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Tall Fescue Based Forage systems Supplemented with Winter Annuals for Stocker Cattle

Brian Thomas Campbell
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Brian Thomas Campbell entitled "Tall Fescue Based Forage systems Supplemented with Winter Annuals for Stocker Cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

John C. Waller, Major Professor

We have read this thesis and recommend its acceptance:

Kelly R. Robbins, Gary E. Bates, James B. Neel

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Tall fescue based forage systems supplemented with winter annuals for stocker cattle

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Brian Thomas Campbell

August, 2008

Abstract

A four year study (2004-2007) was conducted at Highland Rim Research and Education Center near Springfield, TN to compare tall fescue (*Lolium arundinaceum* Schreb.) forage systems in which rye (*Secale cereale* L.)/ryegrass (*Lolium multiflorum* Lam.) was used to supply additional high quality forage to stocker cattle. Twelve 1.2-ha pastures were assigned to two cool-season forages and two forage systems with three replicate pastures each. Cool-season forage treatments were: (1) endophyte-infected (*Neotyphodium coenophialum*) ‘Kentucky-31’ tall fescue and (2) ‘Jesup MaxQ’™ tall fescue. The two forage systems were: (1) stockpiled tall fescue, supplemental feed (a blend of byproduct feeds formulated to provide energy and protein equivalent to tall fescue hay) during winter, spring growth tall fescue and (2) stockpiled tall fescue, rye/ryegrass during winter when available, spring growth tall fescue and rye/ryegrass. Forage systems containing rye/ryegrass were established by drilling 38 kg of rye and 6.8 kg ryegrass in a prepared seedbed in 0.4 ha of the allotted 1.2 ha pasture area. All pastures were clipped in late spring to assure vegetative growth. In late-November, four weaned beef steers were randomly allotted to each pasture based on age, weight, and breed and remained on pastures until mid to late June. Steers grazed rye/ryegrass when it reached average height of 20 cm and were removed at an average height of 8 to 10 cm. Forage heights of rye/ryegrass before and after grazing and the number of days grazing was recorded. When forage was unavailable or insufficient, cattle were fed a byproduct-based supplement. Animal weights were collected on two

consecutive days at the beginning and end of the trial. Data collected at 14-d intervals included: steer weight, forage availability by clipping strips (2 per 0.4-ha pasture), and blood serum for prolactin. Data were analyzed using the MIXED procedure of SAS and differences determined at $P < 0.05$. Steers grazing Jesup MaxQ^{TM} pastures gained more ($P < 0.05$) weight and had higher ($P < 0.05$) serum prolactin levels than those grazing KY-31 regardless of presence of rye/ryegrass.

Table of Contents

List of Tables

List of Figures

Figure **Page**

Introduction

There is an abundance of forage, in the Southeastern US, growing on land that is not suitable for crop production providing a basis for beef production. Beef cattle production in the Southeast is mainly cow/calf operations. With the increasing prices of corn and the subsequent increase in the cost of finishing cattle there has been more emphasis on growing cattle to heavier weights on forage. This creates an opportunity for beef producers in the region to increase their profits by extending the use of their forage resources.

Most of the available forage for these cattle is tall fescue, a perennial cool-season grass. Tall fescue is easily established, and able to withstand drought and heavy grazing pressure, it has a long growing season, making it ideal for part-time farmers in the southeast. Most of the tall fescue is infected with an endophytic fungus (*Neotyphodium coenophialum*) which when grazed by cattle causes a series of signs collectively known as "tall fescue toxicosis." The signs of tall fescue toxicosis include decreased weight gain, dry matter intake, increased respiration rate, and rectal temperature, and a rough hair coat. Mature cows will also have decreased conception rates and produce calves with lower birth weights. The most common outward sign of tall fescue toxicosis is a rough hair coat in late spring and summer when cattle normally have a slick hair coat.

Winter is the most expensive time of the year to feed cattle. Tall fescue has little or no growth during this time of the year and most farmers rely on hay and commercial supplements for feed. Incorporating winter annuals into the pasture system has the possibility of reducing cost of feed through winter and possibly increasing weight per day of age on growing cattle. The addition of these forages should help to fill in gaps in the growth seasons of tall fescue, reducing the amount of supplemental feed and hay needed for stocker cattle. They should provide additional nutrients to support increased weight gain of grazing cattle and possibly reduce the effects of fescue toxicosis.

The objectives of this study were to evaluate the benefits of adding a winter annual mixture of rye and ryegrass to tall fescue pasture systems. To measure animal performance of stocker cattle grazing stockpiled Ky-31 and Jesup MaxQ tall fescue with and without the addition of a rye/ryegrass mixture.

Literature Review

Stocker Production

Improved management of pastures can increase the profitability of pasture land (Hoveland, 1986). In the Southeast there is great potential for cattle to make use of land that is more suited for forage production than crops. Cattle production in the southern US has been mainly a cow/calf production scenario (Allen et al., 2000). This production system is also very inefficient, averaging only 70 kg/ha of calf annually (Hoveland, 1986). Part of the inefficiency comes from the fact that most farms are small and are associated with part time farmers or with crop production (Hoveland, 1986). One of the greatest opportunities for increasing the returns to farmers is by stockering weaned calves (Hoveland, 1986). The goal of stocker operation is to add value to weaned beef calves through a fairly high rate of gain (up to 1.2 kg/head/day) at a low cost in preparation for entering the feedlot (West and Waller, 2007). Stocker cattle are young steers and cull heifers that are grown to heavier weights before going to the feedlot. They average between 180 and 270 kg and the beginning of the stocker phase and will remain there for a set amount of time usually 5 to 7 months. These cattle will enter the feedlot between 270 and 410 kg. The stocker industry has been traditionally in the Midwest with cattle wintered on wheat pastures (Winter and Thompson, 1987). With current high prices for wheat, cattle are no longer grazing wheat pastures.   Within a stocker cattle operation, a producer’s income is based on gain of the animal, normally this is from grazing pasture, primarily tall fescue in the mid-south region of the US.

As of January 1, 2008 there were 195,000 beef steers and heifers above 500 pounds and 520,000 calves below 500 pounds in Tennessee (USDA, 2008). In Tennessee most beef calves are born in late winter to early spring and are weaned and sold in the early fall (Waller et al., 1988). Most of the beef herds in Tennessee will be maintained on tall fescue pastures with some bermuda grass (*Cynodon Dactylon*) in the southern and western parts of the state (Waller et al., 1988). There are an increasing number of calves being retained in order to improve profitability, since weaned calves can efficiently use forage during the winter and early spring (Allen et al., 1992). Most of the bull calves born in the south are sold at weaning. In Louisiana about 90% of male calves born in Louisiana left the state shortly after weaning (Bagley et al., 1988). During the stocker phase calves will make excellent utilization of forages, but few forage systems for stocker calves have been tested (Allen et al., 2000). With the increase in corn prices there is an opportunity for adding weight to calves before they enter the feedlot. In addition to the traditional stocker industry which uses young calves for the feedlot, beef producers are raising replacement heifers using the same program for stocker cattle. These producers can also benefit from better forage utilization allowing heifers to reach proper body condition for breeding at an earlier age.

Forage Resources

In Tennessee the predominant forage is tall fescue, most of which is infected with an endophytic fungus. Tall fescue covers approximately 1.4 million ha in Tennessee (Hilty and Long, 1984). The dominance of tall fescue is not limited to Tennessee but extends through the entire transition zone (West and Waller, 2007). In the Southeastern US, tall fescue makes up the basis of most forage resources (Allen et al., 2000). Most stocker steers are spring born calves that will be weaned in early fall and either sold from the farm and go directly to either a feedlot or a stocker operation. The cattle enter the stocker phase at approximately 226 kg. A producer has three options for growing these cattle through the winter. The calves can either be fed hay that has been harvested from extra growth from spring pastures; they can be fed a commercial supplement, or they can be wintered on stockpiled tall fescue. The least expensive option would be stockpiled tall fescue as there are no added costs due to harvesting because the animals are grazing the forage.

The introduction of winter annuals can offer a high quality forage alternative to feeding hay or other supplements through the winter (Curtis and Kallenbach, 2007). Small grains incorporated into a pasture system can provide excellent winter forage for stocker cattle and planting in early September can give grazing from late October through May (Hubbell et al., 2000). The practice of overseeding tall fescue with winter annuals is not a viable option since the tall fescue is actively growing at planting. The annuals cannot compete with established and growing tall fescue.

Tall Fescue

Beef producers in Tennessee have either Kentucky 31 (KY-31) tall fescue infected with *N. coenophialum* (E+) or the newer tall fescue that does not produce ergovaline (Jesup MaxQ). The vast majority of the tall fescue available is the traditional endophyte infected KY-31. Some of the pastures that have been reestablished in recent years have used Jesup MaxQ tall fescue (MaxQ). Stocker operators and horse producers have planted most of the acreage now in MaxQ. The claims for MaxQ include total elimination of the negative signs associated with tall fescue toxicosis and thus increased profits (Beck et al., 2008).

Tall Fescue (*Lolium arundinaceum* Schreb.), a perennial bunch grass, is the most prevalent forage grass in the Southeastern US with the most prevalent strain of tall fescue being Kentucky 31(Stuedemann and Hoveland, 1988) Tall Fescue is found in what is known as the fescue belt, covering over 14 million ha in the southeastern US (Paterson et al., 1995) mainly in the “transition zone” which encompasses southern Illinois and Ohio, south to northern Mississippi and Georgia, west to eastern Oklahoma, and east to the Piedmont of Virginia and the Carolinas (Fribourg et al., 1991). This unique environment has the conditions which allow for both cool and warm season forage species to be utilized by producers (West and Waller, 2007). This is important because the transition zone is home to more than 20% of the beef cows in the US and most of these are grazing tall fescue (West and Waller, 2007).

Tall Fescue is favorable forage for many reasons. Tall fescue has a fall growth period from mid-September to early December and a spring growth period from early March to late June (Ball et al., 2006). It is easily established, and adaptable to a wide range of environments. Tall fescue is tolerant of grazing pressure and hervibivory by animals and insects (Hill et al., 1991). Most of these positive attributes associated with tall fescue are directly or indirectly linked to the presence of the endophyte (*N. coenophialum*). This endophytic fungus (*N. coenophialum*) lives between the cells of the plant. There are no spores or outward signs of the infection as the fungus will complete its entire lifecycle between the cell walls of the plant (Bacon, 1995).

Endophyte-infected tall fescue is very resistant to drought. In a study where E+ and endophyte-free (E-) plants were placed under drought stress, the E- plants died while the E+ plants experienced death of leaf tissue but the basal areas of the plants remained green and all plants survived (Arechavaleta et al., 1989). This hardiness will help the producer as well because the E+ forage requires less management than many other types of forage because it can withstand external stressors. The reduction in required management of the forage fits well in the southeast where most producers are part-time farmers.

