

IMPACT OF GRAZING STOCKPILED TALL FESCUE  
ON LACTATING BEEF COWS

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by

LEANN ELIZABETH CURTIS

Dr. Robert L. Kallenbach, Thesis Supervisor

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The undersigned appointed by the Dean of the Graduate School, have examined the thesis entitled

IMPACT OF GRAZING STOCKPILED TALL FESCUE  
ON LACTATING BEEF COWS

Presented by LeAnn Elizabeth Curtis

A candidate for the degree of Master of Science.

And hereby certify that in their opinion it is worthy of acceptance.

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(Robert L. Kallenbach)

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(Craig Roberts)

---

(Monty Kerley)

## **DEDICATION**

*TO:  
My parents  
Garyl and Michele Meinhardt  
And  
My loving husband  
Brian*

*Thank you for your unconditional love and support.*

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**IMPACT OF GRAZING STOCKPILED TALL FESCUE  
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LeAnn Elizabeth Curtis

Dr. Robert L. Kallenbach, Thesis Supervisor

**ABSTRACT**

Two experiments are described, in which fall-calving cow-calf pairs grazed stockpiled tall fescue at three different endophyte infection levels (20, 51, and 89%) and four forage allowances (2.25, 3.00, 3.75, and 4.50% of BW). A hay feeding treatment was included as a standard for comparison. Each experiment was a randomized complete block design. Average daily gain, BW, BCS decreased as forage allowance decreased and endophyte infection increased. However by weaning, cow BW averaged 528 kg across all treatments. Calf gain was unaffected by endophyte infection level of stockpiled tall fescue, with an ADG of 0.72 kg d<sup>-1</sup>. Individual calf performance was greatest at forage allowances above 2.25% of BW. However, gain ha<sup>-1</sup> was greatest for the 2.25% of BW forage allowance, averaging 155 kg ha<sup>-1</sup>. A forage allowance of 2.25% of BW is likely the most efficient, since cow weight loss over winter is easily regained, land requirements are low, and calf gain ha<sup>-1</sup> is maximized. Additionally, if used for winter stockpiling, renovation of endophyte-infected tall fescue pastures for fall-calving operations is unneeded in most cases.

## GENERAL INTRODUCTION

Winter feed cost is the major factor separating high and low profit beef cow-calf producers (Clark et al., 2004). This is because of the wide variation in the cost of supplying adequate forage during winter. Generally, producers in the Midwest rely on mechanically harvested forage, mainly hay (Nichols et al., 1990), to supply winter feed. However, forage-livestock systems that maximize the use of pasture for winter feed often have the lowest annual feed costs (Strohbehn, 2001). Research at the University of Missouri found that extending the grazing season into winter reduced dependence on stored feed and decreased winter-feeding costs by one-third to one-half (Bishop-Hurley and Kallenbach, 2001).

One method to extend the grazing season is to utilize stockpiled forages throughout winter, which can reduce labor (Van Keuren, 1970) and almost eliminate the need for hay (Riesterer et al., 2000a; Clark, 2003). Stockpiling is the practice of accumulating forage for grazing at a later time (Fribourg and Bell, 1984; Minson and Whiteman, 1989). Tall fescue (*Festuca arundinacea* Schreb), the predominant forage throughout the cool-temperate and subtropical transition zone of the United States, lends itself well to stockpiling. Tall fescue is commonly used for stockpiling because it produces high amounts of biomass during autumn, responds well to N fertilization, and retains adequate yield and quality throughout winter.

Extensive plot research has been conducted on stockpiled tall fescue. In addition to the effects of fertilization and defoliation on the yield, quality, and subsequent

accumulation of stockpiled tall fescue (Berry and Hoveland, 1969; Collins and Balasko, 1981a, b; Fribourg and Bell, 1984; Kallenbach et al., 2003), there have been several grazing studies to examine its usefulness (Tucker et al., 1989; Allen et al., 1992a, b; Hitz and Russell, 1998). These studies have focused on gestating, spring-calving beef cows and stocker calves. In recent years, producers have been adopting a fall-calving season because of increased pregnancy rates, decreased calf death loss, decreased heat stress during breeding, marketing advantages, and weight cycling (Nelson, 1988; Waller et al., 1988; Freetly et al., 2000). Limited research has been conducted using stockpiled tall fescue with lactating fall-calving cows (Morrow et al., 1988; Waller et al., 1988; Coffey et al., 1999; Gerrish, 2002; Janovick, 2002). Lactating cows have higher nutrient requirements than gestating cows (NRC, 2000) and may require higher forage allowances than those of gestating cows. In addition, milk production and animal performance may be hindered by grazing endophyte-infected tall fescue.

