5-2009

MANAGEMENT STRATEGIES TO IMPROVE DEVELOPMENT OF REPLACEMENT HEIFERS UTILIZING TALL FESCUE-BASED SYSTEMS

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A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Plant and Environmental Sciences

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by
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May 2009

Accepted by:
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ABSTRACT

Research was conducted to determine the effect of tall fescue and alternative management regimens on reproduction in replacement beef heifers. Angus × Simmental heifers (n = 48; 318 ± 4.99 kg initial BW) stratified by weight and pubertal status were assigned to one of three replicated grazing treatments: (1) toxic endophyte-infected tall fescue (TF); (2) toxic endophyte-infected tall fescue with a soybean oil supplement (TFO); or (3) mixed winter annual species (cereal rye, annual ryegrass, crimson clover and hybrid turnip) (M). Tall fescue endophyte infection level was between 74 and 94%. Pastures were grazed from December 12 to April 24. Oil was supplemented once daily at a rate of 1 g/kg BW with a soy hull (4 g/kg BW) carrier. Heifers grazing M had higher ADG than TFO which was higher than TF ($P < 0.01$). Total standing heats and mounts per standing heat did not differ among treatments ($P = 0.89$ and $P = 0.21$). Conception rate did not differ among treatments. Serum cholesterol ($P < 0.01$) and total fatty acids ($P < 0.01$) were greater in TFO than in TF and M heifers. Serum concentrations of 16:0, 18:0, 18:1, 18:2 and 20:4 were greater in TFO heifers than in the TF and M treatments ($P < 0.01$) whereas 18:3 concentration was greatest in the M heifers ($P < 0.01$). While diet affected gain, prolactin, serum fatty acid and cholesterol concentrations, no differences were observed in heifer estrus measures or conception rates.

Key Words: Beef Heifer, Reproduction, Tall Fescue

ACKNOWLEDGEMENTS

First, I would like to thank Dr. John Andrae for his guidance and support during my graduate program. Thanks also to the members of my committee, Drs. Susan Duckett and Scott Pratt for their guidance and input. I am thankful to the staff at Simpson Beef Unit for their assistance and cooperation during this study. Thank you to Jason Schmidt, my fellow research assistant, for help in the lab and in the field, but mostly for his friendship during his time at Clemson. I would like to acknowledge Dr. William Bridges and Ms. Katherine Leith for their assistance with statistical analysis for this project. Finally, I want to recognize my partner, Shell, for her love, support and encouragement during the past three years.

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CHAPTER 1

LITERATURE REVIEW

INTRODUCTION

For many years, tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.) has been an important forage for beef cattle producers in the Southeastern U.S. The mutualistic endophyte (*Neotyphodium coenophialum*), which is often found in tall fescue, increases drought tolerance and pest resistance making tall fescue a reliable perennial forage; however, the endophyte also produces toxic alkaloids which can negatively affect animal gains, reproductive performance and overall herd productivity. Cow-calf operations are the primary cattle enterprise in the southeastern United States (Hoveland, 1993). Ensuring reproductive readiness in replacement heifers is one of the most important ways that cattle producers can enhance lifetime productivity in cow herds. Research has shown that reproductive readiness is affected positively with enhanced nutrition (Short and Bellows, 1971) and negatively by toxic tall fescue (Washburn, 1991). Since tall fescue is a major perennial in the southeast, specific strategies to manage negative reproductive effects must be established. Since renovating pasture is often financially untenable for producers, alternative strategies to profitably augment nutrition and mitigate the toxic effects of tall fescue are needed.

Tall fescue was originally introduced from Europe in the 1800's most likely as a seed contaminant, but became widespread during the 1940's and 1950's following the release of Kentucky 31 (KY-31) as a cultivar in 1942 (Stuedemann and Hoveland, 1988).

Currently, tall fescue is the most widely cultivated pasture grass in the United States (Ball et al., 2002) covering approximately 20 million hectares of pasture land (Bouton, 2001). Tall fescue is adapted to a wide geographical area in the United States (Buckner et al., 1979), but it performs best in the "fescue belt" which is the transition zone between the temperate north and the mild south (Arkansas and Missouri to Georgia, South Carolina and North Carolina) (Burns and Chamblee, 1979).

Tall fescue is known for its ease of establishment, wide range of adaptation, tolerance of poor management, pest resistance, good seed production (Stuedemann and Hoveland, 1988), and tolerance of low fertility and low pH soils (Ball et al., 2002). Crude protein, digestible dry matter, amino acid and mineral content would suggest it to be a high-quality cool-season forage (Bush and Buckner, 1973). However, most tall fescue has an important antiquality component which is responsible for poor animal performance. Soon after the release of KY-31 tall fescue came reports of poor animal grazing performance (Stuedemann and Hoveland, 1988). The mutualistic endophyte *Epichloe typhina* which was later reclassified as *Acremonium coenophialum* and ultimately as *Neotyphodium coenophialum* was identified as the cause of tall fescue toxicosis (Bacon et al., 1977). The fungal-plant relationship is considered mutualistic because each component obtains benefits from the relationship. The plant provides the fungus with nutrients while the fungus provides adaptability to environmental stress for the plant.

Malinowski and Belesky (2000) reviewed several mechanisms for enhanced persistence imparted by the endophyte including drought stress tolerance and greater mineral economy. Alkaloids produced by the endophyte have a bioprotective role. Some alkaloids protect against mammalian herbivores (Malinowski and Belesky, 2000) while other alkaloids such as peramine and loline provide protection against insect predators (Breen, 1994; Dahlman et al., 1997). Elmi et al. (2000) reported an increased resistance to nematodes in the soil. By reducing insect and nematode predation, endophytes can indirectly reduce insect borne disease (Malinowski and Belesky, 2000). In addition to its ability to deter herbivory, endophyte-infected tall fescue has some morphological and physiological characteristics which may give it a competitive advantage over non-endophyte infected cultivars. Hill et al. (1990) reported that endophyte-infected plants had greater yield per tiller, more numerous tillers, and deeper crowns than non-endophyte plants. Malinowski et al. (1999) found an increased number of root hairs and smaller root diameter associated with endophyte-infected tall fescue; factors that could enhance drought avoidance and phosphorus uptake. In addition, roots of endophyte-infected plants are reported to exude phenolic compounds which may have allelopathic effects on competing plants, or may affect nutrient sequestration and uptake (Malinowski and Belesky, 2000). These characteristics contribute to the drought stress tolerance and enhanced persistence seen in endophyte-infected cultivars.

The three classes of ergot alkaloids found in tall fescue are ergopeptine alkaloids (including ergovaline), lysergic acid and lysergic acid amides (Stuedemann et al., 1998). Loline alkaloids such as N-formylloline and N-acetylloline provide protection against insect herbivores and may augment the toxicity of ergot alkaloids (Porter, 1995). Loline and ergot alkaloids have been implicated as the primary cause for tall fescue's toxicity including loline and loline derivatives (Belesky et al., 1987), ergovaline (Lane et al., 1997), lysergic acid and lysergol (Hill et al., 2001). Hill et al. (2001) reported that lysergic acid and lysergol are transported across ruminant gastric tissues at a much greater level than ergovaline suggesting that lysergic acid and lysergol may be the alkaloids most responsible for tall fescue toxicosis symptoms.

Animals grazing tall fescue often exhibit a medley of health problems. Three disorders have been associated with tall fescue; fescue foot, fat necrosis and "summer slump" or fescue toxicosis (Schmidt and Osborn, 1993). Fescue foot is more frequently seen in cold climates (Ball, 1997) and is characterized by increased respiration rate and gangrene of the hooves, tail and ears. These are thought to be a result of moderate vasoconstriction caused by the body's attempt to conserve body heat then exacerbated by endophytic toxins causing further vasoconstriction (Ball, 1997).

Bovine fat necrosis is the accumulation of hard, necrotic fat in the adipose tissue of the abdominal cavity (Schmidt and Osborn, 1993). This accumulation of fat along the intestinal and reproductive tracts can cause dystocia and improper digestion (Wilkinson et al., 1983). Bovine fat necrosis is also associated with lowered plasma cholesterol concentration (Stuedemann et al., 1985). Fat necrosis is more likely to be found in pastures that have received high levels of nitrogen fertilizer either from commercial sources or poultry litter (Stuedemann et al., 1985). Nitrogen fertilization does not directly affect fat necrosis; rather altered fat metabolism is a result of increased alkaloid concentrations resulting from greater plant nutrient availability with fertilization (Rottinghaus et al., 1991).

Fescue toxicosis includes a group of symptoms such as intolerance to heat, retained hair coat, excessive salivation, elevated body temperature, nervousness, and poor gains, decreased milk production and reduced conception rates (Stuedemann and Hoveland, 1988). Although fescue toxicosis, fescue foot, and fat necrosis can all be problematic, fescue foot and fat necrosis tend to be severe but fairly isolated problems. Fescue toxicosis is a more widespread syndrome affecting cattle across the tall fescue producing region of the US (Ball, 1997). It is estimated that tall fescue toxicosis costs the beef cattle industry over $600 million annually (Hoveland, 1993)

REVIEW OF TALL FESCUE TOXICOSIS

Animal Performance

Several studies have reported decreases in average daily gain (Hoveland et al., 1983; Stuedemann et al., 1986; Read and Camp, 1986) and in gain per hectare (Hoveland et al., 1983; Stuedemann et al., 1986) for steers grazing toxic endophyte-infected (E+) tall fescue. A 30 to 100 percent decrease in average daily gain (ADG) was observed in grazers of high endophyte infested pastures versus those grazing low endophyte infested pastures (Stuedemann and Hoveland, 1988). These decreases have been observed across multiple locations (Schmidt and Osborn, 1993; Paterson et al., 1995) and during all seasons of the year (Hoveland et al., 1984). Stuedemann and Hoveland (1988) reported a significant negative linear relationship between endophyte infestation and ADG. Each ten percent increase in endophyte infection level resulted in approximately 0.05 kg decrease in ADG over a grazing season.