Tall Fescue Toxicosis

When consumed by livestock including ruminants and non-ruminants, such as cattle, goats, sheep, and horses this fungus causes a disorder commonly referred to as “Tall Fescue Toxicosis”. Historically there have been three maladies associated with animals consuming E+ tall fescue. These include: Summer Slump, Fescue Foot, and Fat Necrosis. Tall fescue toxicosis (commonly used to describe summer slump) has been shown to cause reduced weight gain, reduced daily feed intake, as well as decreased reproduction rates, and can delay the onset of puberty (Jones et al., 2003). Fescue toxicosis is also linked to reduced blood flow to the peripheral which causes the effects of heat stress. A high endophyte diet has been shown to reduce blood flow to both the core and the periphery reducing the ability of the animal to dissipate heat (Rhodes et al., 1991). These signs are not seen until ambient temperatures exceed 32°C (Hemken et al., 1981). However others have reported signs of tall fescue toxicosis when temperatures are below 32ºC (Paterson et al., 2003).

It has been reported that there are ergot alkaloids produced by the fungus are in all parts of the plant that are visible above ground (Lyons et al., 1986). In vitro studies have shown that the alkaloids are absent in uninfected plants (Lyons et al., 1986). Ergovaline, an ergopeptide and known dopamine agonist that is produced by the endophyte has been implicated as the primary cause of the toxicosis (Yates et al., 1985). The effects of fescue toxicosis have been shown to vary with the level of infestation in the plant and thus the amount of toxin consumed by cattle. Fribourg et al., (1991) reported that as the level of E+ tall fescue decreased from 80% to 3% the signs of fescue toxicosis decreased while the average daily gains of the cattle increased. It has been reported that the toxicosis will reduce blood flow to the skin (Rhodes et al., 1991) reducing the evaporative cooling effects (Aldrich et al., 1993) while increasing the energy expenditure (Zanzalari et al., 1989). Collectively these problems will result in reduced ruminant productivity when grazing E+ tall fescue and this decrease in productivity will be compounded during the summer months when the ambient temperature is above 32°C. Even with these problems, the endophyte does have some favorable characteristics it allows for easy establishment of the forage, it gives fescue an excellent tolerance to drought, as well as insects, and it allows it to withstand heavy grazing pressure.

Fescue Foot

Fescue foot is a problem that is sometimes seen in cattle grazing endophyte infected tall fescue. This is the most severe form of the toxicosis and results in gangrene of the animal's extremities that closely resembles ergotism (Lyons et al., 1986). These problems seem to occur in the colder areas of the fescue growing region and the winters in the southern region (Bacon, 1995). Fescue foot was first reported in New Zealand. When cattle were placed on tall fescue pastures, "within a fortnight" cattle became lame. This was generally seen first in the left hind foot and would sometimes be seen in the right hind foot (Cunningham, 1948). Hyperemia generally coupled with swelling occurs at the coronary band between the dewclaw and the hoof (Hemken et al., 1981). If the cattle are not removed from the (E+) pasture and placed on feed that does not contain the toxins, the hooves may begin to slough followed by a loss of limb between the dewclaw and the hoof (Hemken et al., 1981). This sign of the toxicosis is generally seen in the late fall and winter but it has been reported at other times (Hemken et al., 1981). Fescue foot is the most severe form of the toxicosis but it is also the least seen, and is not a widespread problem in the beef industry.

Fat Necrosis

Fat Necrosis has been described as necrotic fat that deposits in different shapes and sizes in the mesentery of the abdominal cavity of an animal (Smith et al., 2004) This has been seen in cattle, pigs, horses, and Eld's deer (Smith et al., 2004). There have been links between cattle grazing tall fescue pastures that have been highly fertilized with nitrogen to the frequency of these necrotic fat deposits (Stuedemann et al., 1985). Additionally, there is an association between low blood cholesterol concentrations and fat necrosis in brood cows (Stuedemann et al., 1985). The necrotic fat will contain more crude protein and ash, with less ether-extractable material than non-necrotic fat (Stuedemann et al., 1985). Fat necrosis can be a serious problem leading to death in some cases. Stuedemann et al., (1985) reported that cows died as a direct result of intestinal constriction by hard fat and others died as a result of fat which encompassed the omasum. However, the role of the endophyte toxins and metabolites in fat necrosis is not fully understood (Bacon, 1995).

Alleviation of Tall Fescue Toxicosis

In the pursuit of finding a way to alleviate the problems of tall fescue toxicosis, several experiments have been conducted to learn the most profitable method to decrease the signs of the toxicosis associated with tall fescue. Researchers have tried removing the fungus from the plant, used dopamine to reduce the effects of ergovaline, as well as over seeding with clovers and other legumes to dilute the effects.

Planting non-infected tall fescue was the first method tried. When compared with E+ fescue endophyte-free tall fescue (E-) showed improved average daily gains from 30 to 100% while being able to maintain normal reproduction as well as milk production (Hoveland, 1993). However, removal of the endophyte caused plant longevity and hardiness to be greatly reduced (Read and Camp, 1986). When compared in a greenhouse leaf blade thickness was reported to be 18% greater at 60 days and 25% greater at 160 days at low nitrogen levels in endophyte infected plants when compared to endophyte free plants, but at higher nitrogen levels this was not seen (Arechavaleta et al., 1989). At high nitrogen fertilization rates, the herbage mass of E+ fescue was greater than that of E- plants, also regrowth of E+ tall fescue plants was more rapid that that of E- plants (Arechavaleta et al., 1989).

Based on the importance of endophyte presence for plant persistence, others have selected for plants that contain an endophyte that produces low levels of the toxins. The selection for plants that contain endophytes that produce none or low levels of ergovaline could have great benefits on cattle production (Agee and Hill, 1994). Steers grazing tall fescue infected with a novel endophyte produced higher ADG than steers grazing E+ KY-31 tall fescue. Beck et al., (2008) reported ADG of 0.55 kg for cattle gazing KY-31 and 0.78 kg for those grazing MaxQ during fall and winter. During the spring they reported an ADG of 0.45 kg for cattle grazing KY-31 and 0.92 kg for cattle grazing novel endophyte were reported. Economic analysis has indicated that if the infection rate in the pasture were above 74% then there was an economic benefit in establishment of a novel endophyte infected pasture based on net present value (Zhuang et al., 2005). The stocking rate on the pastures has an impact on the profitability of replacing the pastures. Those farmers who are stocking at a relatively high rate may find it more profitable to re-establish the pastures over those who have a lower stocking rate (Zhuang et al., 2005).

Overseeding tall fescue pastures with clovers and other legumes has been shown to help alleviate the effects of the toxicosis in the cattle grazing fescue, as well as increasing the digestibility of the forage. Lusby et al., (1990) showed that steers that grazed a tall fescue/clover combination had higher gains in both the stocker phase and the feedlot than those steers that grazed only low or high endophyte tall fescue. An added benefit of overseeding with legumes is that it will also reduce the need for nitrogen fertilizer in pastures. White clover (*Trifolium repens L.)* is the predominant legume seeded with tall fescue, but red clover (*Trifolium pratense L.*) is also used. A common claim is often made that the higher performance of animals consuming E+ tall fescue with the addition of clovers is attributable to dilution of the toxins. However, increased animal performance is found when animals consume E- tall fescue, orchardgrass, and bermudagrass pastures when clover is present.

Ergot alkaloids produced by the fungus in E+ tall fescue act as dopamine agonists which can cause depression in circulating serum prolactin (PRL) concentration in cattle consuming E+ tall fescue. The use of dopamine antagonists have been show to increase the levels of PRL circulating in animals that are grazing E+ tall fescue (Lipham et al., 1989). This increase in PRL levels would show that the toxicosis is reduced by the administration of dopamine. Domperidone, when given to cattle, has been shown to maintain normal ADG, as well as maintaining normal levels of circulating progesterone leading to the conclusion that treatment with dopamine can stop the effects of the toxicosis (Jones et al., 2003). Dopamine antagonists have been shown to be helpful in the reduction of tall fescue toxicosis not only in cattle but in horses as well. Domperidone has been shown to greatly reduce the effects of the toxicosis in horses without the side effects of other dopamine antagonists (Redmond et al., 1994)

Stockpiling Tall Fescue

The practice of stockpiling is allowing forage to accumulate in the pasture in the fall to supply forage for animals to graze in late fall and early winter. Stockpiled forage is mostly vegetative and usually grazed rather than harvested for hay (Allen et al., 2000). Stockpiled tall fescue has been shown to be an economical and efficient way to store forage into the winter (Waller et al., 1988). Stockpiling also has the advantage of lowered costs due to elimination of labor costs involved with producing and feeding hay. Stockpiling tall fescue has been show to provide forage with high dry matter digestibility into the winter (Brown et al., 1963). It has been reported that stockpiling tall fescue through the late summer and fall growing season can provide high quality forage for stocker cattle beginning in November (Bagley et al., 1988). The herbage mass and nutritive value of the stockpiled tall fescue remains mainly unchanged over the course of the winter but by late winter the ergovaline concentrations of tall fescue have declined to low levels (Kallenbach et al., 2003). Allen et al., (1992) reported that mature beef cows grazing stockpiled forage required less hay to maintain an ideal body condition score (BCS) than cows without access to stockpiled forage. Cattle grazing stockpiled tall fescue have greater gains than those consuming hay or silage made from similar fescue (Allen et al., 1992).

Stockpiled tall fescue is also a way to reduce the amount of supplement that needs to be fed. In a study comparing heifers on dry lot consuming hay to heifers consuming stockpiled forage, it was reported that heifers on dry lot were supplemented with 0.8 kg of DM from corn gluten feed while heifers grazing stockpiled forage only needed 0.1 kg of DM corn gluten feed to maintain adequate body weight (Driskill et al., 2007). Stockpiling tall fescue has also been shown to meet the requirements for growing heifers although there may be a lower than expected ADG due to lower DM intake (Poore et al., 2006). Stockpiling tall fescue is highly dependent upon climate conditions, mainly fall rainfall and late freezes (Waller et al., 1988). Stockpiling is an alternative to feeding hay or a commercial supplement especially when there is adequate moisture for fall forage growth.

Winter Annuals

Reducing the cost of feeding cattle over the winter is very important in increasing the profitability of cattle production in the southeast. Winter annuals can increase the forage available to stocker cattle and should result in increased weight. Most of the research conducted with winter annuals involved conventional tillage. When ryegrass was compared with combinations of either rye or ryegrass to wheat and ryegrass reported that the in vitro dry matter digestibility (IVDMD) concentrations for a rye and ryegrass combination were higher than that of ryegrass alone (Coffey et al., 2002). The addition of winter annuals to a pasture system could allow for reduced hay feeding during the winter and allow cattlemen to retain ownership for the traditionally more favorable spring market (Coffey et al., 2002). The addition of small grains into a forage system has been shown to reduce the cost of production while increasing the ADG. Average daily gain of stocker cattle was highest and the cost of production lowest for those cattle grazing ryegrass followed by a rye and ryegrass mixture (Daniels et al., 2004). It has also been reported that gain per acre during the spring was highest on winter annuals when compared to tall fescue with different legumes and nitrogen fertilizer rates (Hoveland et al., 1991).

