ABSTRACT: A 2-yr grazing experiment was conducted with crossbred steers (8 to 10 mo and with initial BW of 304 kg ± 34 kg in 2008 and 277 kg ± 24 in 2009) to evaluate animal performance and pasture responses of a late maturing tall fescue \textit{(Lolium arundinaceum (Schreb.) Darbysh; KYFA9301)} population infected with the AR584 novel, non-toxic endophyte \textit{(Neotyphodium coenophialum; NE9301)} as compared with Kentucky 31 fescue infected with the common toxic endophyte strain (KY31), Jesup MaxQ fescue infected with the AR542 endophyte (MaxQ), and endophyte-free KYFA9301 (EF9301). Treatments were assigned for seeding in 1.0-ha pastures in a randomized complete block design with 3 replications. Pastures were grazed from 6 May to 23 July in 2008 (76 d) and 2 April to 25 June in 2009 (84 d). Each pasture was grazed with 4 tester steers and put-and-take steers were used to maintain forage mass at 2,500 ± 250 kg DM/ha. Shrunken BW was taken at initiation and termination of grazing each year. Rectal and skin temperatures were recorded, and jugular blood was collected each year at approximately d 28, 56, and study completion. Forage samples were collected at 2-wk intervals for analyzing CP, IVDMD, ADF, and NDF. Responses were analyzed with mixed models, and preplanned orthogonal contrasts were used to compare KY31 with non-toxic fescues, EF9301 vs. novel endophyte fescues, and NE9301 vs. MaxQ. All steer responses were similar \textit{(P > 0.10)} among the non-toxic fescues. Average daily gains and total BW gain/ha for the 3 non-toxic fescues were greater \textit{(P < 0.001)} than for KY31. Rectal/skin temperatures for the 3 non-toxic fescues were less \textit{(P < 0.001)} and serum prolactin concentrations were greater \textit{(P < 0.01)} than for KY-31. Pasture carrying capacity was greater \textit{(P = 0.003)} for KY31 than the 3 non-toxic fescues and was greater for EF9301 \textit{(P = 0.017)} than the 2 novel endophyte fescues. However, stocking rates (kg BW/ha) at the initial and midpoint days of grazing were similar \textit{(P > 0.40)} among endophyte-fescue combinations, but by the end of the grazing season, stocking rate was greater \textit{(P < 0.001)} for KY31 than for the non-toxic fescues and was greater \textit{(P = 0.053)} for NE9301 than for MaxQ. Results indicated that NE9301 is as effective as EF9301 and MaxQ in improving BW gain and alleviating fescue toxicosis and that NE9301 can provide greater carrying capacities than MaxQ in late June and July.

Key words: beef cattle, ergot alkaloids, fescue toxicosis, novel endophytes, tall fescue
rough hair coats, depressed prolactin concentrations, increased core body temperatures, and reduced DM intakes and BW gains (Schmidt and Osborn, 1993).

Endophytes were identified by AgResearch Ltd. (Ruakura Research Center, Hamilton, NZ) that do not produce ergot alkaloids, thereby alleviating toxicosis while maintaining plant tolerances to grazing, heat, and drought stresses (Latch et al., 2000; Bouton et al., 2002). A tall fescue cultivar, ‘Jesup’, adapted to the lower transition zone was infected with a novel endophyte, AR542, and commercially released as Jesup-MaxQ (MaxQ). Parish et al. (2003) reported ADG for steers grazing Jesup-MaxQ was greater than those grazing Jesup infected with the wild-type endophyte and was comparable with those grazing endophyte-free Jesup. Rectal temperatures and serum prolactin concentrations were similar between steers grazing MaxQ and endophyte-free Jesup, further indicating that toxicosis was alleviated.

A late maturing, tall fescue genotype, KYFA9301, adapted to the USA upper transition zone, was bred to improve seedling vigor and productivity (T.D. Phillips, Personal communication). A 2-yr grazing experiment was conducted to evaluate steer performance and forage quality and productivity of KYFA9301 infected with AR584 novel endophyte (NE9301) in comparison with Kentucky 31 infected with the toxic common endophyte (KY31), MaxQ, and endophyte-free KYFA9301 (EF9301).

MATERIALS AND METHODS

The experimental protocol was reviewed and approved by the University of Kentucky Institutional Animal Care and Use Committee (2008-0289).

The grazing experiment was conducted at the University of Kentucky Animal Research Center (UK-ARC) in Woodford County. Crossbred (predominately Angus) steers, 8 to 10 mo, were used in the experiment. The grazing experiment was conducted from 6 May to 23 July in 2008 and 2 April to 25 June in 2009. Rainfall data were collected from a National Weather Service Station, located approximately 13.5 km from the experimental site.