Intake and grazing behavior may contribute to the poor gains often seen in animals grazing E+ tall fescue (Stuedemann and Hoveland, 1988). Stuedemann et al. (1989) reported a decrease in dry matter intake (DMI) from 6.6 kg/d in steers grazing endophyte-free pastures to 4.2 kg/d in steers grazing E+ pasture. Similar results have been reported in steers fed E+ or endophyte-free seed (Osborn et al., 1992) and in cows (Peters et al., 1992) and sheep (Aldrich et al., 1993). Bond et al. (1984) and Howard et al. (1992) reported that steers grazing highly infected tall fescue spent less time grazing than those grazing low-endophyte varieties. In addition, Bond et al. (1984) reported that steers grazing high-endophyte tall fescue spent less time grazing during the day and more time grazing at night. Although reduced intake in steers grazing E+ tall fescue compared to those grazing endophyte-free tall fescue may contribute to reduction in animal gains, reduced intake alone cannot explain the physiological manifestations of fescue toxicosis (Stuedemann and Hoveland, 1988).

Reproductive Performance

Endophyte-infected tall fescue's effect on reproductive performance has been studied extensively. Multiple studies have reported a decrease in pregnancy and calving rates in heifers and cows grazing high endophyte tall fescue when compared to those grazing low endophyte tall fescue (Danilson et al., 1986; Schmidt et al., 1986; Washburn et al., 1991; Gay et al., 1988; Brown et al., 1992). Research continues to further define the cause or causes of this depression in performance.

Cyclicity. Washburn et al. (1989, 1991) reported a delay in the onset of puberty in heifers grazing toxic endophyte-infected tall fescue. Bond et al. (1988) reported similar results in ewes. Jones et al. (2003) found that heifers on endophyte-infected diets had shorter estrous cycles and lower mid-cycle progesterone concentrations than heifers grazing endophyte-free tall fescue. Ewes fed endophyte-infected tall fescue seed exhibited estrous cycles which were more variable in length than those in the control group (Burke et al., 2006). In studies that recorded estrus detection rate, there have been mixed results reported. Burke et al. (2001) reported no difference in estrus detection rate between animals on endophyte-infected and endophyte-free tall fescue while Mahmood et al. (1994) reported differences in estrous behavior between heifers grazing low versus high endophyte tall fescue.

Ovarian function. Several studies have examined the effect of tall fescue toxicosis on ovarian function. Estienne et al. (1990) reported altered luteal function in which display of a corpus luteum (CL) was not accompanied by elevated progesterone concentration. Ahmed et al. (1990) found differences in CL cellularity including number of mitochondria, lipid droplets and secretory granules per mm^2 in ovariectomized heifers grazing endophyte-free and endophyte-infected tall fescue. In a study by McKenzie and Erikson (1989), number of follicles in the high endophyte treatment was decreased by 42 % versus follicles in the control group (137,000 vs. 326,000). Burke and Rorie (2002) reported that CL diameter was not different, but there were fewer class 2 (6-9mm) follicles and the diameter of the largest follicle was smaller in cows grazing toxic endophyte-infected tall fescue. In that study, although there were differences in follicular dynamics, serum progesterone levels, estrous cycle lengths and pregnancy rates were similar between treatments.

Hormone alterations. Browning et al. (1997) reported that administering ergot alkaloids ergotamine and ergonovine altered pituitary hormone levels in steers when compared to saline injection. Luteinizing hormone (LH) and prolactin (PRL) concentration decreased with ergotamine injection. Both alkaloid treatments briefly elevated growth hormone concentrations. Similar results were reported in a study conducted with cows in the luteal phase of the estrous cycle (Browning et al., 1998). In addition, $PGF_{2\alpha}$ metabolite 13, 14-dihydro-15-ketoprostaglandin (PGFM) increased with alkaloid administration. $PGF_{2\alpha}$ is a luteolytic agent and may interfere with the maintenance of pregnancy (Browning et al., 1998).

Calf success. Effects of fescue toxicosis are passed along to the calf through reduced calf birth weights (Beers and Piper, 1987; Bolt and Bond, 1989) and weaning weights (Gay et al., 1988; Peters et al., 1992; Burke et al., 2001; Watson et al., 2004). These effects were not reported in similar work with sheep (Bond et al., 1988). Research has consistently reported a decrease in prolactin in cows (Burke et al., 2001; Mizinga et al., 1992; Watson et al., 2004), heifers (Bolt and Bond, 1989; Bond and Bolt, 1986; Estienne et al., 1990; Hurley et al., 1980), steers (Thompson et al., 1987; Hurley et al., 1980) and sheep (Bond et al., 1988) grazing E+ tall fescue as well as in E+ seed feeding trials (Burke et al., 2006). Because prolactin affects milk secretion in cattle (Eiler, 2004), reduction in weaning weights may be exacerbated by reduced milk production in nursing heifers and cows (Bolt and Bond, 1989; Danilson et al., 1986).

MANAGING TALL FESCUE TOXICOSIS

In tall fescue predominated areas, producers must decide what is the most economical and beneficial management strategy for utilizing this forage. Alternative forages can provide relief at critical periods during the grazing season. Strategies for managing tall fescue toxicosis have ranged from managing forages for decreased toxicity to managing animal nutrition with supplementation of various products.

Pasture Management Strategies

Prior to identifying the toxic endophyte, researchers and producers were aware that certain management practices resulted in lower animal performance on tall fescue. Many management strategies have been proposed for coping with existing toxic endophyte-infected tall fescue. The endophyte is found in the leaf sheaths and seed heads, but not in the leaves themselves. Any alkaloids found in the leaves have been transported there from another site therefore; the leaves themselves contain the lowest concentration of alkaloids in the plant (Rottinghaus et al., 1991). There is evidence that high nitrogen fertilization rates may exacerbate fescue toxicosis effects (Stuedemann et al., 1975, Garner and Cornell, 1978), and increase ergopeptine alkaloids (Belesky et al., 1988; Rottinghaus et al., 1991). Ergovaline levels are the highest in seed heads during the summer months (Rottinghaus et al., 1991) and it has been suggested that seed heads can be clipped to reduce ingestion of this portion (Roberts and Andrae, 2004). In addition, plant growth regulators such as mefluidide have been used to maintain plants in the vegetative state and suppress heading. Turner et al. (1990) reported an increase in ADG and organic matter intake in steers grazing mefluidide treated pastures compared to steers grazing untreated pastures. Belesky and Hill (1997) reported that regular defoliation reduced overall alkaloid production in plants and suggested that management practices such as continuous stocking or frequent herbage removal would reduce overall alkaloid production. Stockpiling winter tall fescue may be another method of minimizing fescue toxicosis when grazing E+ tall fescue. Kallenbach et al. (2003) reported that ergovaline level was decreased 85% from mid-December to mid-March in stockpiled E+ tall fescue in Missouri.

Alternative Forages

One of the difficulties of managing tall fescue toxicosis in cattle is that tall fescue is exceptionally well suited to this region and agronomically superior to other cool season perennial grasses. Therefore it is difficult to find an appropriate replacement which fills the same product niche. The development of tall fescue cultivars which do not cause toxicity has taken two forms.

Endophyte-free tall fescue. Once *Neotyphodium coenophialum* was identified as the cause of fescue toxicosis, the logical next step was to produce tall fescue cultivars which did not contain the endophyte. Endophyte free cultivars were developed which produced acceptable animal performance (Peters et al., 1992) and reproductive performance (Mizinga et al., 1992; Schmidt et al., 1986). Removing the endophyte however, reduces drought tolerance and persistence (West et al., 1993). Endophyte-free swards can decline and be overcome by E+ plants (Thompson et al, 1989; Gwinn et al, 1998). Researchers have suggested that this decline is the result of a phenomenon referred to as accumulated stress. Accumulated stress occurs when a number of physiological factors such reduced water uptake due to root damage from nematode attack combine with reduced drought tolerance mechanisms to produce a less viable sward (Roberts and Andrae, 2004). The reduced persistence of endophyte free cultivars led researchers to investigate cultivars infected with non-toxic endophytes.