Gain from animals grazing sod seeded winter annuals has been shown to be higher than those grazing winter annuals planted in a prepared seedbed. In a study conducted in Tifton, Georgia which used 16 two-acre pastures and compared winter annuals, summer annuals and perennials, it was reported that steers grazing winter annuals drilled into prepared seedbeds had higher average daily gains. Those steers grazing winter annuals in a prepared seedbed gained 1.05 kg per day while those grazing sod seeded winter annuals gained 1.12 kg per day. Yet the stocking rate was higher with prepared seedbeds and those pastures produced gains of 504 kg/ha while the sod seeded pastures produced only 250 kg/ha (Utley et al., 1976).

Annual ryegrass is a cool season pasture grass that is generally grown in the southeastern US. This forage has the ability to produce a high yield and can be high quality forage for grazing (Vendramini et al., 2006). Because of the benefits of annual ryegrass it makes an excellent addition to forage systems when combined with small-grain rye. Rye initiates growth earlier in fall and winter than ryegrass and will help to provide earlier grazing in the winter when the supply of stockpiled tall fescue is dwindling (Vendramini et al., 2006). The growing season of rye and ryegrass is from around Mid-November until Mid-April to May (Ball et al., 2006). With this growing season it makes an ideal compliment to tall fescue in a forage system, because it helps to fill in times during the year where there is little tall fescue forage growth. The addition of winter annuals to a pasture system may be able to increase the grazing days on a pasture, allowing producers to hold cattle longer without having to purchase additional supplement.

Cattle prices vary through out the year. For most weights of cattle the highest prices are generally in April and May with a decline in the fall. This is generally due to simple supply and demand. Most cow calf producers will sell calves after weaning in the fall and the increased supply will cause a decrease in price. Growing cattle through a stocker program can allow the producer to obtain higher prices for their cattle and extend the use of their forage resource. However it is important to note that as the cattle increase in weight the $/kg generally decreases so selling at the height of the market may not be the best time to sell depending on the price spread between light and heavy cattle (McKinnon and Snodgrass, 2000)

In Tennessee and most of the southeast tall fescue makes up the bulk of the forage base. The majority of the tall fescue is KY-31 E+ with Jesup MaxQ planting increasing primarily for stocker and horse operations. Stocker producers have 3 options for winter feeding, either stockpiled fescue, hay, or commercial feeds. The most cost effective method is stockpiling. Even with stockpiling there is still the need for some additional feeding. Winter annuals can help to fill this void, because they are high quality forages that will grow when fescue is dormant. The objective of this study was to evaluate the effectiveness of planting winter annuals in a tall fescue based forage system. These annuals should increase the amount of forage for grazing, the quality of the forage, and decrease the cost of winter feeding.

Materials and Methods

General Procedures

Twelve 1.2 ha pastures used for this study were part of previous grazing trials at the Highland Rim Research and Education Center near Springfield, TN (36^o 28'N, 86^o 50'W). There were four pasture systems with three replications. Pasture systems were: 1) KY-31 E+ tall fescue; 2) KY-31 E+ tall fescue with rye/ryegrass; 3) Jesup MaxQ tall fescue; and 4) Jesup MaxQ tall Fescue with rye/ryegrass. System 1 was 1.2 ha of KY-31 E+ tall fescue. This tall fescue was infected with the “wild type” of endophyte that produces alkaloids that induce the signs of tall fescue toxicosis. System 2 was 0.8 ha of KY-31 E+ tall fescue and an annual planting of 0.4 ha rye and ryegrass. System 3 was 1.2 ha of Jesup MaxQ tall fescue. This fescue is infected with the MaxQ endophyte which does not produce ergovaline and when consumed by cattle should not induce fescue toxicosis. System 4 was 0.8 ha of Jesup MaxQ tall fescue and an annual planting of 0.4 ha of rye and ryegrass.

In August of each year all tall fescue pastures were clipped and fertilized with 27.12 kg of nitrogen per ha. Tall fescue was stockpiled from September through November. One half of the pastures, systems 2 and 4, were planted by drilling a rye/ryegrass mixture into a prepared seed bed. Systems 1 and 3, tall fescue was stockpiled in the fall by applying nitrogen fertilizer at a rate of 27.12 kg/ha and were allowed to grow from September until early November. This was designed to supply forage for animals to graze through early winter. In all pastures when forage heights were estimated to be below 8 cm a blended supplement was fed at the rate of 4 kg/steer/day.

In systems 2 and 4, the 0.4 ha areas designated for rye/ryegrass mixture were then prepared through conventional tillage and 95.25 kg/ha of rye and 17 kg/ha of annual ryegrass, from separate seed boxes, were drilled into the prepared seed bed. In the first year of the study these areas were sprayed with glyphosate to kill the existing tall fescue stands. In spring all pastures were fertilized with 20.4 kg Nitrogen/ha in a balanced fertilizer, to obtain medium fertility levels according to soil tests.

Animals

During year 1 (*Bos taurus*), six steers were placed in each pasture. In the three subsequent years, four steers were grazed in each pasture. Beginning weights of the steers averaged 200 kg. The steers were weighed every 14 days, and blood samples and rectal temperatures were taken. Blood samples were used for serum prolactin analysis. These were analyzed using the procedure described by Bernard et al., (1993). Steers were weighed on two consecutive days at the stat and cessation of grazing. The weights were used to calculate average daily gain (ADG) for each individual animal. Hair coat scores were also determined on the last weigh date of each year by a trained individual. Hair coat scores were determined on a 1-5 system for cattle: 1 = slicked off shiny coat with no retained hair; 2 = <25% of body covered in dead unshed hair; 25-50% of body covered in dead unshed hair; 4 = 50-75% of body covered in dead unshed hair; 5

= >50% of body covered in dead unshed hair, with evidence of having laid in mud deliberately (Saker et al., 2001)

Grazing Seasons

The fall-winter grazing season was from November through mid-March; the spring grazing season was from mid-March and through late June. Steers were allowed on the rye/ryegrass sections of the pasture when the forage height reached approximately 20 cm in the rye/ryegrass sections and steers were removed when the forage was grazed to approximately 10 cm. The number of days where cattle were grazing rye/ryegrass was recorded.

Supplement

When forage availability was too low to support adequate intake (height less than 10 cm), a supplement, blended from commodities, was fed at the rate of 4.08 kg/steer/day and the number of days a supplement was fed was recorded. The supplement was used to replace hay feeding in the study. The supplement was blended from citrus pulp, cracked corn, cottonseed hulls, cottonseed meal, and molasses. This blend was designed to mimic the nutrient profile of medium quality tall fescue hay. The supplement was contained for 8.66% crude protein, 21.53% crude fiber and estimated total digestible nutrients (TDN) of 71%.

Price Determination

Supplement prices were determined using March prices based on Atlanta market except for molasses which was based on the Memphis market. The cost of rye and ryegrass pastures was estimated using budgets developed by University of Tennessee economic specialists (Bowling, 2008).

Forage Collection

Forages were collected every two weeks during the trial when the grass was growing. The samples were taken via lawnmower in swaths that were 0.53 m wide and 3.05 m long to a height of 2.5 cm. The samples were weighed, mixed, sub sampled with one for each pasture for each sampling date. The samples were dried at 60°C for 24 hours. The dry weights were used to estimate the forage availability for each pasture. The samples were ground to pass a 1 mm Wiley Mill Screen. The samples were then subsequently ground to pass a 0.5 mm screen in a UDY Cyclone Mill. The samples were analyzed for dry matter (Redmond et al.), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP) via Near-Infrared Reflectance Spectroscopy (NIR) on (Foss NIR Systems, Model 5000) using the method of scanning, calibration and validation as described by Westerhaus et al., (2004).

Near Infrared Spectroscopy

Calibration of the NIR was accomplished by running routine diagnostics to ensure that the diagnostics tests were in date and still applicable. Once all tests were passed and the internal standardization was set, the samples were then placed in a ¼ full rectangular transport cup, with enough sample to completely cover the glass face of the transport cup. The samples were scanned and spectra were stored. Once all samples had been scanned the select algorithm was used to determine a representative sample to perform wet chemistry on in order to create a regression equation that could be applied to samples. The equation was applied to the saved spectral values and values were generated for DM, Ash, NDF, ADF, and CP.

Dry Matter

Dry matter was analyzed for calibration of the NIR by weighing 0.5 grams of dried forage sample, in duplicate, to 1/10000th g on a Mettler-Toledo AB104 analytical balance (Mettler-Toledo, Inc., Columbus, OH, 43240) into a dry crucible. The crucibles plus samples were then dried in a Baxter DK-63 100°C forced air oven over night. The samples and crucibles were removed and placed in a desiccator for approximately two hours, and were then weighed to 1/10000thg on the same balance as before. Dry Matter was determined by the formula: DM% = (dry sample weight (g) / wet sample weight (g)) x 100

Ash

Ash for calibration of the NIR was determined by using the dry sample used for DM calculation. The samples were placed in a muffle furnace over night at 600°C (L&L Hot Box XL Industrial Furnace L&L Special Furnace Company Aston, PA 19014). The crucibles were removed and placed in a desiccator for approximately 3 hours. The samples were weighed to 1/10000th g on the same balance that was used for DM. The ash content of the sample was determined by the formula: Ash% = (ash sample weight (g) / dry sample weight (g)) x 100

Crude Protein

Samples for protein were analyzed on a LECO FT2000 nitrogen analyzer (LECO St. Joseph, Michigan 49085) using the AOAC official method 990.03.

Samples were weighed to 0.5 g to 1/10000thg, in duplicate, on a Mettler-Toledo AB104 analytical balance (Mettler-Toledo, Inc., Columbus, OH, 43240) to 1/10000thg. The samples were combusted at 950°C in an environment of 99.99% oxygen, and nitrogen released was measured. Percent protein was estimated with the following formula: CP = percent nitrogen times 6.25

Neutral Detergent Fiber

Samples for NDF determination were weighed, in duplicate, on a Mettler-Toledo AB104 analytical balance (Mettler-Toledo, Inc., Columbus, OH, 43240) to 0.5 g to 1/10000thg. The samples were then placed in Ankom F57 fiber bags (Ankom Technology, Macedon, NY, 14502) and double sealed with an impulse heat sealer (The J.J. Elemer Corporation, St. Louis, MO, 63146). The samples were placed in the Ankom 200 fiber analyzer (Ankom Technology, Macedon, NY, 14502) and 2000mL NDF solution (Ankom Technology, Macedon, NY, 14502) was added for 75 min, this allowed 15 min for heating to 100°C and then the 100°C temperature was maintained for 1 hour. The NDF solution was drained and a series of three washes was performed. The washes consisted of covering the samples with water and heating to a temperature of approximately 92°C and agitating for 5 min. The samples were removed, patted dry and placed in acetone for five min. After being soaked in acetone, the samples were patted dry and allowed to air dry in the chemical hood until dry to the touch. The samples were then placed in a forced air drying oven at 100°C over night and after removal were placed in Moisture Stop™ weigh pouches (Ankom Technology, Macedon, NY, 14502) for approximately 1 hour before being weighed.