Experimental Site Preparation and Design

In September of 2005, a 12-ha pasture of wild-type endophyte infected tall fescue was treated twice in 2 wk with glyphosate (Roundup, Monsanto, St. Louis, MO). The area was no-till planted with winter wheat (Triticum aestivum L.). Wheat was closely grazed in early spring of 2006 and was subsequently no-till sown with corn (Zea mays L.) in May of 2006. After harvest of silage in September and a third application of glyphosate, 4 tall fescue-endophyte treatments were assigned for no-till planting into 1.0-ha areas in a randomized complete block design with 3 replications. Treatments were 1) Kentucky 31 tall fescue infected with the toxic common endophyte (KY31), 2) KYFA9301 fescue infected with AR584 novel endophyte (NE9301), 3) Jesup tall fescue infected with AR542 novel, non-toxic endophyte (MaxQ), and 4) endophyte-free KYFA9301 (EF9301). The tall fescue-endophyte combinations were planted in late September 2006 at a seeding rate of 28 kg/ha. Soils at the site were either Maury (fine, mixed, semiactive, mesic Typic Paleudalfs) or McAfee (fine, mixed, active, mesic Mollic Hapludalfs) silt loams.

After planting of the endophyte-fescue combinations, pastures were fertilized with aqueous N (56 kg N/ha) approximately 3 wk after seedling emergence. Hay was harvested in late June 2007, and cows grazed the area to an 8- to 12-cm stubble in early fall to promote tillering. Before grazing in 2008, the 1.0-ha pastures were fenced and water facilities were installed.

Pasture Management and Responses

Pastures were continuously grazed using put-and-take stocking (Mott and Lucas, 1952) to maintain forage mass at approximately 2,500 ± 250 kg/ha to optimize the availability of greater quality plant components. Put-and-take steers were added or removed on 5 June, 1 July, and 8 July in 2008 and on 5 May, 26 May, and 8 June in 2009.

Pastures were fertilized with aqueous N (67 kg N/ha) on 18 March 2008 and on 16 March 2009 with polycoated urea (Agrium Inc; Calgary, Alberta; 67 kg N/ha). Herbicides were applied after establishment and again the next spring for weed control. On 6 April 2007, 5.68 L/ha of 2,4-D amine were applied to each pasture. Aminopyralid (Milestone, Dow AgroSciences, Indianapolis, IN) was applied each spring at 355 g/ha on 10 April 2008 and 283 g/ha on 4 April 2009.

Forage mass (kg DM/ha) was estimated using a disk meter similar to one described by Bransby et al. (1977). Disk meter heights (DMH) were measured every 5 steps over 2 complete passes across each pasture and collected at approximately 4-wk intervals. Number of DMH measurements per pasture ranged from 125 to 150. Herbage was also clipped to the soil surface beneath the disk at 3 random locations in each pasture for disk meter calibration each year. Samples were dried in a forced-air oven at 60°C for 48 h and weighed. Calibration equations were calculated by regressing sample dry weight over DMH to estimate forage mass (kg DM/ha) from mean DMH for each pasture [2008: forage mass = 874 + 304 DMH (cm), r² = 0.75; 2009: forage mass = 647 + 458 DMH (cm), r² = 0.63]. Forage was clipped to a 5.0-cm height within 0.25-m² quadrats from 3 randomly chosen sites within each
pasture at approximately 2-wk intervals. Samples were
dried at 60°C for 48 h and combined for each pasture
and sample date for grinding in a Wiley mill to pass a
1-mm sieve and stored for analysis. Samples were ana-
lyzed for NDF and ADF using the ANKOM200 Fiber
Analyzer (ANKOM Technology Corp., Macedon, NY).
True IVDMD were determined using a Daisy II incubator
(ANKOM Technology Corp.). Rumen fluid was collected
from a ruminally fistulated Holstein steer maintained on
an orchardgrass (Dactylis glomerata L.) and tall fescue
mixed hay. Nitrogen content was determined using a
Leco FP-528 Nitrogen Analyzer (Leco Corp., St. Joseph,
MO) and then multiplied by 6.25 for adjustment to CP.