Novel endophyte tall fescue. Novel endophyte cultivars (E++) have an endophyte which affords the plant protection but does not produce the toxic alkaloids which are detrimental to grazing livestock performance. In the original study by Bouton et al. (2002), which introduced the novel endophyte, Jesup cultivars of AR542 novel endophyte infected tall fescue persisted as well as E+ stands while Georgia 5/novel endophyte stands were intermediate. The Jesup/AR542 novel endophyte cultivar is currently marketed under the trademark name MaxQ™. Thus far, novel endophyte tall fescue has been used successfully in many locations. Burns et al. (2006) reported four year old stands in the North Carolina Piedmont of novel endophyte and wild type tall fescue to be similarly persistent and the novel endophyte stand to have a significantly higher stand index than the endophyte free stand. Similar results were reported in the South Central US (Hopkins and Alison, 2006). Bouton et al. (2002) found lambs consuming novel endophyte-infected tall fescue gained as well as those on endophyte-free tall fescue and gained 57% better than those on toxic-endophyte tall fescue. In subsequent studies using either lambs (Parish et al., 2003a) or stocker cattle (Parish et al., 2003b) similar results were found. In addition, lambs did not exhibit depressed prolactin concentration or elevated rectal temperature with the novel endophyte tall fescue as with the E+ tall fescue (Parish et al., 2003a). Nihsen et al. (2004) found that steers grazing

ArkPlus™, a novel endophyte containing cultivar, gained similarly to the endophyte free check and gained better than steers grazing the toxic endophyte-infected KY-31. As in Parish et al. (2003b), steers grazing toxic KY-31 exhibited more tall fescue toxicosis symptoms than those grazing novel endophyte or endophyte free pastures. Burke et al. (2006) compared reproductive performance of ewes fed novel and toxic endophyte tall fescue seed. The novel endophyte tall fescue seed did not produce symptoms of reproductive disruption that were observed with the toxic seed.

Cool season annuals. Cool season annuals such as ryegrass, wheat or cereal rye can be used as part of a pasture rotation within a tall fescue system or as a substitute for tall fescue winter grazing. In addition, feeding supplemental hay and concentrate can be reduced with the incorporation of cool season annuals in cow-calf production systems (DeRouen et al., 1991). Beck et al. (2008) found that steers grazing wheat/cereal rye and annual ryegrass gained 0.88 and 0.84 kg/d respectively while those grazing toxic tall fescue gained 0.64 kg/d. The steers grazing cool season annuals gained comparably to steers grazing novel-endophyte tall fescue (0.86 kg/d). Beck et al. (2005) reported similar results with even higher gains on the wheat/rye and ryegrass (1.18 and 1.07 kg/d respectively). In addition to increased animal gains, Sanson and Coombs (2003) reported an improved pregnancy rate in cows grazing annual ryegrass (87.4 %) versus those grazing E+ tall fescue (64.2%). Poor cool season annual stands can reduce animal gains to a level below that of toxic tall fescue (Beck et al., 2008). Drought or excessive rain can cause establishment problems. Including cool season annuals as part of a perennial pasture rotation system, could decrease the risks of establishing annuals each year and improve overall net returns.

Warm season grasses. Endophyte levels in tall fescue are greatest during the summer months (Rottinghaus et al., 1991). Removing cattle from endophyte-infected tall fescue pastures to warm season grasses during the summer months provides additional grazing when tall fescue is in its summer slump, and provides relief from toxins at a time when they are in their highest concentration in the plant (Joost, 1995). Aiken and Piper (1999) reported improved weight gains of steers moved from tall fescue to eastern gamagrass (*Tripsacum dactyloides* L.) in the late spring. Forcherio et al. (1992) reported that moving steers from high endophyte tall fescue to warm season grasses such as caucasian bluestem (*Bothriocloa caucasica*) during the summer grazing period improved ADG compared to steers grazing high endophyte tall fescue for the entire season. Aldrich et al. (1990) found that rotating steers to sorghum-sudan (*Sorghum bicolor*) pastures significantly increased forage intake over that of steers grazing tall fescue alone, however, no differences were reported in overall steer performance. Additionally, grazing mixed pastures of tall fescue and warm season grasses such as bermudagrass (*Cynodon dactlyon*) can dilute the toxic effects of E+ tall fescue (Chestnut et al. 1991).

Legumes. Because of their compatibility with tall fescue, legumes have been used in mixtures with tall fescue to dilute its toxic effects. The nitrogen fixing property of legumes also reduces or eliminates the need for costly N fertilizer. Legumes in a forage mixture increase overall digestibility (Rayburn et al., 1980). Interseeding of clover into

E+ tall fescue can increase performance of steers (McMurphy et al., 1988, 1990) and heifers (Woods et al., 1988) to a level similar to that of low endophyte tall fescue. Ellis et al. (1983) reported an increase in cow and calf ADG for cow-calf pairs grazing tall fescue plus clover in the summer months when compared to nitrogen fertilized tall fescue. Gay et al. (1988) found that while calves grazing high endophyte tall fescue plus clover gained similarly to those grazing low endophyte tall fescue, cows grazing the same high endophyte tall fescue plus clover still exhibited lower pregnancy rates than those on low endophyte tall fescue. In a review of multiple tall fescue grazing studies, Thompson et al. (1993) reported that in high endophyte stands being spring grazed, clover may not alleviate fescue toxicosis symptoms to an acceptable level.

Supplementation

Supplementation of animals grazing toxic tall fescue can improve ADG (Elizalde et al. 1998) and dilute the toxic effects of tall fescue by limiting toxin intake and increasing dietary energy or protein (Roberts and Andrae 2004).

Energy supplementation. Several studies have reported an improvement in animal performance with the addition of supplemental energy to grazed E+ tall fescue diets. Hannah et al. (1989) reported a decrease in forage organic matter (OM) intake but an increase in total OM intake in steers supplemented with corn or corn gluten compared to unsupplemented steers. Studies by Elizalde et al. (1998) and Feiser and Vanzant (2004) compared starch-based versus fiber-based energy supplements. Elizalde et al. compared cracked corn to corn gluten feed. The Feiser and Vanzant study compared coarse cracked corn and pelleted soybean hulls. In both studies, supplementation improved total intake over no supplementation, but there was no difference in intake as a result of supplement type.

The importance of adequate energy on reproductive performance in beef cattle is well established (Wiltbank et al., 1962, 1964; Dunn et al., 1969). However, research on the reproductive performance of cattle grazing toxic tall fescue with energy supplementation is limited (Ellis et al., 1983; Looper et al., 2005). Ellis et al. (1983) reported an increase in pregnancy rates from 79% in unsupplemented cows to 95% in cows supplemented with a corn/soybean meal mixture. Looper et al. (2005) reported a similar tendency (P=0.10) with cows grazing stockpiled and spring growth E+ tall fescue. Energy supplementation may be appropriate during key production times and if affordable sources are available.

Fat supplementation. Supplementation of lipids in the ruminant diet is a calorie dense source of energy. Supplemental fat can decrease forage intake (Pavan et al., 2007) and therefore may be useful in decreasing consumption of toxic tall fescue at critical times during reproduction and production. As fat supplementation is considered, it is important to note that it must be fed at a level that is not detrimental to digestion. Coppock and Wilks (1991) reported that consumption of fat in excess of 5% of total dry matter intake can reduce dry matter intake and fiber digestibility. Overconditioning can also be detrimental to fertility (Hess et al. 2008), so fat should be supplemented at the lowest level possible to get the desired effect. Research on the performance of beef heifers grazing endophyte-infected tall fescue supplemented with fat is limited (Poore et al., 2006). Heifers grazing stockpiled KY-31 tall fescue showed improved ADG when supplemented with whole cottonseed (Poore et al., 2006), but no reproductive data was reported in the study. Whitney et al. (2000) reported a higher ADG for heifers supplemented with soybean oil at 3% of dry matter (DM) level compared to those receiving bromegrass hay with no supplement, cracked corn plus soybean meal and soybean oil at a 6% DM level.

FAT SUPPLEMENTATION AND REPRODUCTION

Some studies have shown that fat supplementation can have a positive effect on reproduction in cattle above that of additional dietary energy (Funston, 2004). Reproductive response to fat supplementation has been measured across different stages of reproduction and in various tissues. Fat supplementation increased percent of replacement heifers reaching puberty prior to the beginning of breeding season (Lammoglia et al., 2000) and resulted in heifers conceiving earlier in the breeding season (Whitney et al., 2000). Long et al. (2007) reported a trend for an increase in pregnancy rates in heifers fed a rumen-protected fat supplement versus heifers with no supplementation. Several researchers (Lammoglia et al., 2000; Vann et al., 2003; Talavera et al., 1985) have reported an increase in progesterone and cholesterol in fat supplemented heifers.   Similar results were observed in fat supplemented beef cows (Williams, 1989; Hightshoe et al., 1991 and Lammoglia et al., 1996; Thomas et al., 1997). Cholesterol is a metabolic precursor to progesterone (Eiler 2004). Increase in serum cholesterol may affect progesterone biosynthesis (Talavera et al., 1985), resumption of postpartum luteal activity (Wehrman et al., 1991) and ovarian follicular dynamics (Thomas and Williams 1996). Multiple studies report changes in ovarian follicular growth accompanying fat supplementation. These changes were characterized by increased number of total follicles (Lammoglia et al., 1996) and number of medium-sized follicles (Ryan et al., 1992; Thomas and Williams, 1996). Targeting specific windows during the female reproductive cycle for supplementation has been a focus of fat supplementation research. Researchers investigating the effects of peripuberal fat supplementation have found no improvement in overall pregnancy rates (Lammoglia et al. 2000, Whitney et al., 2000; Funston et al., 2002). This result may be a factor of the control groups in these studies being on an acceptable nutritional plane for reproduction independent of fat supplementation. Similar responses have been found with postpartum fat supplementation (Bottger et al., 2002; Lloyd et al., 2002.; Hightshoe et al., 1991). Hess et al. (2008) suggested that fat supplementation should be used in replacement heifers only as a supplemental energy source. Alexander et al. (2002) and Bellows et al. (2001) did show an improvement in pregnancy rates in pre-partum fat supplemented cows over control cows. Hess et al. (2005) suggested a potential 10.5% increase in pregnancy rates for pre-partum fat supplemented cows based on a meta-analysis of existing literature. To date, no research has been published on the effect of fat supplementation on reproduction in cattle grazing toxic tall fescue.