Acid Detergent Fiber

The same sample bags used in the NDF procedure above were placed back in the Ankom 200 Fiber analyzer and were covered with 2000mL of ADF solution (Ankom Technology, Macedon, NY, 14502). These samples were maintained at 100°C for 75 min, as with the NDF procedure. The ADF solution was drained and a series of six washes was performed. The first three washes were fast washes. Water was added to the fiber analyzer and was then heated to approximately 92°C, and was drained and repeated two more times. The subsequent three washes were longer washes of the same manner as those described for NDF. After all washes the samples were removed, patted dry, and allowed to soak in acetone for 5 min. Afterwards the acetone was removed and the samples were patted dry and placed in the chemical hood until they were dry to the touch. After air drying the samples were placed in the forced air oven at 100°C over night. They were then placed in a Moisture Stop™ weigh pouch (Ankom Technology., Macedon, NY, 14502) for approximately one hour and were then weighed to 1/10000thg.

Prolactin

Blood samples, approximately 8 mL, were taken via jugular vena puncture into a Luer-Monovette with serum clotting activator (Sarstedt, Inc. Newton, NC). They were then inverted several times and placed in a cooler with ice and allowed to clot. The samples were then centrifuged at 3000 rpm for 20 min in order to separate serum. Serum was poured off into 15x45 mm glass vials and frozen. Prolactin concentrations were determined on each serum sample by radioimmunoassay as described by Bernard et al., (1993)

Experimental design and Statistical analysis

The experiment was conducted over four years (2004-2007) in a randomized block design with factorial arrangement of treatment. The first year 72 crossbred steers were randomly assigned to twelve 1.2-ha pastures and the following 3 years 48 crossbred steers were randomly assigned to twelve 1.2-ha pastures. Each year there were 3 replications of each treatment. The first year there were 6 steers per pastures and the subsequent 3 years there were 4 steers per pastures. Data were analyzed using PROC MIXED, mixed model analysis of SAS (SAS, 9.1, 2002). Fixed effects were type of fescue and rye/ryegrass treatment for serum prolactin, ADG, HCS, and RT.

Results and Discussion

Pastures and Forage

Greater than 52% of the tiller samples of Kentucky 31 and Jesup MaxQ tall fescue pastures were infected with an endophytic fungus. These levels of infection indicate the fungus was present at sufficient levels to assure the pastures were infested. However, ergovaline levels in KY-31 were 325 to 340 ppb while ergovaline levels in Jesup MaxQ were < 50 ppb. The ergovaline levels in KY-31 are typical of those seen in pastures where cattle have signs of tall fescue toxicosis. (Cornell et al., 1990). The low levels of ergovaline in Jesup MaxQ was similar to those reported by Parish et al., (2003)

All tall fescue pastures were successfully stockpiled each of the four years of the study. The 0.4 ha of rye/ryegrass used in Systems 2 and 4 were successfully established each year. However in year one, there was more rye present than ryegrass. In all years stands of rye/ryegrass were sufficient to produce at least 97grazing days. The range of grazing days for rye/ryegrass was 25 to 77 per pasture (Figure B4; all tables and figures are in the appendix). The steers on KY-31 grazed rye/ryegrass for an average of 52 days and the steers grazing MaxQ grazed rye/ryegrass for an average of 51 days. During the first year, steers began grazing the pastures on December 17, 2003 and the steers were removed from the pastures on June 23, 2004 for a total of 190 grazing days. In the second year, the steers began grazing on November 11, 2004 and were removed from the pasture on June 22, 2005 for a total of 224 grazing days. In year three, grazing began on November 21, 2005 and ended on July 16, 2006 for a total of 239 grazing days. In year four, grazing began on December 5, 2006 and the study was terminated on June 20, 2007 for a total of 197 grazing days.

The nutrient content of clipped forage samples are presented in figures 1, 2, and 3. Crude protein content was below the recommended level for these steers during January and February (Figure B1). The levels of ADF were highest in January and February. Kallenbach et al., (2003) found similar levels. This is probably due to the age of the stockpiled fescue. The levels of ADF (Figure B2) and NDF (Figure B3) remain relatively constant over the grazing season indicating the stocking rate used during this trial assured the animals were consuming vegetative growth. The fiber (ADF and NDF) composition would have increased over the grazing season if excess forage was available and allowed to mature. The NDF decline in late spring may have resulted in an increase in dry matter intake which would explain the improved ADG during late spring.

There was no significant difference ($P > 0.05$) in nutrient composition of forage. This lack of difference in nutrient composition between KY-31 and MaxQ has been reported by (Nihsen et al., 2004). Therefore the difference in animal performance of cattle grazing tall fescue differing in ergovaline levels cannot be explained by differences in nutrient content in tall fescue.

The rye/ryegrass pastures were evaluated for the same nutrient content as the entire pastures were. The CP, NDF, and ADF values are 19.49, 56.59, and 30.88% respectively.

Average daily gain

The total grazing season was divided into a fall-winter grazing season and a spring grazing season for each year. The fall-winter grazing season was from initiation of the study until the weigh day closest to March 15th. The spring grazing season was from the closest weigh day to March 15th until the termination of grazing in June. Average daily gain was also calculated for the entire study. In year one, ADG of cattle grazing MaxQ with rye/ryegrass was different from those grazing KY-31(P <0.0001). In year two, there were no differences (P > 0.05) among any of the treatments. However the average daily gains for that year were the lowest for all four years so the lack of difference is an effect of the year. Year three, both KY-31 and MaxQ with rye/ryegrass had a lower ADG than the steers grazing the treatments without rye/ryegrass (P > 0.0001). This was an unexpected result because rye/ryegrass should have provided higher quality forage than tall fescue alone. In year four there was no significant difference (P >0.05) among the treatments. There was no significant difference (P > 0.05) in ADG among treatments in the fall-winter of the year when ADG was averaged over all years. However this is the time of the year when tall fescue toxicosis signs are rarely observed. Results were consistent with those reported by Hopkins and Alison, (2006) when grazing “GA-5 MaxQ” and KY-31 tall fescue the ADG during the fall-winter was similar.

Steers ADG during the spring grazing season were higher than in the fall-winter grazing season and there were larger differences among treatments (Table A3). In year one, steers grazing MaxQ had a higher (P >0.0001) ADG than all of the other treatments. In year two, steers grazing KY-31 had a significantly lower (*P* > 0.0001) ADG than all other treatments. In the spring of year two there was not the depression in ADG that was observed during the fall-winter grazing season of the same year. In years three and four steers grazing MaxQ pastures with and without rye/ryegrass had higher (*P* < 0.0001) ADG than steers grazing KY-31 and KY-31 with rye/ryegrass. The differences observed during year three and four were similar to those found when ADG was averaged for all four years (*P* < 0.0001). The animal performance observed in this study was consistent with the reports of others (Gunter and Beck, 2004; Parish et al., 2003). During the spring grazing season the ambient temperature increases and differences in ADG of cattle grazing tall fescue with different levels of ergovaline have been observed (Parish et al., 2003).

The ADG for the entire grazing season is presented in Table A4. During the first year of the study, steers grazing MaxQ had higher ADG (*P* < 0.0001) than all other treatments. This was also observed during the spring grazing season of year one. In year two, steers grazing MaxQ with rye/ryegrass had the highest ADG (*P* < 0.0001) and this was significantly higher than both KY-31 treatments. Year three, steers grazing MaxQ had the highest ADG (P <0.0001) followed by those grazing MaxQ with rye/ryegrass with those grazing both KY-31 treatments being the lowest. In Year 4 and for all years there was a significant difference (P < 0.0001) between the ADG of steers grazing MaxQ treatments and those grazing KY-31 treatments. The difference in ADG between the “wild type” and novel endophytes (MaxQ) was also reported by Parish et al., (2003) and

Hopkins and Alison, (2006). The increase in ADG in the spring can lead to stocker producers filling their contracts based on weight faster when cattle are grazing MaxQ rather that E+ tall fescue pastures. Knowing ADG from forages will allow stocker producers to better estimate when the cattle will reach the desired weight should help to insure that their contracts are met on time.

Rectal temperatures

Rectal temperatures of steers grazing MaxQ with rye/ryegrass during year one had lower ($P < 0.0001$) rectal temperatures than steers grazing all other treatments (Table A5). This was the lowest temperature observed for any treatment for the entire trial and is a year effect. In years two and three there were no differences ($P > 0.05$) among any of the treatments. During year four and when all years are averaged together there was a difference ($P > 0.0001$) between the MaxQ pastures and the KY-31 pastures regardless of the presence of rye/ryegrass. The elevation of rectal temperatures has been used as one of the classic signs for detecting tall fescue toxicosis. This is caused by vaso-constriction leading to a reduction in the ability of the body to dissipate heat. The growth of rye and ryegrass slows during the warmer months when signs of tall fescue toxicosis are the most severe. This is why there is no effect on the rectal temperatures during this time, as they do not have the ability to graze the rye/ryegrass to dilute the effects of the toxins from tall fescue (Oliver et al., 1993).

Hair Coat Scores

Hair coat scores were analyzed and the type of fescue the steers were grazing had a significant effect (Table A7). In Year one, steers grazing KY-31 with and without rye/ryegrass had the highest ($P < 0.0001$) hair coat scores while those grazing MaxQ without rye/ryegrass had the lowest. In year two, steers grazing KY-31 had the highest hair coat score but those grazing KY-31 with rye/ryegrass was significantly lower ($P < 0.0001$). This difference may be due to a better stand of ryegrass in year two. During year thee the steers grazing KY-31 had the highest hair coat scores ($P < 0.0001$), those grazing KY-31 with rye/ryegrass had the second highest and the steers grazing the MaxQ treatments were the lowest. In year three and four steers grazing MaxQ treatments were lower ($P < 0.0001$) than the KY-31 treatments. The elevated hair coat scores for cattle grazing wild type endophyte was an indication that they are consuming enough ergovaline to cause the toxicosis. The reduction in hair coat scores in cattle grazing novel endophyte tall fescue has also been reported by Gunter and Beck, (2004) and Bond et al., (1984).

Serum Prolactin

Serum prolactin levels are reported for fall-winter and spring grazing season and the full trial (Table A7). All prolactin values are reported as transformed values. In the fall-winter grazing season of year 1 there was no difference between prolactin levels of steers grazing KY-31 with rye/ryegrass and both of the MaxQ treatments while those grazing KY-31 without the rye/ryegrass had the lowest levels ($P < 0.0001$). This indicates that the rye/ryegrass was able to help maintain the prolactin levels. In year two there was a difference ($P < 0.0001$) in prolactin levels between steers grazing the MaxQ pastures and the steers grazing KY-31 pastures. During year three, steers grazing MaxQ without rye/ryegrass had higher (P < 0.01) serum prolactin than steers grazing MaxQ with rye/ryegrass. This trend was found through most of the study. In year 4 there was a difference (P < 0.0001) between the steers grazing MaxQ treatments and the steers grazing KY-31 treatments, but the addition of rye/ryegrass seemed to have no effect on serum prolactin levels. This difference in year four may be due to the harsh drought conditions during that year. For all years the steers grazing MaxQ pastures had significantly higher (P < 0.0001) serum prolactin levels than the steers grazing KY-31 treatments.