Single tall fescue tillers were randomly chosen and
collected from 25 plants within each pasture on 2 dates
in 2009 (9 June and 7 July) for estimating endophyte
infection using an immunoblot procedure (Gwinn et al.,
1991). To verify that the endophyte-free and novel endo-
phyte pastures were void of ergot alkaloids, tiller samples
were clipped at the tiller base for 25 plants in each pasture
on 10 June 2008 and 8 June 2009. Samples were placed
on ice and subsequently frozen (−20°C) until analysis.
Tiller samples were freeze-dried, ground through a 1-mm
screen, and assayed for ergovaline and ergovalanine
concentrations by HPLC fluorescence using modified pro-
dcedures described by Yates and Powell (1983). Separation
was conducted with an Altima C18 150 mm × 4.6
mm column with a 3-μm particle size (Grace Davison
Discovery Science, 2051 Waukegan Rd., Deerfield, IL).
Elution solutions were 75 mM ammonium acetate (A) in
water:acetonitrile (3:1, v/v) and acetonitrile (B). The elu-
tion gradient was 95:5 (A:B) for 1 min, linear change to
60:40 (A:B) during next 15 min and maintained for 5 min,
changed to 0:100 (A:B) in 1.5 min and maintained for 5
min, changed to 100:0 (A:B) in 1 min, and maintained
for 6 min before returning to 95:5.

In 2009, there was encroachment of Kentucky blue-
grass (Poa pratensis L.) into each pasture. Botanical com-
position of tall fescue and bluegrass were determined
on 24 June 2009 using a double sampling procedure
(Ortega-Santos et al., 1992). Two observers separately estimated
DM composition of each grass within 25, 0.16-m² rings,
tossed at random for each pasture (n = 50). Botanical
composition also was estimated within 3 rings in each
pasture for each observer and then was clipped to the soil
surface for subsequent separation into the 2 grass com-
ponents. Components were dried at 60°C for 48 h and
weighed for calculating DM composition. A linear regres-
sion equation was calculated for estimating DM percent-
age of tall fescue by regressing actual DM composition
over estimated DM percentage of tall fescue. A test for the
heterogeneity of slopes (Littell et al., 1991) determined
similar y-intercepts (P = 0.332) and slopes (P = 0.607)
between the observers. Observer bias was not detected (P
= 0.45) by a t-test of actual minus predicted values. The
regression equations were used to adjust visual estimates
of each observer used to measure mean DM composition
of the 2 grasses in each pasture.

Steer Management and Responses

Forty-eight steers in each year were assigned to sub-
groups within pastures so that mean BW and variance was
similar across the 12 subgroups (4 tester steers/pasture).
Tester steers in 2008 had initial mean BW of 304 kg ± 34
kg and those in 2009 had initial mean BW of 277 kg ± 24
kg. Steers were weighed after fasting from feed and water
for 12 to 14 h. Cattle were weighed shrunk at 0700 h on
the initial and terminal dates of the experiment. On the
initial weigh date, steers were treated for internal and ex-
ternal parasites with Moxidectin (1 mL/10 kg BW pour-on;
Cydectin, Fort Dodge Animal Health, Fort Dodge, IA) and were ear implanted with Synovex-S (200 mg pro-
gesterone-20 mg estradiol; Fort Dodge Animal Health).
Steers were provided free-choice mineral (Burkmann
Mills, Danville, KY; zinc, 0.35% min.; manganese, 0.2%
min.; iron, 0.2% min.; copper, 0.03% min.; selenium,
0.009% max.; iodine, 0.007% min.; cobalt, 0.005% min.).

Rectal and skin temperatures were recorded on 5
June, 1 July, and 22 July in 2008 and on 5 May, 1 June,
and 24 June in 2009. Steers were removed from pastures
at approximately 1630 h as the daily ambient tempera-
tures were declining from daily maximums. Rectal tem-
peratures were measured using a Cooper TM99A digital
thermometer (Cooper-Atkins Corp.; Middletown, CT),
and skin temperatures were measured using a Raytek
Ranger ST60 infrared thermometer (Raytek Corp.;
Santa Cruz, CA) on a 2-× 2-cm area over the shoulder
that was clipped to the skin surface. Approximately 7
mL of jugular blood was collected from each tester steer.
Blood samples were centrifuged (3,000 × g for 15 min
at −20°C) to collect serum, which was stored at −25°C.
Serum prolactin concentrations were assayed by RIA
procedures of Bernard et al. (1993). The intra- and inter-
assay CV were 5.0 and 15.0%, respectively.