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CHAPTER 2

MANAGEMENT STRATEGIES TO IMPROVE DEVELOPMENT OF REPLACEMENT HEIFERS UTILIZING TALL FESCUE-BASED SYSTEMS

INTRODUCTION

Tall fescue toxicosis severely impacts beef reproduction and reduces the profitability of beef farms in the Southeastern U.S. (Hoveland, 1993). Current estimates place the annual economic impact of tall fescue toxicosis at over $600 million to the beef industry alone (Fribourg and Waller, 2005). Multiple studies have established the negative impact of fescue toxicosis on reproductive development of replacement heifers (Danilson et al., 1986; Schmidt et al., 1986; Washburn and Greene, 1991); however, none of these is a peer reviewed publication. Limited research has been conducted examining methods to improve heifer reproductive performance. Management strategies for improving reproduction in heifers from toxic tall fescue-based systems must provide an acceptable level of performance and be affordable to the producer. Grazing cool season annuals prior to breeding can improve reproductive performance in beef females over those grazing toxic endophyte infected tall fescue (Sanson and Coombs, 2003). Oil supplementation can decrease forage intake while maintaining animal performance (Pavan et al., 2007) Supplementing heifers with fat prior to breeding can improve pregnancy rates (Hess et al., 2002). The objectives of this study were to examine the potential of two alternative nutritional regimens to reduce the impact of tall fescue toxicosis on replacement heifer reproduction and to establish baseline information on the effect of tall fescue toxicosis on heifer estrous behavior.

MATERIALS AND METHODS

Pasture Treatments, Establishment and Management

Three dietary treatments: (1) toxic endophyte-infected tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.) (TF); (2) toxic endophyte-infected tall fescue with a soybean oil supplement (TFO); or (3) mixed winter annuals consisting of cereal rye (*Secale cereale*), annual ryegrass (*Lolium multiflorum*), crimson clover (*Trifolium incarnatum*), and hybrid forage brassica (*Brassica rapa x B. napus*) (M) were compared to evaluate heifer gain and reproductive performance responses. Experimental pastures were located at the Dalton Farm area of Simpson Agricultural Experiment Station in Pendleton, SC. The soil was a Cataula sandy loam.

The wild-type endophyte- (*Neotyphodium coenophialum*) infected tall fescue pastures (avg. 4.75 ha/replicate) were well established. Endophyte infection level of each experimental area was determined by analysis of 50 tiller samples from each paddock using a commercial ELISA test kit (Agrinostics Ltd. Co., Watkinsville, GA). Pastures were blocked by endophyte infection level. Blocks A and B had 74 and 94% infection levels respectively. Each block was divided in half with each half randomly assigned to TF or TFO treatment. Tall fescue pastures were defoliated in August and fertilized in early September with 67 kg N/ha for stockpiling. Tall fescue hay was supplemented to heifers grazing tall fescue from d 37 to 80 (Jan 18, 2008- March 1, 2008) due to lack of forage.

Cereal rye (c.v. ‘Wrens Abruzzi’)(70 kg/ha), annual ryegrass (c.v. ‘Fantastic’)(18 kg/ha), crimson clover (c.v. ‘Dixie’) (9 kg/ha), and hybrid forage brassica (c.v. ‘Pasja’) (4 kg/ha) were seeded into a prepared seed bed in mid-September (6.45 ha/replicate). Nitrogen fertilizer (56 kg/ha) was applied to the winter annual mixture in early January. All pastures were strip grazed throughout the trial. Heifers were rotated from grazed paddocks when pasture forage height was reduced to approximately 6 cm. Monthly forage availability was estimated by harvesting 10 random quadrat samples (0.3 m^2) at a height of 4 cm from each paddock. Samples were dried at 55°C for 48 hours. Samples from each paddock were weighed for available dry matter estimation then pooled and stored at room temperature for subsequent chemical analysis.

All forage and soy hull samples were ground to pass through a 1 mm screen of a Wiley Mill (Thomas Scientific, Swedesboro, NJ). Forage and soybean hull samples were analyzed for dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), and fatty acid content (FA). Soybean oil samples were pooled and analyzed for FA content. DM and CP was determined according to AOAC (2005). NDF and ADF were determined sequentially using an Ankom 200 Fiber Analyzer (Ankom Corp., Fairpark, NY) using the method of Van Soest et al. (1991). Forage fatty acids were transmethylated using the method of Park and Goins (1994). Fatty acid methyl esters (FAME) were analyzed using a gas chromatograph (GC) according to the method of Duckett et al. (2002). Fatty acids were identified by comparing retention times to reference standards and quantified using the internal standard C23:0.

Animals

The use of animals in this trial was approved by the Clemson University Institutional Animal Care and Use Committee. Forty-eight spring-born Angus x

Simmental heifers obtained from the Clemson University Simpson Beef Unit were weaned in late-September onto a corn silage based diet. Prior to treatment assignment, blood samples were collected for P4 levels on d -42 and -29. All blood samples were drawn via jugular venipuncture. Blood samples were collected into 10 ml serum separating tubes (Corvac, Kendall, Mansfield, MA) placed immediately on ice and allowed to clot at 4° C for 24 h. Blood was centrifuged at 1500 × g for 20 minutes and serum was collected. Serum was stored at -20° C prior to analysis. Serum was analyzed for progesterone (P4) using RIA (Coat-A-Count Progesterone, Siemens Medical Solutions Diagnostics, Los Angeles, CA). The percentage binding of the radiolabeled hormone was 58%. All samples were analyzed in duplicate in a single assay. The intra-assay CV was 10.6. Heifers were considered to be cycling if they had one P4 level of ≥1 ng/ml. Heifers were stratified by weight and pubertal status, and randomly assigned to one of the three grazing treatments.

Two replicate pastures of each treatment were grazed by eight head per replicate with a beginning date of December 12, 2007. Heifers in the TFO treatment received soybean oil supplement provided once daily at a level of 1 g/kg BW. Soybean hulls were used as a carrier and fed at a rate of 4 g/kg BW. Soybean oil and hulls were sampled weekly and stored at -20° C. Samples for serum prolactin (PRL) levels were drawn via jugular venipuncture on d -29 for a baseline level and on d 27. All heifers had ad libitum access to fresh water and a vitamin-mineral premix (Kowpoke One to One, Sweetlix, Mankato, MN) for the duration of the trial (Table 1). On d 73, all heifers were vaccinated (Pyramid 10, Fort Dodge Animal Health, Fort Dodge, IA) and treated with an internal and external paraciticide (Eprinex, Merial Limited, Duluth, GA). Body weight (BW) was determined on d 0, 27, 58, 86, 107 and 134 at 0800 prior to daily supplementation. Monthly BW was used to determine ADG and to adjust supplement amounts.

Heifers were synchronized using the CO-Synch + CIDR protocol according to Stevenson et al. (2003) with timed artificial insemination (TAI) occuring 54 hours after $PGF_{2\alpha}$ injection. Visual heat detection was performed at 0700 and 1900 for 60 d post TAI. Heifers were artificially inseminated 12 hours post visual standing heat detection. All heifers were bred at each insemination using semen from the same bull. Heifers remained on treatment 30 d post TAI.

Ultrasound measures of subcutaneous (s.c.) fat thickness over the 12^{th} and 13^{th} rib were collected on d 0, d 58, d 107 and d 134 using an Aloka 550-V ultrasonograph (Corometrics Medical Systems, Wallingford, CT) equipped with a 17-cm, 3.5-MHz linear probe. The images were interpreted using Feedlot Chute-Side Software (Biotronics Inc., Ames, IA).

Serum samples for determination of cholesterol, triglycerides and fatty acids were collected on d 27, d 86 and d 134. Serum fatty acids were extracted using the method of Folch et al. (1957) then transmethylated according to Park and Goins (1994). Fatty acid methyl esters (FAME) were analyzed using a gas chromatograph (GC) according to Duckett et al. (2002) Fatty acids were identified by comparing retention times to reference standards and quantified using an internal standard of C23:0.

Serum cholesterol was determined according to Du and Ahn (2002) and quantified by comparing retention time to an internal standard, 5α-cholestane (Sigma, St. Louis, MO). Serum triglycerides were determined using a commercial kit (Serum Triglyceride Determination Kit; Sigma, St. Louis, MO).

Reproductive Parameters

Serum PRL was assayed with a specific double-antibody radioimmunoassay (RIA) using rabbit anti-bovine PRL, as described by Wallner et al. (1983). The first antibody was used at 1:40,000 dilution, with 38% binding of ^{125}I-labeled PRL. The second antibody (goat anti-rabbit anti-guinea pig) (National Hormone and Peptide Program, Torrance, CA; Pell-Freeze Biologicals, Rogers, AZ) was diluted 1:20 before use. The RIA PRL standard used was USDA-b-PRL-1 (AFP-5300; from Dr. D.J. Bolt, USDA, Beltsville, MD). All samples were assayed in triplicate in one assay. The intra-assay CV was 9.4.

A remote electronic estrus detection system (Heatwatch® II, Cow Chips, LLC, Manalapan, NJ) was used from d 44 to d 104 to determine synchronization response, cycle duration, time of day of standing heat, standing heat duration, frequency and duration of mounting activity. Measures to determine reproductive readiness and fitness included cycle duration, first service conception rate, services to conception, pregnancy rate, calving rate and calf birth weight. Pregnancy was determined via manual palpation and transrectal ultrasound (Aloka 500-V, Corometrics Medical Systems, Wallingford, CT) 120 d post-synchronization. Calving rate was defined as heifers calving as a percentage of heifers inseminated using breeding and calving records.