For the spring grazing season, in year 1 there were higher serum prolactin levels (P < 0.0001) for steers grazing MaxQ and MaxQ with rye/ryegrass than those grazing KY-31 treatments (Table A8). During year 2 MaxQ had the highest serum prolactin levels followed by both the KY-31 and MaxQ pastures with rye/ryegrass, and the lowest (P < 0.05) serum prolactin level was KY-31 without rye/ryegrass. In year three there was a difference (P < 0.02) between MaxQ and KY-31 treatments, but the rye/ryegrass had no effect on prolactin levels. This difference was also seen in year 4 (P < 0.0001). When all four years were averaged all treatments were significantly different from highest to lowest they were MaxQ, MaxQ with rye/ryegrass, KY-31 with rye/ryegrass, and KY-31 respectively (P < 0.04).

When serum prolactin was analyzed over the entire grazing period (Table A9), in years one through four and all four years averaged there was a difference (P <0.05) between the MaxQ treatments and the KY-31 treatments, but the rye/ryegrass treatments had no effect (P > 0.05). Others have reported the difference in prolactin between cattle grazing MaxQ tall fescue and those grazing KY-31 tall fescue (Parish et al., 2003).

Supplement

There were periods in all years when forage production was limited and steers were supplemented (Table A10). In year one of the study there was no difference among treatments (*P* > 0.05). However one of the KY-31 pastures required supplementation more than 20 days more than the other two KY-31 pastures (Figure B5). All of the KY-31 pastures with rye/ryegrass and the MaxQ pastures with rye/ryegrass required similar amounts of supplement. Two of the MaxQ pastures without rye/ryegrass required almost 40 more days of supplement than did the third MaxQ pasture.

During year two there were no differences (*P* > 0.05) among days of supplement among treatments. However one of the KY-31 pastures did not require any supplement while one of the other KY-31 pastures required almost 120 days of supplementation (Figure B6). The KY-31 pastures with rye/ryegrass had one pasture that required more supplementation than the others and was similar to that of the MaxQ pastures in amount of supplementation required. One of the MaxQ pastures with rye/ryegrass required less than one half of the supplement required by the other two.

During year three of the study the addition of rye/ryegrass reduced the amount of supplement (*P* < 0.03) that needed to be fed regardless of which tall fescue was used with rye/ryegrass. Some pastures were fed more supplement than others but the differences in amounts fed were not as pronounced as in the first two years (Figure B7). One of the KY-31 pastures required more supplement than the other two KY-31 pastures. There was one KY-31 pasture with rye/ryegrass that required slightly more supplement than the other two pastures.

In year 4 KY-31 required less supplement ($P > 0.03$) than did any of the other treatments (Table A10). This could be due to the steers on MaxQ pastures consuming more forage than the steers on KY-31 pastures. There were also two KY-31 pastures that did not require any supplement during year four (Figure B8). The production of these two pastures is probably the reason for the low supplementation needs of this treatment.

When the supplementation was averaged over all four years the MaxQ pasture without rye/ryegrass was significantly higher ($P > 0.0001$) than the other treatments (Table A10). In this trial the decision to feed steers a supplement was made based on the average height of forage in the pasture. When forage height was at or below 10 cm, supplement was fed. Difference is dry matter intake have been reported fore KY-31 and MaxQ pastures (Nihsen et al., 2004; Parish et al., 2003). Although dry matter intake was not measured in this trial; differences in amount of supplement fed was consistent with observations made by Nihsen et al., (2004) and Parish et al., (2003), that there would be more forage available in KY-31 pastures than in MaxQ at the same stocking rate. Because the endophyte in MaxQ does not cause the reduced dry matter intake that is caused by the "wild type" endophyte in KY-31 there is less need to supplement the KY-31 pastures because the steers are consuming less of the forage.

Cost

The cost of the supplement was determined by the price of the ingredients for each year based on prices from March of each year (Feedstuffs, Minnetonka, MN). The cost of the supplement per ton was: 115.90, 111.25, 122.65, and 158.75 for year 1-4 respectively. The cost of the establishment of winter annuals was based on budgets from The University of Tennessee Extension (Bowling et al., 2008). The cost of total feeding for the grazing season for KY-31, KY-31 with rye/ryegrass, MaxQ and MaxQ with rye/rye grass was $780.60, 667.56, 899.76, and 745.32 respectively. The cost of feeding was broken down to a cost/steer basis (Table B9) The cost of gain for KY-31, KY-31 with rye/ryegrass, MaxQ and MaxQ with rye/ryegrass was 0.47, 0.42, 0.46, 0.41 $/kg respectively, based on an average grazing season of 212 days (Figure B10). The addition of rye/ryegrass resulted in reduced cost of winter feeding in MaxQ based systems.

Conclusion

Including rye/ryegrass for winter feed in tall fescue stocker forage systems resulted in reduced quantity and cost of supplemental feed for MaxQ tall fescue based forage systems. The severity of tall fescue toxicosis was reduced more by having MaxQ as the base forage than including rye/ryegrass in the KY-31 based system.

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Appendices

Appendix A

Tables

Table A1. Least squares means for nutrient quality of forage[1,2,3]

Treatment[4]	CP[4]	ADF[5]	NDF[6]	Ash
KY-31	15.51[a]	33.99[a]	62.62[a]	12.56[a]
KY-31R/R	15.12[a]	34.54[a]	63.35[a]	11.60[a]
MaxQ	15.45[a]	34.35[a]	62.46[a]	13.24[a]
MaxQ R/R	15.07[a]	33.30[a]	61.50[a]	12.05[a]

[1] All nutrients expressed on a dry matter basis
[2] Means in a column with no common letter differ, $P > 0.05$
[3] All values in % of dry matter
[4] KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass
[4,5,6] CP = Crude protein; ADF = Acid detergent fiber; NDF = Neutral detergent fiber

Table A2. Least squares means for average daily gain (kg/day) during fall-winter growing season (November to Mid-March)[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	0.39[b]	0.12[a]	0.41[a]	0.43[a]	0.34[a]
KY-31 R/R	0.48[ab]	0.16[a]	0.24[b]	0.36[a]	0.31[a]
MaxQ	0.49[ab]	0.20[a]	0.40[a]	0.44[a]	0.38[a]
MaxQ R/R	0.55[a]	0.24[a]	0.27[b]	0.36[a]	0.35[a]

[1] ADG calculated as (EW-IW)/d; where EW = ending weight for period; IW = initial weight for period; and d = days in period
[2]Means within a column with no common letter differ, $P > 0.05$
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass.

Table A3.Least squares means for average daily gain (kg/day) during spring growing season (Mid-March to Late June)[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	0.68[b]	0.87[b]	0.78[c]	0.78[b]	0.78[b]
KY-31 R/R	0.69[b]	1.11[a]	0.93[b]	0.81[b]	0.88[b]
MaxQ	0.83[a]	1.18[a]	1.12[a]	1.15[a]	1.08[a]
MaxQ R/R	0.65[b]	1.24[a]	1.18[a]	1.00[ab]	1.04[a]

[1] ADG calculated as (EW-IW)/d; where EW = ending weight for period; IW = initial weight for period; and d = days in period
[2]Means within a column with no common letter differ, $P > 0.05$
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass.

Table A4. Least squares means for average daily gain (kg/day) during the entire trial (November to Late-June)[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	0.55[b]	0.56[c]	0.60[c]	0.61[b]	0.59[b]
KY-31 R/R	0.59[b]	0.71[b]	0.60[c]	0.59[b]	0.62[b]
MaxQ	0.70[a]	0.77[ab]	0.78[a]	0.81[a]	0.77[a]
MaxQ R/R	0.59[b]	0.83[a]	0.71[b]	0.75[a]	0.72[a]

[1]ADG calculated as (EW-IW)/d; where EW = ending weight for period; IW = initial weight for period; and d = days in period
[2]Means within a column with no common letter differ, $P > 0.05$
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass.

Table A5. Rectal temperatures ºC least squares means[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	39.28[a]	39.24[a]	39.16[a]	39.26[a]	39.27[a]
KY-31R/R	39.28[a]	39.18[a]	39.12[a]	39.10[ab]	39.18[a]
MaxQ	39.18[a]	38.63[a]	38.96[a]	39.10[ab]	38.99[b]
MaxQ R/R	35.65[b]	38.79[a]	38.89[a]	38.82[b]	38.03[b]

[1]Means within a column with no common letter differ, *P* > 0.05
[2] Rectal temperatures are averaged over the entire trial
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass.

Table A6. Hair coat scores least squares means[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	2.72[a]	2.37[a]	2.19[a]	2.36[a]	2.41[a]
KY-31 R/R	2.62[a]	1.91[b]	1.82[b]	1.98[b]	2.09[b]
MaxQ	1.65[c]	1.68[bc]	1.11[c]	1.24[c]	1.42[c]
MaxQ R/R	2.04[b]	1.58[c]	1.25[c]	1.27[c]	1.54[c]

[1]Hair Coat Score, 1-5 system for cattle with 1 = slicked off shiny coat with no retained hair; 2 = <25% of body covered in dead unshed hair; 25-50% of body covered in dead unshed hair; 4 = 50-75% of body covered in dead unshed hair; 5 = >50% of body covered in dead unshed hair, with evidence of having laid in mud deliberately (Saker et al., 2001)
[2] Means within a column with no common letter differ, *P* > 0.05
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

Table A7. Least squares means for serum prolactin during the fall-winter growing season (November to Mid-March)[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	2.18[b]	0.94[b]	2.24[bc]	3.15[b]	2.30[b]
KY-31 R/R	2.54[ab]	1.23[b]	2.06[c]	3.15[b]	2.47[b]
MaxQ	3.57[a]	2.38[a]	3.18[a]	4.15[a]	3.50[a]
MaxQ R/R	3.14[ab]	2.45[a]	2.96[ab]	4.13[a]	3.29[a]

[1]Serum prolactin was measured in ng/mL and a log transformation was performed to correct normality
[2]Means within a column with no common letter differ, *P* > 0.05
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

Table A8. Least squares means for serum prolactin during the spring growing season (Mid-March to Late-June)[1,2]

Treatment[3]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	2.92[b]	3.17[c]	2.55[b]	2.70[b]	3.05[d]
KY-31 R/R	3.36[b]	4.01[b]	2.93[b]	3.42[b]	3.41[c]
MaxQ	4.96[a]	4.72[a]	4.97[a]	5.14[a]	4.90[a]
MaxQ R/R	4.56[a]	4.16[ab]	4.50[a]	4.94[a]	4.42[b]