Statistical Analyses

Data were analyzed as a randomized complete block
design with 3 replications, with pasture serving as the
experimental unit for all statistical analyses. Animal and
pasture responses were analyzed using mixed models
capacity [steer d/ha; summation of daily stocking rates
(steers/ha)], stocking rates, on the basis of BW (kg BW/
ha) at initial, middle (average of initial and final shrunk
BW of testers × steers/ha), and final days of grazing, for-
age allowance (kg DM/100 kg BW), steer ADG, and total
Responses for a novel endophyte-tall fescue BW gain/ha were analyzed with year, fescue-endophyte combination, and year × fescue-endophyte combination interaction in the model as fixed effects. Block and block × endophyte-fescue combinations were analyzed as random effects. For rectal/skin temperatures and serum prolactin concentrations, the date within year effect was included in the model as a random effect. Dates that forage samples were collected differed between years but needed to be analyzed as a fixed effect to evaluate maturity effects on the nutritive values; therefore, these data were analyzed for each year separately with endophyte-fescue combination and dates being analyzed as fixed effects and block and block × endophyte-fescue combination being evaluated as a random effect. Mean separations for dates were performed on least square means using the PDIF option. Preplanned orthogonal contrasts were used to compare toxic versus non-toxic fescues, EF9301 versus AR584 and MaxQ, and AR584 versus MaxQ. Data collected over dates (rectal and skin temperatures, serum prolactin concentrations, and forage nutritive values) were analyzed as repeated measures using the first-order autoregressive covariance structure.

RESULTS AND DISCUSSION

Rainfall varied during and between years of the experiment (Figure 1). In 2008, rainfall was above the 39-yr average in April but below the long-term average in May, June, and July. Rainfall in 2009 was above the 39-yr average for each month of grazing. Therefore, 2008 and 2009 represented dry and wet weather conditions, respectively, for the region.

Endophyte infection percentages in 2009 for KY31, NE9301, MaxQ, and EF9301 were 66.8 ± 4.1, 86.3 ± 2.7, 81.2 ± 2.1, and 2.8 ± 0.9%, respectively. Non-toxic, novel endophytes produce alkaloids that improve plant tolerances to environmental stresses and, therefore, increased infection levels with novel endophytes are needed to improve stand persistence (Bouton et al., 2002). Fribourg et al. (1991) concluded that symptoms of fescue toxicosis are elicited in beef cattle with toxic endophyte infection percentages above 22%. Infection percentage for EF9301 was well below this threshold. Although endophyte infections in KY31 pastures were less than expected, symptoms of toxicosis were exhibited by these steers.

Ergovaline is the ergot alkaloid produced in greatest concentration by the toxic endophyte of KY31 (Lyons et al., 1986) and has been shown to be potent in causing vasoconstriction (Klotz et al., 2007). Concentration of ergovaline combined with ergovalanine, the stereoisomer of ergovaline, in KY31 herbage was 0.26 ± 0.09 g/kg DM for the 10 June measurement date in 2008 and 0.54 ± 0.04 g/kg DM for the 8 June measurement date in 2009. These concentrations indicate that KY31 could have been more toxic in 2009 than in 2008; however, these measures represent single points in time in each year and herbage ergot alkaloid concentrations vary within and between grazing seasons (Carter et al., 2010). Ergovaline/ergovalanine concentrations for the 3 non-toxic fescues averaged less than 0.01 g/kg DM in 2008 and 0.03 ± 0.01 g/kg DM in 2009. Threshold concentrations of ergovaline in the diet above which produce clinical symptoms of toxicosis were established at 0.4 to 0.75 g/kg DM by Aldrich-Markham et al. (2007).

As previously discussed, forage mass was controlled by varying stocking rate and, therefore, was not a response variable. It was analyzed, however, to verify that forage masses were similar among endophyte-fescue combinations. Forage masses were similar among endophyte-fescue combinations (P = 0.121) and there was no year × endophyte-fescue combination interaction (P = 0.312); however, it was greater (P = 0.067) in 2009 (2,773 ± 25 kg DM/ha) than in 2008 (2,471 ± 26 kg DM/ha). Forage masses for KY31, NE9301, MaxQ, and EF9301 in 2008 were 2,547 ± 94; 2,439 ± 126; 2,339 ± 151; and 2,557 ± 83 kg DM/ha; respectively, and in 2009 were 2,764 ± 69, 2,749 ± 26, 2,732 ± 45, and 2,762 ± kg DM/ha, respectively. Forage masses for KY31 and EF9301 were slightly greater than the targeted range, but these masses were likely not large enough to affect diet selectivity or quality.