Statistical Analysis

One heifer on the TF treatment was removed from the study due to injury. Forage availability and quality was analyzed with treatment as a fixed effect using the GLM procedure of SAS (SAS Institute Inc., Cary, NC) with replicate as the experimental unit. Average daily gain, services to conception, and reproductive behavior data were analyzed with treatment as a fixed effect and replicate as the experimental unit using the GLM procedure of SAS. Weight, serum fatty acids, serum triglycerides, serum cholesterol and s.c. back fat data was analyzed as a repeated measures design using GLM procedure of SAS (SAS Institute Inc., Cary, NC) with the main effects of treatment and time and replicate as the experimental unit. Day × treatment was significant for serum analytes, so means are presented by day. Prolactin data were subjected to a square root transformation then analyzed using the GLM procedure of SAS. Means are reported untransformed. First service conception, pregnancy rate, calving rate and response to synchronization were subjected to chi-square analysis using the FREQ procedure of SAS.

RESULTS AND DISCUSSION

Climatological Data

Rainfall was below the 30-yr average during the establishment period for winter annuals and stockpiling period for tall fescue (Figure 1a). This resulted in reduced forage availability and, as a result, hay was fed to the TF and TFO treatments from January 18 to March 1. Temperatures were similar to 30-yr averages throughout the trial (Figure 1b).

Forage Data

Forage availability (Table 2) was similar ($P > 0.05$) among treatments except for the final sampling period ($P < 0.05$). During this sampling period, the cereal rye and annual ryegrass was mature; therefore, forage availability was greater for M than the fescue and overall nutritional quality was reduced. Nutritive composition is presented in Figure 2. Crude protein did not differ across the season among forage treatments. Crude protein content of TF and TFO treatments increased during the grazing season and peaked in April whereas M peaked in January. Fiber concentrations (NDF and ADF) were lower in the mixed winter annuals than in either tall fescue treatment ($P < 0.01$). Whereas the TF and TFO treatments decreased in NDF and ADF during the trial, being the lowest in April, M was lowest in January and increased throughout the trial. Forage and supplement fatty acids are presented in Table 3. The predominant fatty acid in the soybean hulls and oil is linoleic (C 18:2) acid (47.65 and 52.10 % respectively) and the predominant fatty acid in the tall fescue and mixed winter annuals is linolenic (C 18:3) acid (39.41 and 46.57% respectively).

Heifer Performance

Weight Gain. Initial BW did not differ ($P > 0.10$) among treatments; however, final BW was different ($P < 0.01$) for TF, TFO and M (385 ± 7.7, 421 ± 2.25 and 448 ± 6.15 kg respectively). There was also a treatment × time interaction ($P < 0.01$) for BW (Figure 3). On d 27, M was greater than TF and TFO was intermediate. Starting on d 58 and continuing to the end of the trial, M was greater than TFO which was greater than TF. Heifers grazing M had greater ADG than those grazing TFO which was greater ($P < 0.01$) than TF (P < 0.01). Average daily gain was 0.51 ± 0.02, 0.74 ± 0.02, and 0.97 ± 0.03 kg/d for TF, TFO and M respectively. The ADG for all treatments was at or above a level which previous research indicates is adequate for developing replacement heifers (Short and Bellows, 1971). Additionally, all treatment groups achieved the generally recommended 60% mature BW target for breeding (NRC, 1996) at 62, 66 and 71% for TF, TFO and M respectively. Mature BW was determined from herd averages for individual heifer breed type of the Clemson University Simpson Beef Unit.

Fat Thickness. Ultrasound, s.c. fat thickness data is presented in Figure 4. All treatments showed a decrease in fat thickness from d 59 to d 108 followed by an increase from d 108 to d 134. All heifers were weaned onto a corn silage-based ration prior to treatment assignment. The initial decrease in fat thickness may be due to some initial adjustment to forage diets. Fat thickness did not differ among treatments, but there was a trend ($P = 0.10$) for a treatment by period interaction. On d 108, TFO was greater than TF ($P < 0.05$) and M tended to be greater than TF ($P < 0.10$). On d 134, TFO was greater than M ($P<0.05$) and TF tended to be greater than M ($P < 0.10$). This is consistent with

Pavan et al. (2007) who reported an increase in back fat thickness with corn oil supplementation.

Serum Analytes

Serum Prolactin. Pre-treatment serum prolactin levels did not differ ($P > 0.10$). D 27 serum prolactin was lower in TF than in TFO which was lower than M ($P < 0.01$) (Table 4). Depressed serum prolactin is a well-documented sign of fescue toxicosis (Hurley et al., 1980; Thompson et al., 1987). The intermediate level of the oil supplemented heifers may indicate that oil supplementation was moderating some of the fescue toxicosis symptoms.

Serum Cholesterol. There was a time × treatment interaction ($P < 0.01$) for serum cholesterol concentrations. Total cholesterol of TFO was higher than TF and M ($P < 0.01$) for each sampling date; however, there was a decrease in TFO cholesterol from d 86 to d 134 (Figure 5). Increased serum cholesterol with soybean oil supplementation is consistent with Whitney et al. (2000) who examined in vitro digestion and performance of beef heifers consuming two levels of soybean oil. In a study examining dietary fatty acids and follicular growth in beef cows, Thomas et al. (1997) also reported an increase in total serum cholesterol with soybean oil, animal tallow and fish oil. Lammoglia et al. (2000) and Whitney et al. (2000) reported a decrease in serum cholesterol beyond day 84 and 60 respectively of supplementation in fat supplemented heifers. Cholesterol availability is considered to be the limiting factor in progesterone synthesis, therefore it has been suggested that increasing serum cholesterol may positively affect reproduction (Henderson et al., 1981).

Serum Glycerol and Triglycerides. Serum glycerol was not affected by treatment, time or any interactions ($P > 0.10$) (data not shown). There was a significant treatment × time interaction for serum triglycerides ($P < 0.05$) (Figure 6). The TFO triglyceride levels were not affected by time throughout the trial ($P > 0.05$); whereas TF and M increased on d 86 and decreased on d 134. Most of the lipid in a plant is contained in the chloroplasts which increase in number with spring growth. As a plant matures, the tissue becomes more fibrous and the lipid fraction decreases (Hawke, 1973). Change in serum triglycerides of TF and M heifers is likely a response to the changing forage lipid concentrations. The decrease in serum triglycerides of M heifers from d 27 to d 134 is reflective of the decrease in forage fatty acids from January (d 22) to April (d 120) (Table 3). Serum triglycerides in TF heifers were not different on d 27 and d 134. Although, there was an increase in forage total fatty acids between January and April, this increase may not have been large enough to change the serum triglyceride profile of TF heifers. Nihsen et al. (2004) reported decreased triglyceride levels in heifers grazing toxic endophyte fescue compared to novel-endophyte fescue. In our study, serum triglyceride levels were higher in TF than in M.

Serum Fatty Acids. There was a significant time × treatment interaction on total fatty acids (Figure 7; $P < 0.01$). Total fatty acids were higher in TFO than in TF and M throughout the trial. Total fatty acids in TFO increased from d 27 to d 86; then decreased below the original level by d 134. TF and M were not different for d 27 and 86 but M was higher than TF on d 134. The decrease in total fatty acids between d 86 and d 134 for the oil supplemented heifers may indicate a metabolic compensation in response to the previously discussed elevated fatty acid levels in oil supplemented heifers. Treatment × time interactions were detected for all individual serum fatty acids except C18:1 and C18:3 (Table 5). Proportion of C16:0 was lower in TFO than in the unsupplemented treatments ($P < 0.01$). TF and M C16:0 levels were similar with exception of d 134 when M was higher than TF. Unsupplemented heifers had higher serum C18:0 proportions than TFO with the exception of d 134 when M dropped to a level similar to TFO. M heifers had higher C18:1 proportions than either TF or TFO heifers ($P < 0.05$) with no treatment × time interaction. Whitney et al. (2000) showed similar results with a lower proportion of C16:0 and C18:0 in plasma of heifers supplemented with soybean oil versus those not supplemented with oil. C18:2 is the predominant fatty acid in soybean oil. Heifers receiving oil supplement had higher proportions of C18:2 than the unsupplemented treatments ($P < 0.01$). This is consistent with Whitney et al., (2000) and Alexander et al., (2002) who supplemented with soybean oil and lipid from soybean soapstock respectively. Serum proportions of C18:2 in TFO increased from d 27 to d 86; then decreased below the original level by d 134. TF was higher in C18:2 than M for d 27 and 86 but they were similar on d 134. C18:3 is the predominant fatty acid in forages. This is reflected in the serum fatty acids of TF and M heifers. Throughout the study, heifers grazing M had higher C18:3 concentrations than those grazing TF which were higher than heifers supplemented with oil (TFO).

Reproduction

Reproductive Behavior. No significant treatment differences were observed for any of the reproductive behaviors measured including estrous cycle duration ($P = 0.40$)

and estrus activity in response to synchronization (*P* = 0.20) (Table 6). In contrast, Jones et al. (2003) reported shorter estrous cycle duration using transrectal ultrasound in heifers consuming E+ fescue vs. non-toxic fescue seed. No behavioral observations were reported. Mahmood et al. (1994) reported trends (P < 0.10) for reduced estrus activity in response to synchronization in heifers grazing high versus low endophyte infected tall fescue. In that trial, grazing initiation began in April, a time when alkaloid concentrations are increasing in the plant (Rottinghaus et al., 1991). Seasonal alkaloid production may account for the reported differences in synchronization responses.