[1] Serum prolactin was measured in ng/mL and a log transformation was performed to correct normality
[2]Means within a column with no common letter differ, *P* > 0.05
[3]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

Table A9. Least squares means for serum prolactin during the entire trial (November to Late-June)[1,2]

Treatment	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	2.55[b]	2.05[c]	2.38[b]	2.98[b]	2.00[b]
KY-31 R/R	2.95[b]	2.62[b]	2.45[b]	3.25[b]	2.25[b]
MaxQ	4.26[a]	3.55[a]	3.98[a]	4.52[a]	3.70[a]
MaxQ R/R	3.85[a]	3.30[a]	3.64[a]	4.43[a]	3.36[a]

[1]Serum prolactin was measured in ng/mL and a log transformation was performed to correct normality
[2]Means within a column with no common letter differ, $P > 0.05$
[3]KY-31 = Kentucky 31 Tall fescue; KY-31R/R = Kentucky 31 Tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ Tall fescue; MaxQR/R = Jesup MaxQ Tall fescue with Rye/Ryegrass

Table A10. Least squares means for days of supplement fed[1,3]

Treatment[2]	Year 1	Year 2	Year 3	Year 4	All Years
KY-31	38.33[a]	65.33[a]	82.00[ab]	29.00[b]	53.67[b]
KY-31 R/R	26.00[a]	50.00[a]	43.00[c]	45.00[ab]	41.00[b]
MaxQ	54.33[a]	80.00[a]	104.67[a]	87.00[a]	81.50[a]
MaxQ R/R	35.00[a]	70.00[a]	61.67[bc]	42.67[ab]	52.33[b]

[1]Means within a column with no common letter differ, $P > 0.05$
[2]KY-31 = Kentucky 31 Tall fescue; KY-31R/R = Kentucky 31 Tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ Tall fescue; MaxQR/R = Jesup MaxQ Tall fescue with Rye/Ryegrass.
[3]Nutrient composition of supplement on a dry matter basis was: Estimated TDN = 71.07%; Crude protein = 8.66%; Calcium = 0.53%; Phosphorus = 0.22%

Table A11. Winter annual, traditional establishment for winter grazing, estimated expenses per hectacre[1]

Item	Description	Unit	Quantity	Price	Amount ($/ha)
Variable Expenses					
Seed	Rye	kg	95.25	0.50	47.63
	Ryegrass	kg	17.00	1.28	21.75
Fertilizer[2]	Nitrogen	kg	68.00	3.47	94.50
	Nitrogen	kg	51.00	3.47	70.88
Custom Application		ha	0.8	31.25	25.00
Machinery					
Fuel		ha[3]	0.405	16.13	16.13
Oil & Filter		ha	0.405	2.42	2.42
Repairs and Maintenance		ha	0.405	6.78	6.78
Interest	6 months	ha	129.08	8.0%	10.32
Fixed Expenses					
Machinery					
Depreciation		ha	0.405	5.09	5.09
Interest		ha	0.405	6.22	6.22
Housing and Insurance		ha	0.405	.82	0.82
Labor Expenses					
Labor[4]		hour	0.91	8.50	7.74
Total					315.28

[1]Budgets from http://economics.ag.utk.edu/budgets.html
[2]27.2kg of nitrogen applied at seeding, 20.4kg applied in spring
[3]ha = hectare
[4]Labor expense in $8.50 per hour, including wages, Social Security and Medicaid taxes and payroll administration costs.

Appendix B

Figures

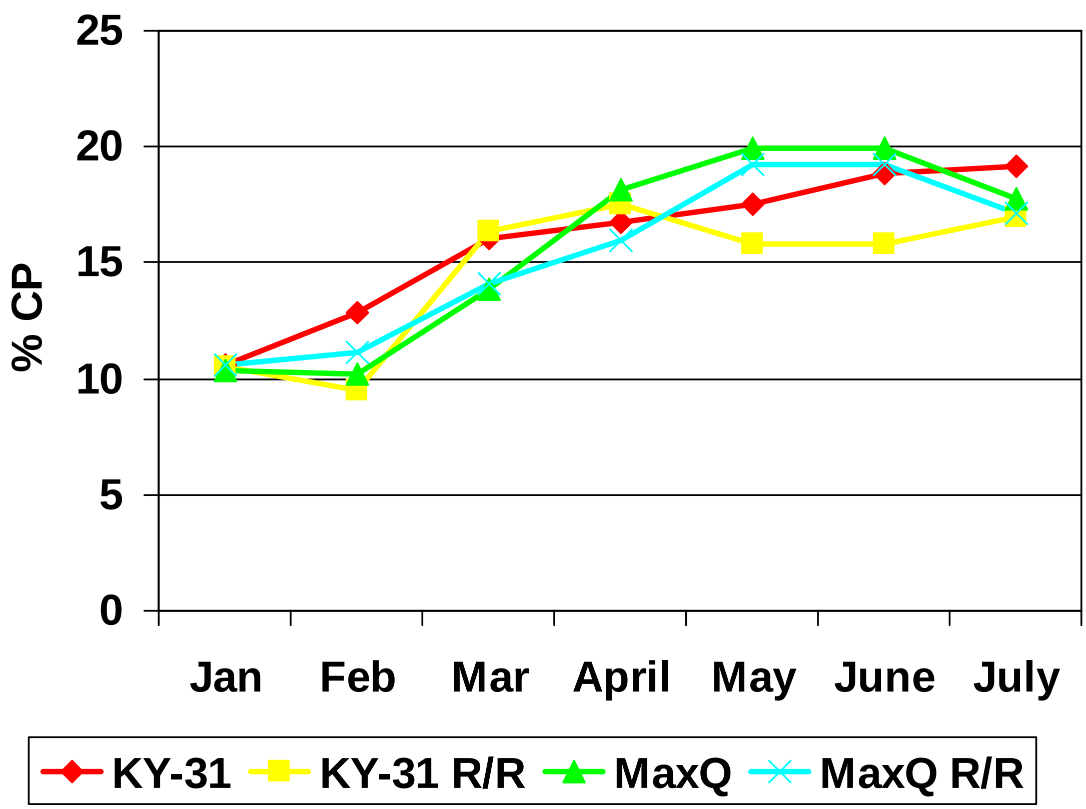

Figure B1. Crude protein of clipped forage samples over time[1,2]

[1]Protein determined by % nitrogen of the forage times 6.25 expressed on a dry matter basis

[2]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

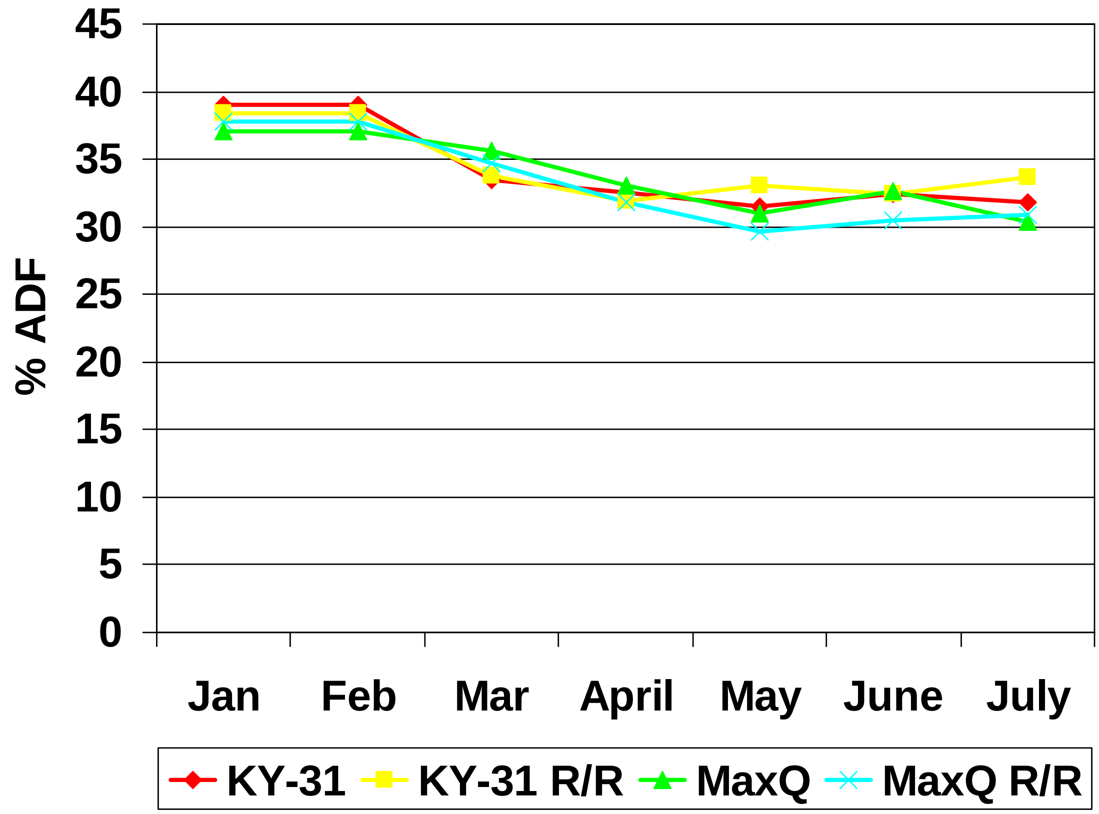

Figure B2. Acid detergent fiber of clipped forage samples over time[1,2]

[1]Expressed on a dry matter basis
[2]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

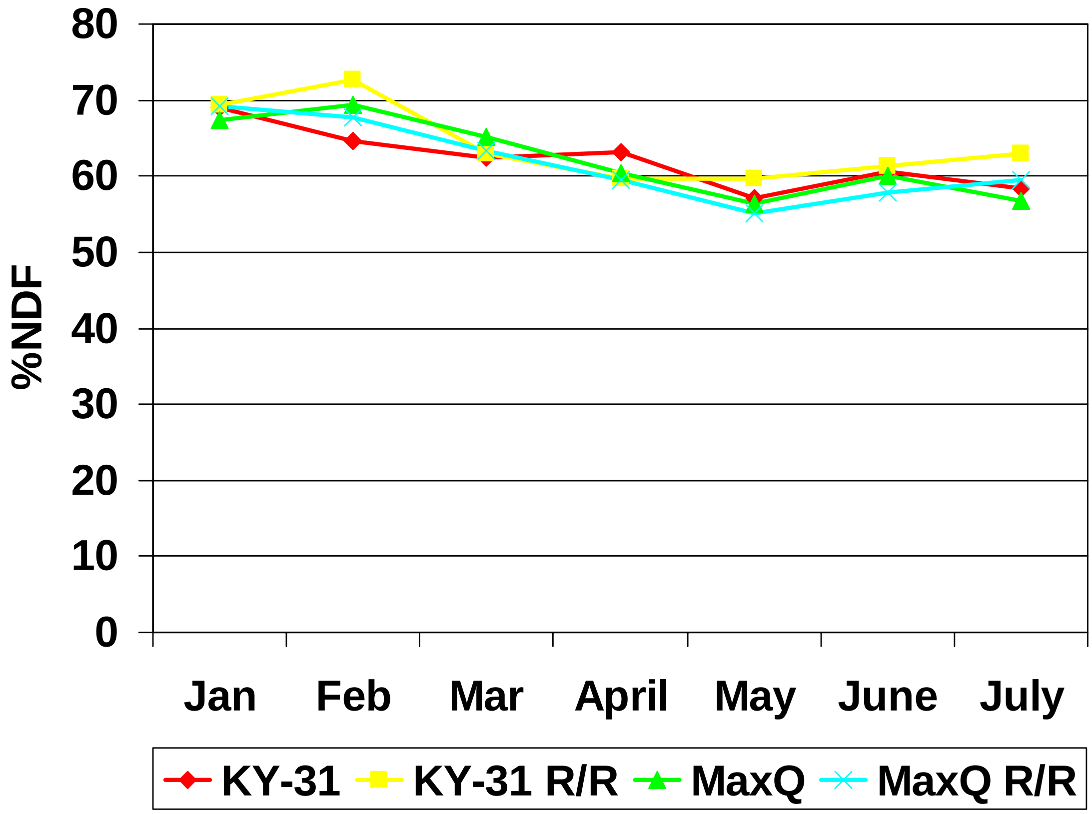

Figure B3. Neutral detergent fiber of clipped forage samples over time[1,2]

