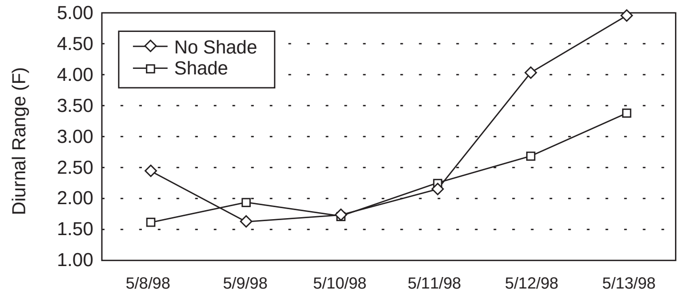


**Figure 9.** Diurnal range of body temperature for cows on high rotation fescue/alfalfa pastures.

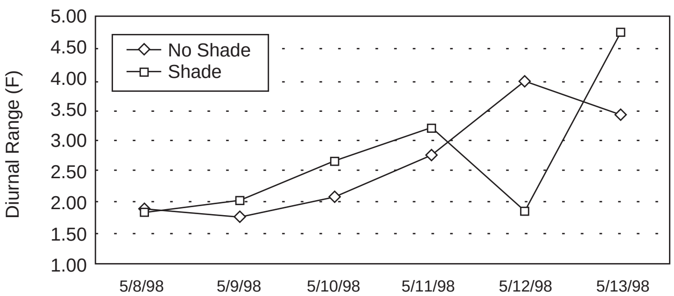


**Figure 10.** Diurnal range of body temperature for cows on high rotation fescue pastures.

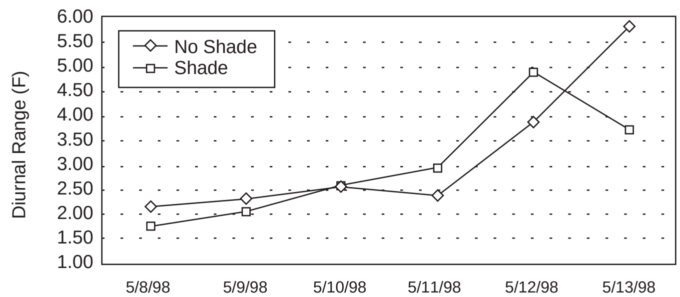


**Figure 11.** Summary of deep body temperature data across all pasture treatments.