Reproductive Performance. Reproductive performance data are presented in Table 7. No treatment differences were observed in 120 d post-synchronization pregnancy rates (*P = 0.56*) or in calving rates (*P* = 0.63). It is possible that the small number of animals in this study precluded us from detecting differences in pregnancy and calving rates. Further study with larger numbers of animals may yield different results. In the TF and M treatments, fewer heifers calved than were determined to be pregnant at 120 d post synchronization (12/15 vs. 10/15 and 11/16 vs. 8/16 for TF and M respectively). All heifers were grouped together on toxic endophyte pastures on d 134 of this trial. Fescue consumption during the summer months may be responsible for the differences in heifers determined to be pregnant versus those who produced a calf. Spontaneous abortions are associated with the consumption of toxic tall fescue in mares (Porter and Thompson, 1992), but no research exists in this area in beef cattle. The first service conception rates were different (*P* < 0.05) with 11/15 (TF), 8/16 (TFO), 3/16 (M) heifers conceiving at first service. As a result, the number of services to conception was higher ($P < 0.05$) for M (2.02) than for TF (1.07) and TFO (1.17). In contrast, Whitney et al. (2000) reported that heifers supplemented with oil conceived 10 d earlier than heifers receiving no oil supplementation. Arnett et al. (1971) reported a decrease in conception rates in heifers that were overconditioned. Although the heifers in the TFO and M groups did have higher ADG than the TF group, it is unlikely that these heifers were overconditioned. Subcutaneous back fat did not differ between TFO and TF or between M and TF on d 134.

IMPLICATIONS

Heifers grazing toxic tall fescue had reduced rates of gain and altered serum prolactin levels. Live weight gains were improved with oil supplementation or by grazing mixed winter annual forage species. Oil supplementation altered serum cholesterol and fatty acid profiles. No differences in estrous behavior were observed as a result of forage or supplementation. Reproductive performance was not negatively affected by endophyte-infected tall fescue, but no positive reproductive effects were observed as a result of supplementation or grazing winter annual species.

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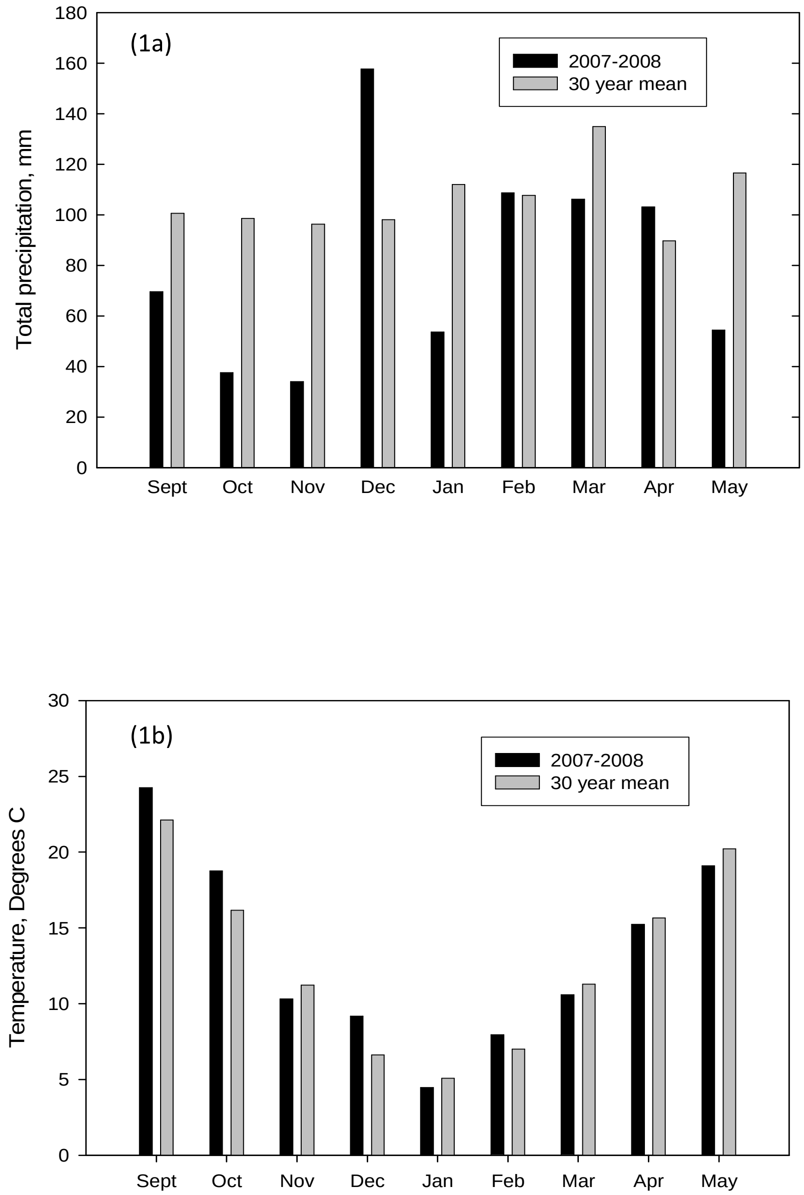

Figure 1. Monthly precipitation (1a) and average monthly temperatures and 30 year mean (1b) at Simpson Experiment Station September 2007 through May 2008

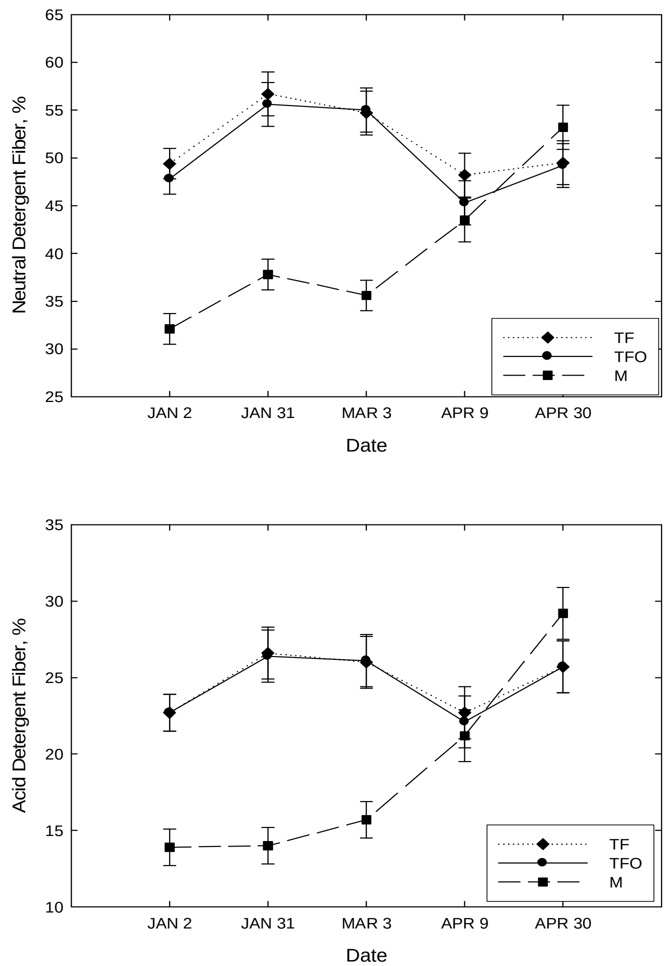

Figure 2. Forage quality of tall fescue (TF), tall fescue supplemented with soybean oil (TFO) or mixed winter annuals (M) across the grazing period

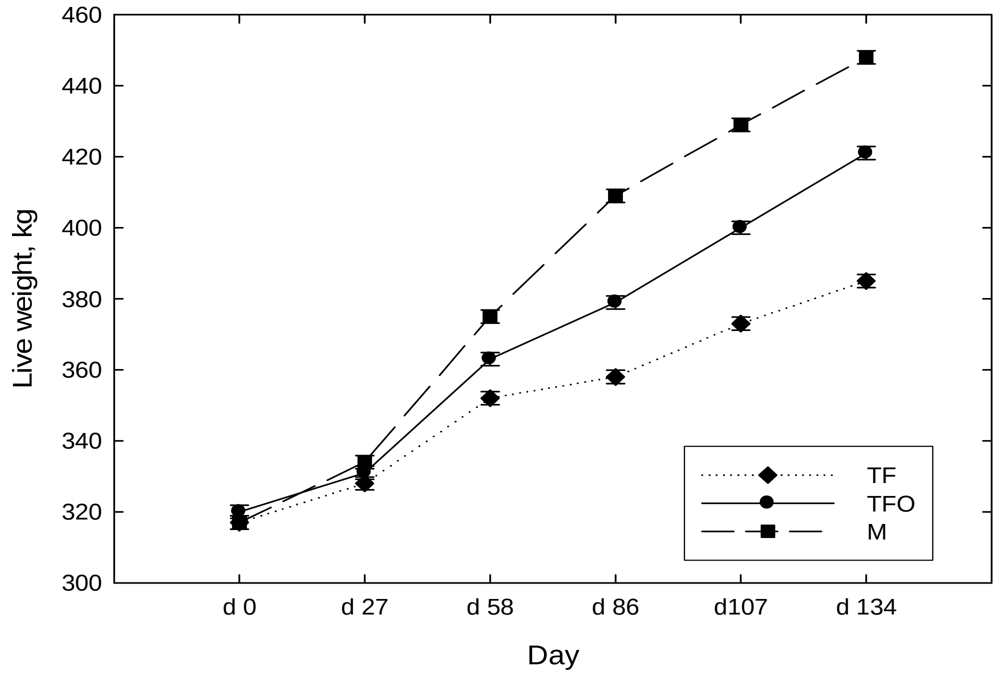

Figure 3. Live weight of heifers grazing tall fescue (TF), tall fescue supplemented with soybean oil (TFO) or mixed winter annuals (M) as affected by treatment × days on treatment (P < 0.01; SEM = 1.85)