[1]Expressed on a dry matter basis

[2]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

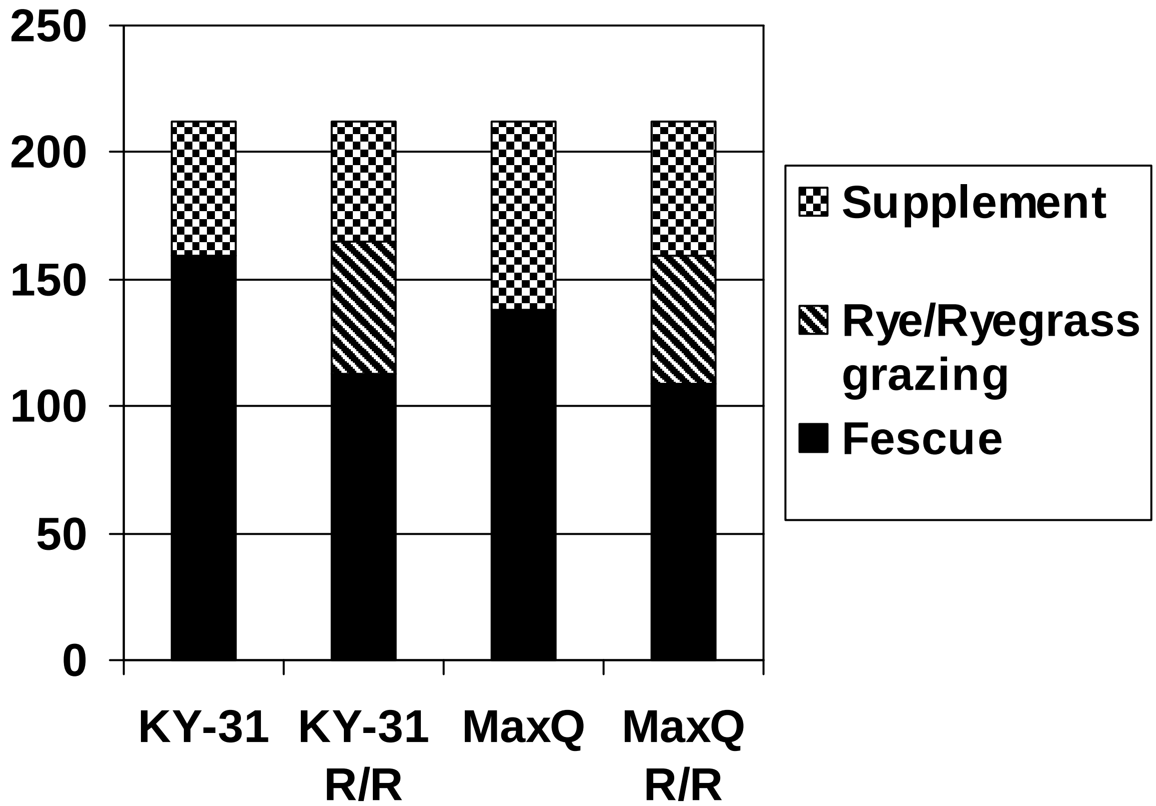

Figure B4. Days of grazing and supplement feeding by treatment[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

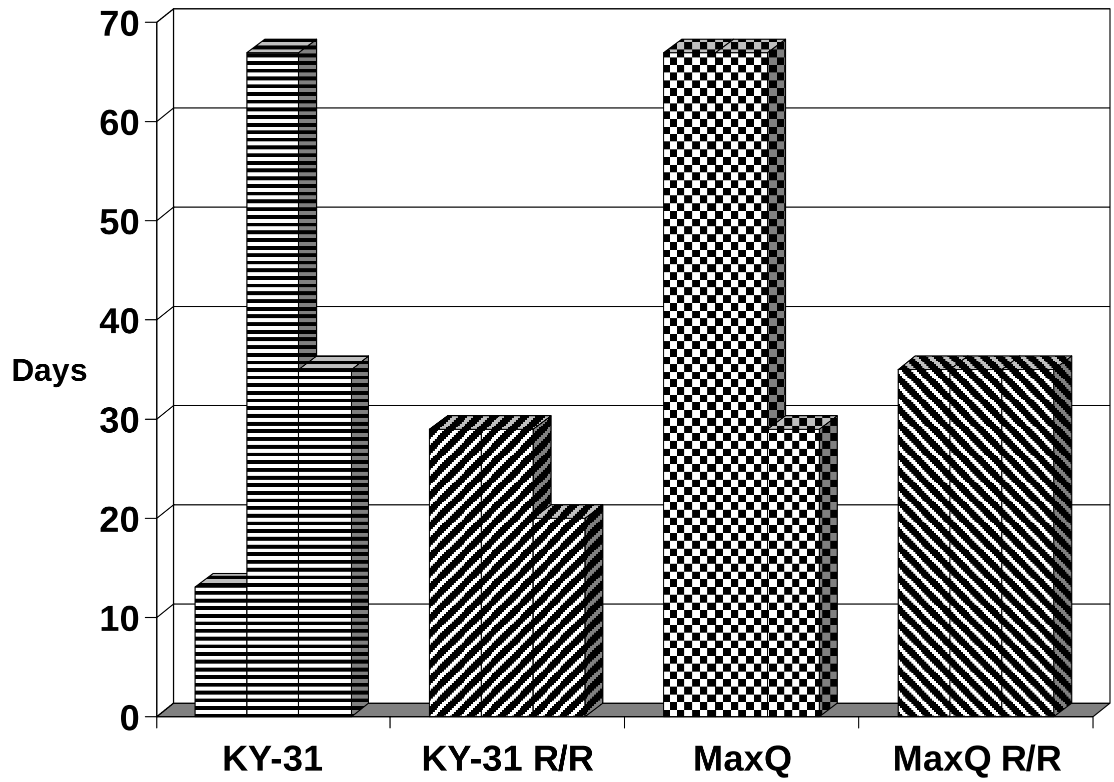

Figure B5. Days of supplement feeding in each pasture during year1[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

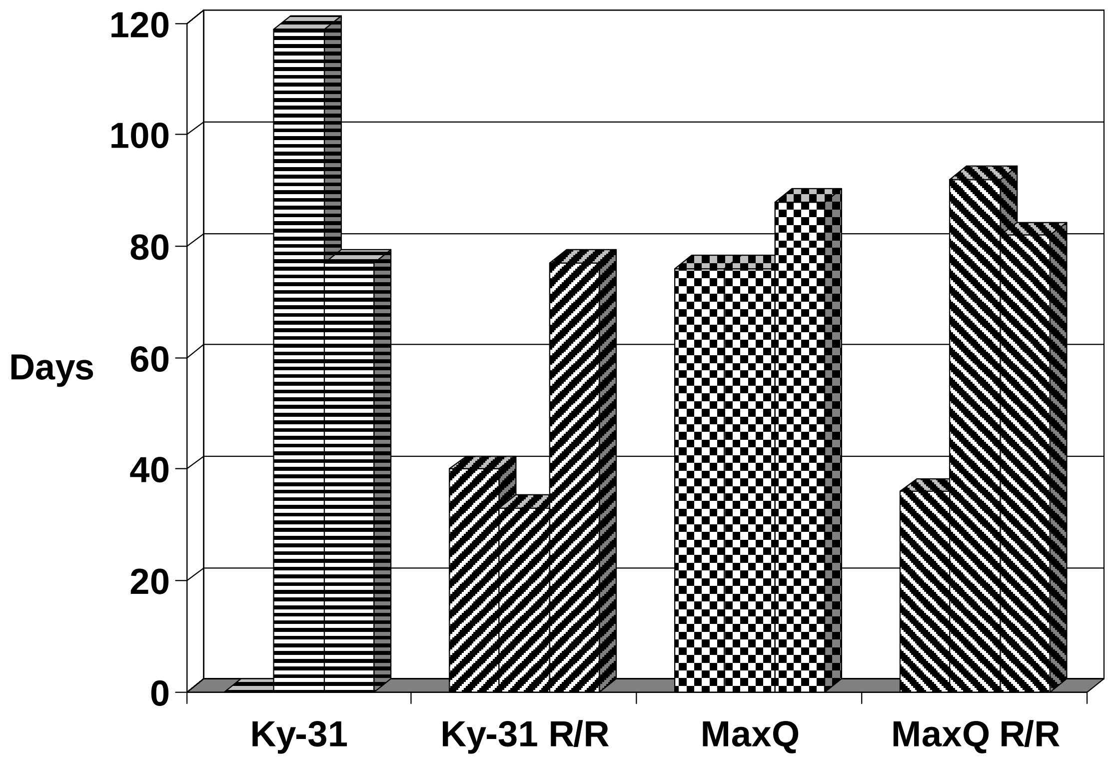

Figure B6. Days of supplement feeding in each pasture during year2[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