Pasture Responses

Pasture carrying capacities differed among endophyte-fescue combinations, but the responses were similar (P = 0.446) between years (Table 1). Carrying capacity was greatest for KY31, which is a reflection of the adverse effect that fescue toxicosis has on DM in-
Table 1. Forage production measures for ‘Kentucky 31’ tall fescue infected with the toxic common endophyte (KY31), KYFA9301 infected with AR584 endophyte (NE9301), ‘Jesup’ MaxQ tall fescue infected with AR542 endophyte (MaxQ), or endophyte-free KYFA9301 (EF9301) that were grazed by steers during 2 grazing seasons

<table>
<thead>
<tr>
<th>Item</th>
<th>KY31</th>
<th>MaxQ</th>
<th>NE9301</th>
<th>EF9301</th>
<th>SEM</th>
<th>P-value</th>
<th>KY31 vs. non-toxics²</th>
<th>EF9301 vs. Novels³</th>
<th>MaxQ vs NE9301</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage allowance, kg DM/100 kg BW</td>
<td>149</td>
<td>153</td>
<td>152</td>
<td>151</td>
<td>6</td>
<td>0.794</td>
<td>0.372</td>
<td>0.771</td>
<td>0.784</td>
</tr>
<tr>
<td>Carrying capacity, steer d/ha</td>
<td>471</td>
<td>416</td>
<td>434</td>
<td>453</td>
<td>15</td>
<td>0.003</td>
<td>0.003</td>
<td>0.017</td>
<td>0.155</td>
</tr>
<tr>
<td>Stocking rates at points in time kg BW/ha :</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>1600</td>
<td>1625</td>
<td>1658</td>
<td>1736</td>
<td>123</td>
<td>0.426</td>
<td>0.615</td>
<td>0.623</td>
<td>0.857</td>
</tr>
<tr>
<td>Midpoint</td>
<td>1895</td>
<td>1854</td>
<td>1874</td>
<td>1816</td>
<td>123</td>
<td>0.615</td>
<td>0.651</td>
<td>0.623</td>
<td>0.857</td>
</tr>
<tr>
<td>Final</td>
<td>1978</td>
<td>1446</td>
<td>1684</td>
<td>1700</td>
<td>123</td>
<td>0.011</td>
<td>0.001</td>
<td>0.184</td>
<td>0.053</td>
</tr>
</tbody>
</table>

¹ Least square means for endophyte-fescue combinations are across 3 replications and 2 years (n = 6).
² NE9301, MaxQ, and EF9301.
³ NE9301 and MaxQ.

Matthews et al. (2005) reported less DM intake by steers consuming tall fescue hay infected with the toxic endophyte than by those consuming fescue hay that was either non-infected or infected with a non-toxic novel endophyte. Dry matter consumption by steers grazing wild-type Jesup tall fescue was shown by Parish et al. (2003) to be less than those grazing endophyte-free or novel endophyte (AR542) infected Jesup. The negative effect of ergot alkaloids on DM intake is likely exacerbated by toxicosis-induced heat stress that occurs with higher ambient temperature and humidity.

Carrying capacity over the entire grazing season in both years was greater for EF9301 than for the 2 novel endophyte tall fescues (Table 1); however, stocking rates at initial, mid-point, and final days of grazing were not greater for EF9301. Greater stocking rates for KY31 were not detected until the final day of grazing. Greater carrying capacities for KY31 probably are not realized until a threshold ambient temperature is reached, above which the cattle are above their thermoneutral zone and heat stress reduces the time spent grazing (McClanahan et al. 2008) and DM consumption. Greater mean carrying capacity for EF9301 than for the 2 novel endophyte fescues appears to be related to substantial numeric differences between EF9301 and MaxQ at the initial and final days of grazing. Stocking rates between NE9301 and MaxQ did not differ at the initial and mid-point of grazing, but NE9301 had a greater stocking rate by the final day of grazing, indicating that NE9301 provided more forage growth in late spring and early summer to carry more steers than MaxQ during the second half of the grazing seasons.

The light grazing pressures used in the experiment resulted in mean forage allowances above 140 kg DM/100 kg BW that offered animals the opportunity to selectively graze (Table 1). Dry matter intake of cool-season grasses is positively related to herbage allowance (Dougherty et al., 1992). Similar to forage mass, forage allowance was greater (P = 0.015) in 2009 (166 kg DM/100 kg BW) than in 2008 (136 kg DM/100 kg BW) but was similar among fescue-endophyte combinations (P = 0.794) in both years. Sollenberger et al. (2005) concluded that herbage allowance integrates herbage mass and stocking rates in explaining animal performance. Herbage mass was controlled in the present experiment, but stocking rate was a response variable. Differences in stocking rates in the latter half of the experiment apparently were not of a magnitude to increase steer BW/ha enough to cause differences in mean herbage allowances among endophyte-fescue combination.