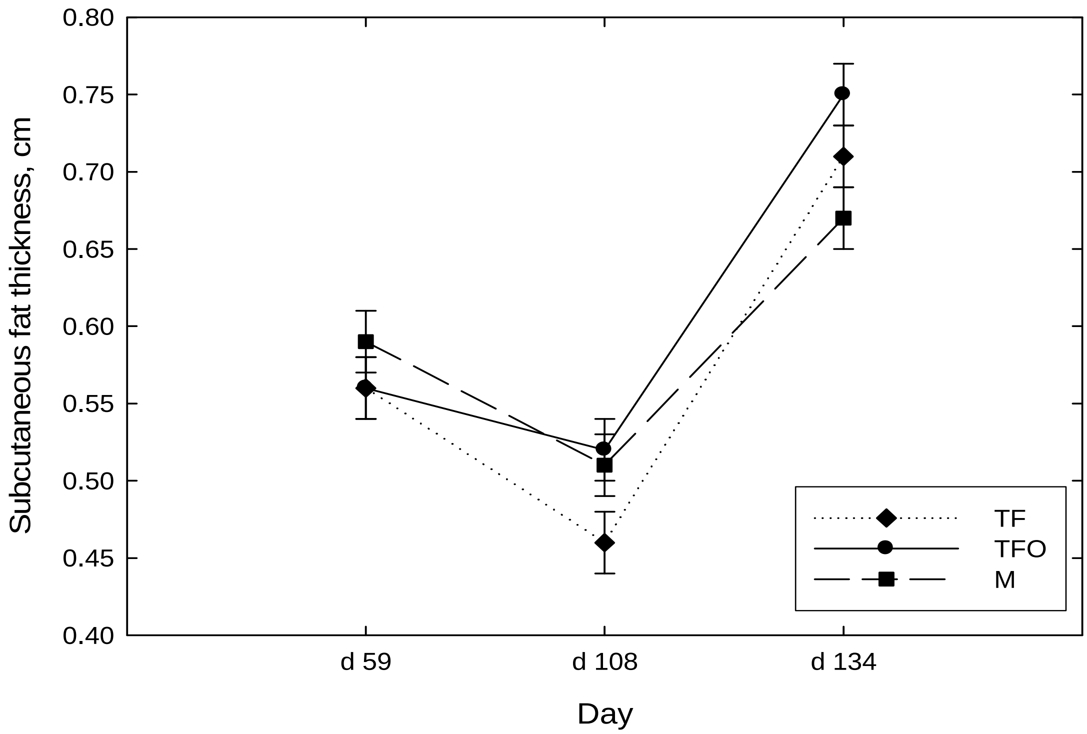

Figure 4. Subcutaneous fat thickness for heifers on tall fescue (TF), tall fescue supplemented with soybean oil (TFO) and mixed winter annuals (M) as affected by treatment × days on treatment (P = 0.09; SEM = 0.02)

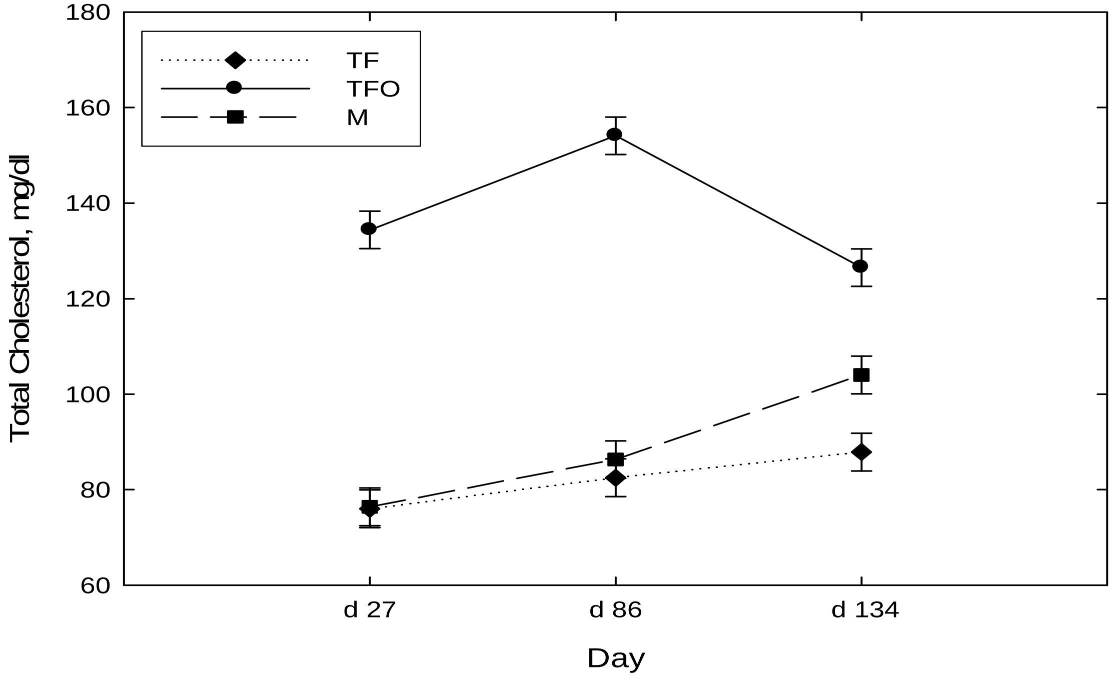

Figure 5. Serum cholesterol concentrations of heifers grazing tall endophyte-infected tall fescue (TF), tall fescue with soybean oil supplementation (TFO), and mixed winter annuals (M) as affected by treatment × days on treatment ($P < 0.01$; SEM = 3.94)

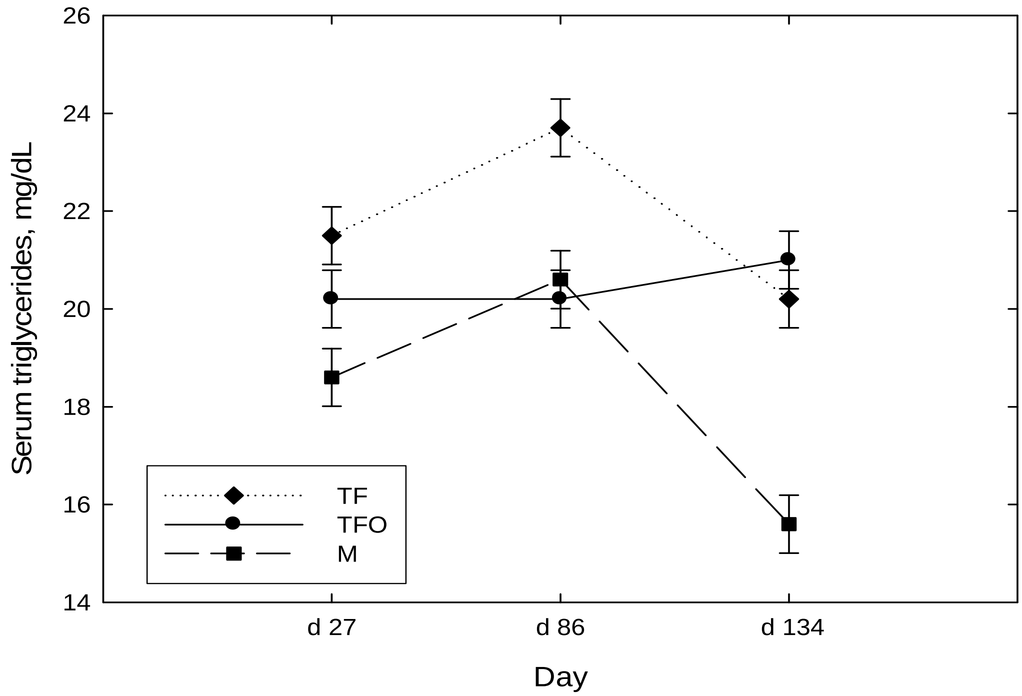

Figure 6. Serum triglyceride concentrations of heifers grazing endophyte-infected tall fescue (TF), tall fescue with soybean oil supplementation (TFO), and mixed winter annuals (M) as affected by dietary treatment × days on treatment ($P < 0.05$; SEM = 0.59)