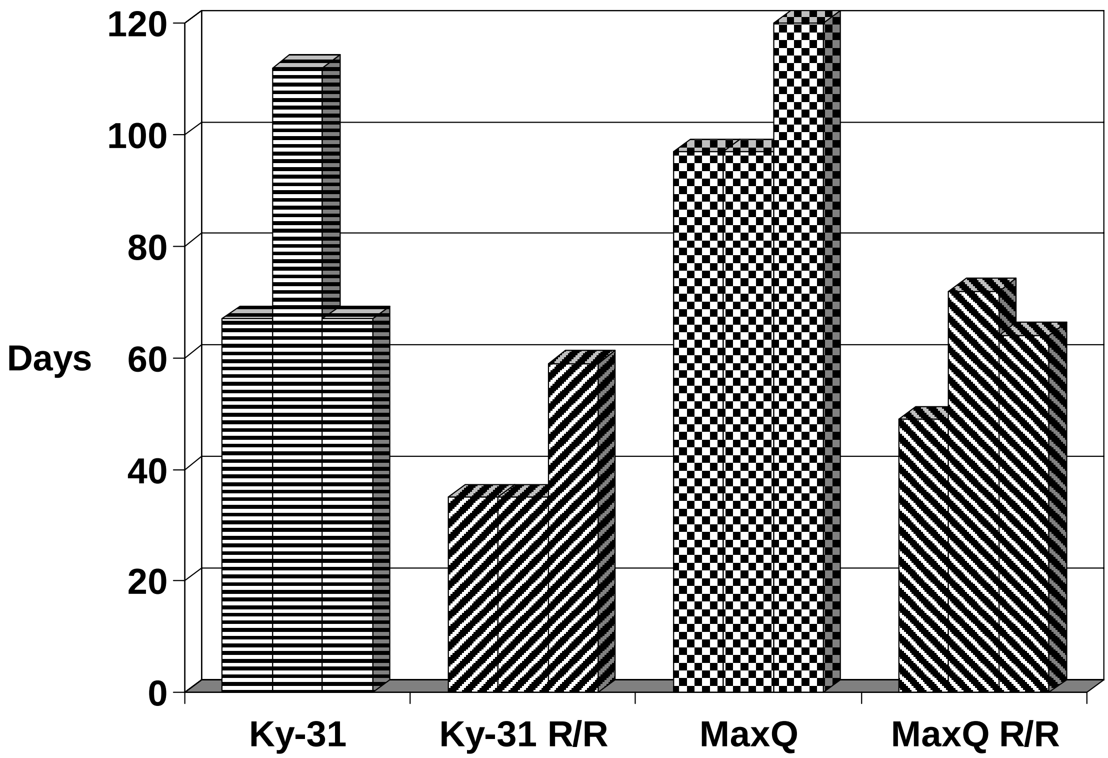

Figure B7. Days of supplement feeding in each pasture during year3[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

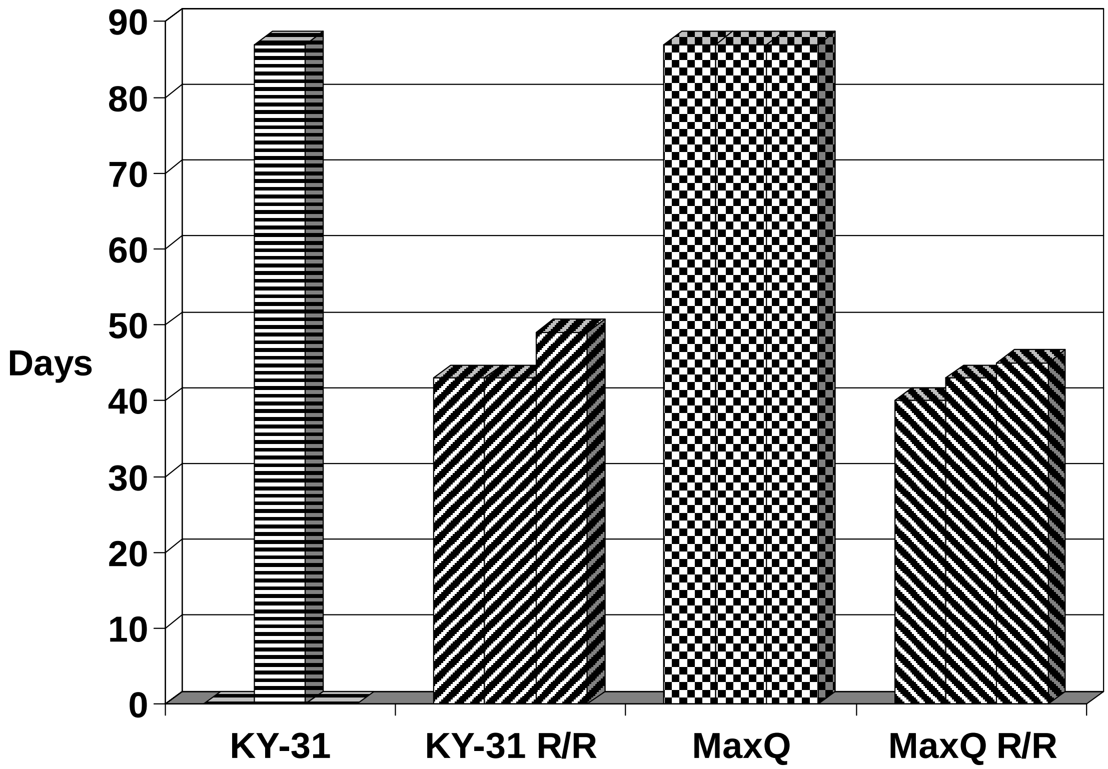

Figure B8. Days of supplement feeding in each pasture during year4[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

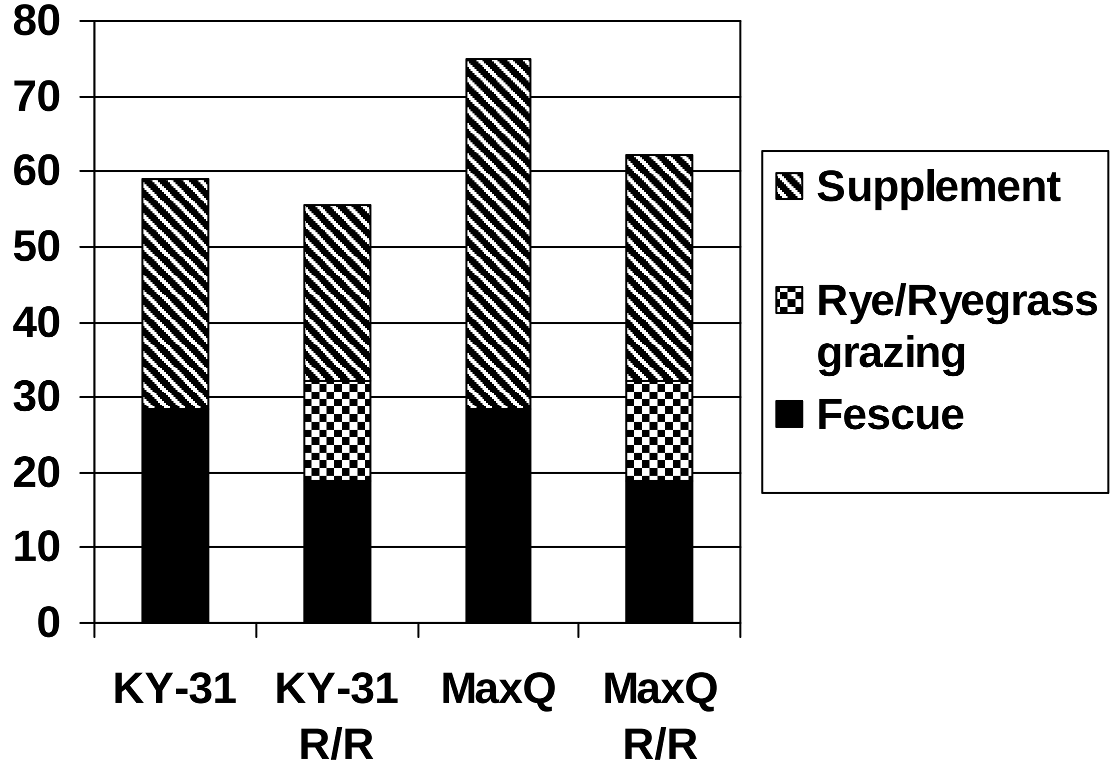

Figure B9. Cost of winter feeding per head by treatment[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

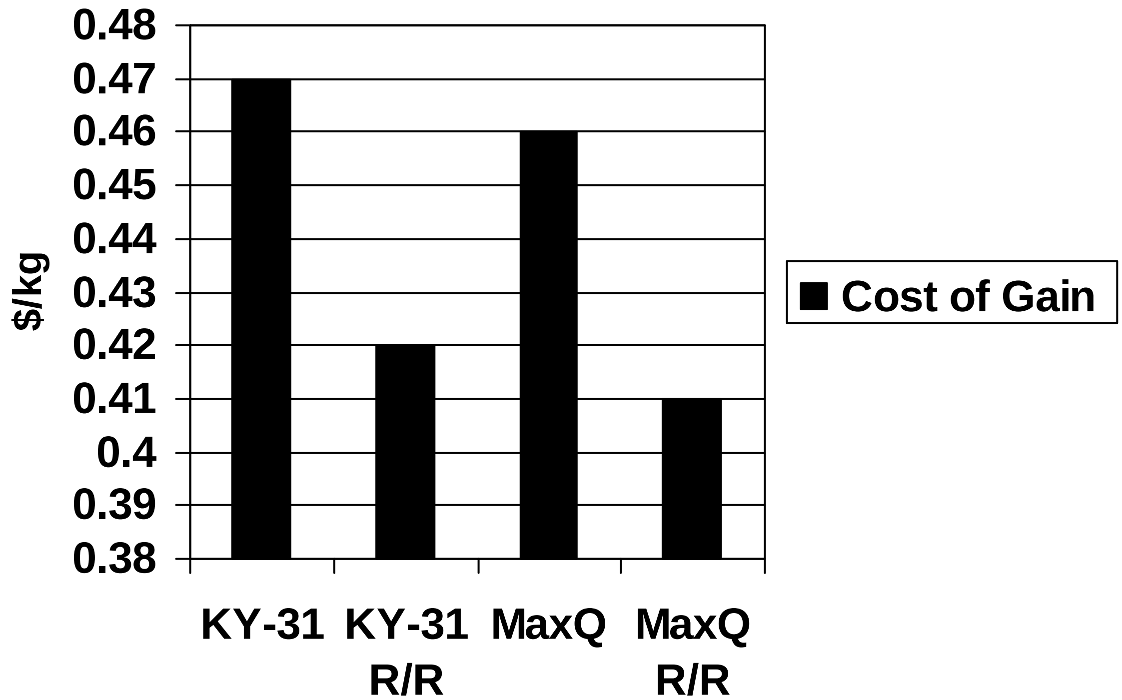

Figure B10. Cost of gain per treatment in $/kg[1]

[1]KY-31 = Kentucky 31 tall fescue; KY-31R/R = Kentucky 31 tall fescue with Rye/Ryegrass; MaxQ = Jesup MaxQ tall fescue; MaxQR/R = Jesup MaxQ tall fescue with Rye/Ryegrass

Vita

Brian Campbell was born in Fort Knox, KY in December of 1983. He was raised in Virginia. Brian graduated from Colonial Heights High School in 2002. He obtained his Bachelors degree from Texas A&M-Commerce in 2005 with a major in Animal Science. Brian began his graduate career at The University of Tennessee in August of 2006, with a major in Animal Science.