In 2008, pastures were visually estimated to be less than 10% Kentucky bluegrass, but encroachment of Kentucky bluegrass increased in 2009. Percentage tall fescue in DM in 2009 was greatest in KY31 pastures (67.7 ± 3.3%), and contrasts were similar among EF9301 (57.9 ± 3.3%), NE9301 (53.5 ± 3.3%), and MaxQ (61.8 ± 3.3%) (EF9301 vs. novels, P = 0.959; NE9301 vs. MaxQ, P = 0.124). Although a decreased percentage of bluegrass in KY31 pastures was a confounding factor, steers were observed to selectively graze tall fescue. Kentucky bluegrass began reproductive development during late April, 2 to 3 wk earlier than tall fescue. Bluegrass seedheads readily emerged, matured, and accumulated, whereas culms of tall fescue were grazed, and there was minimal accumulation of seedheads. There apparently was some consumption of bluegrass, but observance of the canopies and observance of grazing behavior indicated that consumption of bluegrass was very low compared with tall fescue. There were no differences among endophyte-fescue combinations (P > 0.10) on CP, ADF, or NDF for either year, but IVDMD in 2008 was greater for KY31 than for the non-toxic fescues (Table 2). Parish et al. (2003) reported that toxic common endophyte-infected Jesup tall fescue had lower IVDMD than endophyte-free Jesup but was similar to that of Jesup MaxQ. In vitro DMD was moderately high (767%) for all endophyte-fescue combinations over sample dates in both years. Crude protein percentages in 2008 were marginal in meeting require-
ments for the range of steer BW used in the experiment, but percentages in 2009 were consistently above CP requirements (NRC, 1996). Decreased rainfall in May and June of 2008 could have resulted in less uptake of N by fescue root systems.

There were no endophyte-fescue combination × sample date interactions (P > 0.10) on any of the nutritive values, but there were differences (P < 0.001) among sample dates for each nutritive value (Table 3). Overall forage quality for each combination declined over sample dates, but lack of interactions between combinations and sample dates indicated the declines in forage quality were consistent among endophyte-fescue combinations.

Table 2. Dry matter percentages of CP, IVDMD, NDF, and ADF in ‘Kentucky 31’ tall fescue infected with the toxic common endophyte (KY31), KYFA9301 infected with AR584 endophyte (NE9301), ‘Jesup’ MaxQ tall fescue infected with AR542 endophyte (MaxQ), or endophyte-free KYFA9301 (EF9301) that were grazed by steers during 2 grazing seasons

<table>
<thead>
<tr>
<th>Item</th>
<th>KY31</th>
<th>MaxQ</th>
<th>NE9301</th>
<th>EF9302</th>
<th>SEM</th>
<th>P value</th>
<th>Contrasts</th>
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</thead>
<tbody>
<tr>
<td>CP, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>KY31 vs. non-toxics</td>
</tr>
<tr>
<td>2008</td>
<td>9.1</td>
<td>8.6</td>
<td>9.1</td>
<td>8.8</td>
<td>0.2</td>
<td>0.212</td>
<td>0.168 0.882 0.113</td>
</tr>
<tr>
<td>2009</td>
<td>15.4</td>
<td>15.2</td>
<td>15.2</td>
<td>15.2</td>
<td>0.4</td>
<td>0.955</td>
<td>0.599 0.994 0.968</td>
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<tr>
<td>IVDMD, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NE9301 vs. novels</td>
</tr>
<tr>
<td>2008</td>
<td>70.4</td>
<td>68.1</td>
<td>69.8</td>
<td>67.3</td>
<td>0.9</td>
<td>0.074</td>
<td>0.0516 0.127 0.141</td>
</tr>
<tr>
<td>2009</td>
<td>74.2</td>
<td>74.2</td>
<td>72.7</td>
<td>74.8</td>
<td>0.8</td>
<td>0.310</td>
<td>0.623 0.176 0.208</td>
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<tr>
<td>NDF, %</td>
<td></td>
<td></td>
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<td></td>
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<td>MaxQ vs. NE9301</td>
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<tr>
<td>2008</td>
<td>59.7</td>
<td>59.7</td>
<td>59.5</td>
<td>60.7</td>
<td>0.5</td>
<td>0.521</td>
<td>0.661 0.182 0.767</td>
</tr>
<tr>
<td>2009</td>
<td>59.1</td>
<td>59.1</td>
<td>59.3</td>
<td>58.8</td>
<td>0.6</td>
<td>0.915</td>
<td>0.951 0.531 0.826</td>
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<tr>
<td>ADF, %</td>
<td></td>
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<tr>
<td>2008</td>
<td>35.2</td>
<td>35.5</td>
<td>35.9</td>
<td>36.6</td>
<td>0.5</td>
<td>0.182</td>
<td>0.134 0.119 0.519</td>
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<tr>
<td>2009</td>
<td>33.7</td>
<td>33.2</td>
<td>33.1</td>
<td>32.7</td>
<td>0.5</td>
<td>0.593</td>
<td>0.305 0.411 0.890</td>
</tr>
</tbody>
</table>