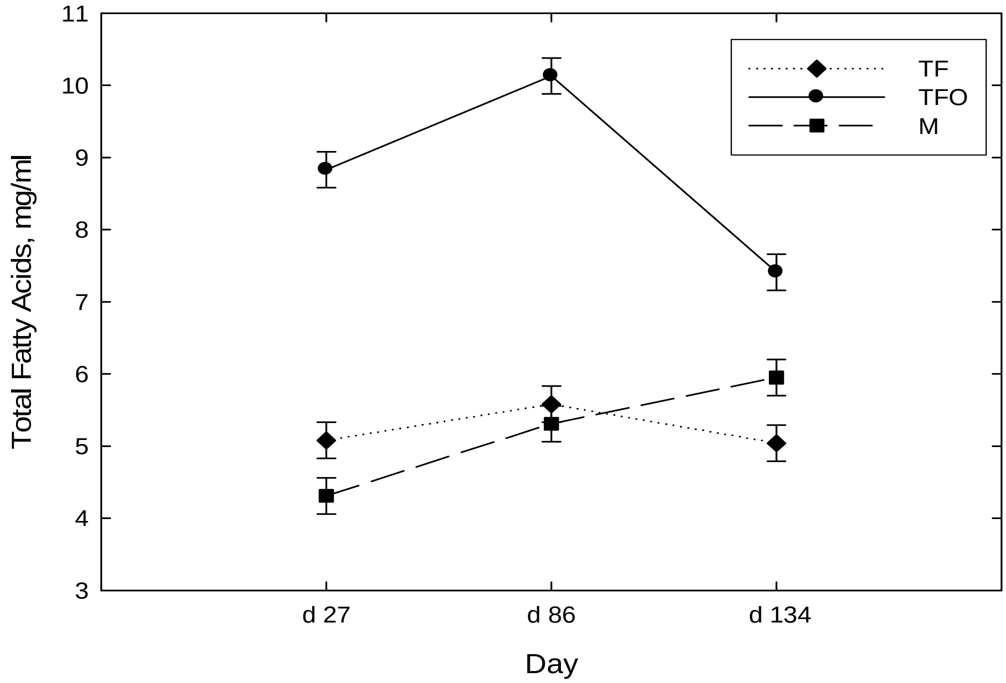

Figure 7. Serum total fatty acids for heifers grazing tall fescue alone (TF), tall fescue with oil supplementation (TFO) or mixed winter annuals (M) as affected by treatment × days on treatment ($P < 0.01$; SEM = 0.25)

Table 1. Composition of free-choice mineral supplement

Item	As-fed basis
Calcium, minimum %	12.00
Calcium, maximum %	14.40
Phosphorus, minimum %	12.00
NaCl, minimum %	11.00
NaCl, maximum %	13.00
Magnesium, minimum %	3.00
Potassium, minimum %	1.20
Sulfur, minimum %	1.75
Cobalt, minimum ppm	50
Copper, minimum ppm	240
Iodine, minimum ppm	70
Manganese, minimum ppm	750
Selenium, ppm	26
Zinc, minimum ppm	950
Vitamin A, minimum IU/lb	100,000
Vitamin D-3, minimum IU/lb	25,000
Vitamin E, minimum IU/lb	25

Table 2. Forage availability (DM basis) of tall fescue (TF), tall fescue supplemented with soybean oil (TFO) or mixed winter annuals (M) across the grazing period

Date	Treatment			
	TF	TFO	M	SEM
Forage availability, kg/ha				
Jan. 2	880[a]	1152[a]	1166[a]	189.5
Jan. 31	1254[a]	1408[a]	1046[a]	241.8
Mar. 3	1115[a]	1259[a]	792[a]	241.8
Apr. 9	1294[a]	1189[a]	1282[a]	268.0
Apr. 30	3064[b]	2235[b]	4872[a]	268.0

[a,b]Means in the same row with different superscripts differ, $P < 0.05$.

Table 3. Forage and supplement fatty acid composition of tall fescue, mixed winter annuals, soy hulls, and soy oil for two sample periods during the grazing season

Fatty Acid, %	Tall Fescue[a]		Mixed Winter Annuals		Soy Hulls[b]	Soy Oil[b]
	January	April	January	April		
C16:0	15.17	15.60	12.59	17.88	13.23	10.52
C18:0	1.92	1.61	1.13	1.93	5.62	3.74
C18:1	4.22	3.68	1.44	3.52	20.53	24.16
C18:2	14.56	13.15	8.93	15.80	47.65	52.10
C18:3	36.14	42.71	57.84	35.29	7.69	6.59
Total Fatty Acids, mg/g	12.5	15.5	21.1	8.7	24.0	7.9g/ml

[a]Forage samples from TF and TFO were composited for fatty acid analysis.

[b]Samples composited.

Table 4. Serum prolactin (PRL) concentrations for heifers on tall fescue (TF), tall fescue supplemented with soybean oil (TFO) and mixed winter annuals (M)

	Treatment		
Item	TF	TFO	M
Initial PRL concentration, ng/mL[a]	24	20	24
Post-treatment PRL concentrations, ng/mL[a]	3[b]	23[c]	67[d]

[a]Data were subjected to square root transformation for statistical analysis. Means are reported untransformed. Because serum PRL data were not normally distributed, the variations around the means are not reported.

[bcd] Row means with a different superscript differ, $P < 0.05$.

Table 5. Serum fatty acid composition (%) for heifers on tall fescue (TF), tall fescue supplemented with soybean oil (TFO) and mixed winter annuals (M)

	Diet						
Fatty Acid, %	TF	TFO	M	SEM	Trt.	Per	Trt. × Per.
Palmitic 16:0							
d 27	12.32[b]	10.29[d]	12.02[b]	0.15	0.01	<.01	0.03
d 86	12.01[b]	9.92[d]	11.93[b]				
d 134	12.08[b]	10.83[c]	13.04[a]				
Stearic 18:0							
d 27	19.71[a]	16.31[b]	20.47[a]	0.37	0.01	0.02	<0.01
d 86	20.6[a]	17.01[b]	20.86[a]				
d 134	20.38[a]	16.86[b]	17.50[b]				
Oleic 18:1							
d 27	10.92[cd]	9.6[d]	14.34[a]	0.63	0.05	0.75	0.30
d 86	11.78[bcd]	10.1[d]	13.74[ab]				
d 134	11.46[cd]	10.53[cd]	12.45[abc]				
Linoleic 18:2							
d 27	23.31[c]	38.11[a]	16.45[d]	0.91	<0.01	0.08	<0.01
d 86	21.08[c]	36.85[ab]	14.96[d]				
d 134	22.57[c]	33.93[b]	22.36[c]				
Linolenic 18:3							
d 27	13.04[b]	5.5[c]	15.71[a]	0.27	<0.01	0.38	0.51
d 86	12.86[b]	5.79[c]	15.20[a]				
d 134	12.35[b]	5.62[c]	15.27[a]				
Arachidonic 20:4							
d 27	4.36[a]	3.14[de]	3.71[b]	0.10	0.04	<0.01	0.02
d 86	3.34[cd]	2.67[f]	3.01[e]				
d 134	3.50[bc]	3.26[cde]	3.23[cde]				

[a-f]Means for each fatty acid with a different superscript differ, $P < 0.05$.

Table 6. Reproductive measures for heifers on tall fescue (TF), tall fescue supplemented with soybean oil (TFO) and mixed winter annuals (M) recorded from d 44 to 104 using remote estrus detection system

Trait	TF	TFO	M	SEM	P-value
Estrous Cycle Duration, days	20.5	23.6	19.8	2.19	0.4
Number of Estrous Cycles, d44-104	0.73	0.75	0.69	0.11	0.9
Mounts per Estrous Cycle	21.8	22.5	13.5	4.5	0.3
Mount Duration, seconds	4.1	3.9	4.2	0.24	0.7
Standing Heat Duration, hours	26.5	21.2	25.6	4.6	0.7
Time of Day of Standing Heat	9:30	11:30	13:45	1:04	0.3
Response to synchronization	10/15	6/16	10/16	—	0.2

Table 7. Reproductive performance for heifers on tall fescue (TF), tall fescue supplemented with soybean oil (TFO) and mixed winter annuals (M)

Item	TF		TFO		M		SE
	No.	%	No.	%	No.	%	
First Service Conception Rate	11/15[a]	73	8/16[b]	50	3/16[c]	19	
Pregnancy Rate	12/15	80	10/16	63	11/16	69	
Services to Conception	1.07[a]		1.17[a]		2.02[b]		0.19
Calving Rate	10/15	67	10/16	63	8/16	50	
Calf Birth Weight, kg	36.0		37.1		34.4		2.8

[abc]Row means with a different superscripts differ, $P < 0.05$.

CONCLUSIONS

Replacement heifer reproduction is an important component of cow-calf production systems. Providing an adequate plane of nutrition for successful reproduction has often been a challenge on toxic tall fescue based forage systems. This study demonstrates that cool-season annuals, toxic tall fescue with oil supplementation, and toxic tall fescue alone grazed in the winter-spring pre-breeding season can provide adequate gains for acceptable reproductive performance.

The relatively high animal gains of heifers grazing TF in this study may be a result of grazing winter stockpiled and early spring growth fescue, both of which research has shown to have relatively low alkaloid levels. Alternative forage and supplementation strategies may prove more beneficial during seasons when toxin concentrations of E+ tall fescue are greater. Because of the increased input costs and risk associated with establishing winter annuals, this may not be a practical solution for producers who are achieving production goals with existing toxic tall fescue systems. However, winter annuals may be useful in reducing the need for hay during the winter when tall fescue availability is limited.

Currently soybean oil is an expensive fat supplementation source and may not increase production to a level that warrants its use. A shorter supplementation period (60 to 90 d prior to breeding season) may be more favorable both in terms of improving reproduction and in cost effectiveness; however, no data currently exists regarding the efficacy of this practice. Further study examining the efficacy of readily available fat supplements is warranted.