1 Least square means for endophyte-fescue combinations are across 3 replications and 2 years (n = 6).
2 NE9301, MaxQ, and EF9301.
3 NE9301 and MaxQ.

Table 3. Dry matter percentages of CP, IVDMD, NDF, and ADF for sample dates averaged over pastures of ‘Kentucky 31’ tall fescue infected with the toxic common endophyte (KY31), KYFA9301 infected with AR584 endophyte (NE9301), ‘Jesup’ MaxQ tall fescue infected with AR542 endophyte (MaxQ), or endophyte-free KYFA9301 (EF9301) that were grazed by steers during 2 grazing seasons

<table>
<thead>
<tr>
<th>Item</th>
<th>Sample times²</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>1 2 3 4 5 SEM P-value</td>
</tr>
<tr>
<td>2008</td>
<td>10.1ab 8.9bc 8.6bc 8.0c 8.7b 0.2 0.0001</td>
</tr>
<tr>
<td>2009</td>
<td>18.9a 16.6b 14.0c 13.4c 13.1b 0.3 0.0001</td>
</tr>
<tr>
<td>IVDMD, %</td>
<td>77.1a 73.8b 67.4c 62.8b 63.1d 1.0 0.0001</td>
</tr>
<tr>
<td>2009</td>
<td>83.2a 79.3a 73.8a 67.7b 65.7b 0.8 0.0001</td>
</tr>
<tr>
<td>NDF, %</td>
<td>53.8d 57.9c 61.4b 61.7b 64.8a 0.6 0.0001</td>
</tr>
<tr>
<td>2009</td>
<td>50.6d 56.1c 60.8b 63.4b 64.2a 0.5 0.0001</td>
</tr>
<tr>
<td>ADF, %</td>
<td>31.2d 33.7c 36.2b 39.4a 38.3a 0.5 0.0001</td>
</tr>
<tr>
<td>2009</td>
<td>29.1d 32.8a 31.9d 34.5b 37.4a 0.5 0.0001</td>
</tr>
</tbody>
</table>

a-d Within a row, means without a common superscript differ, P < 0.05.
1 Least square means for sample dates are across 3 replications (n = 3).
2 Dates corresponding to sequential sample times in 2008 were 19 May, 6 June, 18 June, 30 June, and 16 July, and in 2009 were 16 Apr., 30 Apr., 21 May, 2 June, and 15 June.
Table 4. Body weight gain and physiologic measures for steers grazing ‘Kentucky 31’ tall fescue infected with the toxic common endophyte (KY31), KYFA9301 infected with AR584 endophyte (NE9301), ‘Jesp’ MaxQ tall fescue infected with AR542 endophyte (MaxQ), or endophyte free KYFA9301 (EF9301)

<table>
<thead>
<tr>
<th>Item</th>
<th>KY31</th>
<th>MaxQ</th>
<th>NE9301</th>
<th>EF9301</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, kg/d</td>
<td>0.63</td>
<td>0.84</td>
<td>0.81</td>
<td>0.81</td>
<td>0.04</td>
<td>0.010</td>
</tr>
<tr>
<td>Total BW gain/ha, kg/ha</td>
<td>351</td>
<td>364</td>
<td>364</td>
<td>351</td>
<td>27</td>
<td>0.035</td>
</tr>
<tr>
<td>Rectal temperature, °C</td>
<td>40.3</td>
<td>39.9</td>
<td>39.8</td>
<td>39.8</td>
<td>0.1</td>
<td>0.002</td>
</tr>
<tr>
<td>Skin temperature, °C</td>
<td>37.2</td>
<td>36.5</td>
<td>36.5</td>
<td>36.4</td>
<td>0.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Serum prolactin, ng/mL</td>
<td>82</td>
<td>230</td>
<td>207</td>
<td>194</td>
<td>12</td>
<td>0.001</td>
</tr>
</tbody>
</table>

1 Least square mean for endophyte-fescue combinations are across 3 replications and 2 years (n = 6).
2 NE9301, MaxQ, and EF9301.
3 NE9301 and MaxQ.

Steer Responses

Average daily BW gains (Table 4) differed among fescue-endophyte combinations (P = 0.01), and responses were similar for each year (P = 0.189), which indicated that intrusion of bluegrass into the pastures in 2009 did not affect steer performance. Steers grazing toxic KY31 pastures had less ADG than those grazing the 3 non-toxic combinations, which reflects the adverse effect of toxicosis on BW gain performance. Average daily BW gain for the novel endophyte fescues was similar to EF9301 and did not differ between NE9301 and MaxQ. Daily gain of steers grazing non-toxic pastures averaged 20% greater than those grazing KY31 pastures.

Total BW gain/ha responses paralleled the ADG responses, with the exception that total BW gain was greater (P = 0.003) in 2009 (383 ± 21.6 kg/ha) than in 2008 (312 ± 21.6 kg/ha). There were differences (P = 0.035) among endophyte-fescue combinations. Contrasts for BW gain/ha were less for KY31 pastures than the 3 non-toxic fescues, but were not different between EF 9301 and the novel endophyte fescues and between NE9301 and MaxQ. The greater carrying capacity of KY31 pastures did not compensate for the reduced ADG of the steers to provide greater BW gain/ha. It appears increasing stocking rate will not compensate for BW gain loss resulting from tall fescue toxicosis.

These results are consistent with other grazing trials comparing non-toxic endophyte and endophyte-free tall fescue with toxic-endophyte tall fescue. Parish et al. (2003) reported stockers grazing non-toxic cultivars had greater ADG (0.84 kg/d) and total BW gain/ha (295 kg/ha) across all sites and dates as compared with those grazing the toxic endophyte infected cultivars (ADG = 0.45 kg/d; BW gain/ha = 157 kg/ha). Total ergot alkaloid concentrations at initiation and termination of grazing were reported to range from 0.8 to 1.2 g/kg DM for toxic endophyte-infected pastures and 0 to 0.04 for the non-toxic endophyte-infected pastures. A 2-yr study by Nihsen et al. (2004) determined that steers grazing EF KY31 and ‘HiMag’ tall fescue infected with the Strain 4 novel endophyte had greater ADG than those grazing toxic endophyte-infected KY31.

Body temperature measurements were recorded in the late afternoon (between 1500 and 1700 h) after maximum ambient temperature occurred. The time of temperature collection in this study likely improved detection of effects as compared with morning measurements. Rectal and skin temperatures were both greater in 2009 (rectal, P = 0.023; skin, P = 0.004; rectal = 40.2 ± 0.2°C; skin = 37.0 ± 0.5°C) than in 2008 (rectal: 39.8 ± 0.2°C; skin = 36.3 ± 0.5°C). Endophyte-fescue combinations differed in rectal (P = 0.011) and skin (P = 0.014) temperatures and the differences were consistent (year × endophyte-fescue combination; rectal, P = 0.252; skin P = 0.466) for each year (Table 4). Steers grazing KY31 had greater rectal (P < 0.001) and skin (P < 0.001) temperatures than those grazing non-toxic fescues, but contrasts did not differ between EF9301 and the novel endophyte fescues and between NE9301 and MaxQ.

Decreased serum and plasma prolactin concentrations have been used as a bio-marker for toxicosis (Strickland et al., 1993; Rice et al., 1997). Hurley et al. (1980) concluded that consumption of toxic endophyte-infected tall fescue will depress serum prolactin regardless of ambient temperature. Serum prolactin concentrations differed (P < 0.001) among endophyte-fescue combinations, and the responses were similar (P = 0.548) in each year (Table 4). Serum prolactin concentrations were least (P < 0.001) in steers grazing KY31, and contrasts were similar between steers grazing EF9301 and the novel endophyte fescues (P = 0.842) and between steers grazing NE9301 and MaxQ (P = 0.34). Serum prolactin concentrations across pastures in 2008 (192 ± 12.8 ng/mL) were greater (P = 0.05) than in 2009 (165 ± 11.5 ng/mL).

Results indicated that steer ADG and total BW gain/ha on NE9301, MaxQ, and EF9301 were superior to those on KY31 fescue pastures. Steers grazing NE9301, MaxQ, and EF9301 did not exhibit decreased serum prolactin concentrations or increased rectal and
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