The majority of tall fescue (90%; Ball et al., 2002) is infected with a fungal endophyte, *Neotyphodium coenophialum* [(Morgan-Jones and Gams) Glenn, Bacon and Hanlin]. *Neotyphodium coenophialum* has a mutualistic, symbiotic relationship with tall fescue plants. The tall fescue plant provides a living environment, while the endophyte increases plant persistence by improving resistance to insect and nematode feeding, and stress and drought tolerance (Sleper and West, 1996). Endophyte infection results in an accumulation of toxic alkaloids known to cause a series of animal health disorders collectively called tall fescue toxicosis. Tall fescue toxicosis costs the United States livestock industry over \$609 million annually (Hoveland, 1993; Roberts and Andrae, 2004). Recent small plot research indicates fescue toxicosis should be less severe in

stockpiled tall fescue (Kallenbach et al., 2003). However, more research is needed to determine the effects of grazing endophyte-infected stockpiled tall fescue on cow-calf performance.

This study examined the effects of four daily forage allowances (2.50, 3.00, 3.75, and 4.50 percent of the animal's body weight) and three endophyte infection levels (20, 51, and 89 percent) of stockpiled tall fescue. Our hypothesis was cattle allocated high forage allowances and low endophyte infection levels would exhibit higher body condition scores and calf gain compared to the other treatments; however when looking at beef production per hectare, we hypothesized the lower forage allowances would be more economical. The objective of this study was to evaluate the impact of different forage allowance and endophyte infection levels of stockpiled tall fescue on the performance and pasture utilization of lactating beef cows and their calves. A secondary objective was to determine if spring growth of pastures was altered by allocating different levels of forage through the winter. Conventional winter hay-feeding practices were also evaluated for a comparison of animal performance with stockpiled tall fescue.



## **LITERATURE REVIEW**

Tall fescue is a perennial, cool-season bunchgrass grown for pasture, hay, silage, soil conservation, and turf. It was introduced to the United States in the late 1800's from Europe and northern Africa (Sleper and West, 1996). Since the 1940s, it has become the principal cool-season grass throughout the transition zone of the United States. Covering approximately 12–14 million ha of land in pure and mixed stands (Sleper and Buckner, 1995), it forms the forage base for beef cow-calf production, supporting over 8.5 million beef animals (Hoveland, 1993). This widespread use is due to its ability to tolerate a wide range of soil and climatic factors, persistence under continuous grazing, response to renovation, and low-input management (Hanson, 1979; Waller et al., 1988).

### **STOCKPILED TALL FESCUE**

Typical of cool-season grasses, peak growth rate of tall fescue occurs in spring, with a secondary peak of vegetative growth in the autumn (Wolf et al., 1979). Tall fescue's autumn growth peak is especially useful for stockpiling, the practice of accumulating autumn growth for grazing at a later time (Waller et al., 1988). Winter grazing of stockpiled forage, also called “deferred grazing,” has gained popularity as a low-cost means of maintaining beef cows through the winter because it can reduce labor (Van Keuren, 1970) and almost eliminate the need for stored feed (Riesterer et al., 2000a; Clark, 2003). Tall fescue has many characteristics that make it a superior cool-season grass to stockpile. These characteristics include upright leaves, waxy cuticle layer, and a dense sod (Bryan et al., 1970; Ocumpaugh and Matches, 1977; Fribourg and Bell, 1984;

Sleper and West, 1996; Riesterer et al., 2000a). The importance of each of these characteristics is described in more detail below.

### ***Upright Leaves***

The literature shows that tall fescue maintains yield throughout autumn and winter better than most cool-season grasses (Baker et al., 1965; Bryan et al., 1970; Taylor and Templeton, 1976; Archer and Decker, 1977a and b; Collins and Balasko, 1981a and b; Gerrish et al., 1994). Riesterer et al., (2000a) suggested that the upright leaf of tall fescue may possibly be linked to this attribute. It is thought that upright leaves decrease the number of leaves at ground level, thereby reducing yield losses.

In Iowa, Wedin et al. (1966) evaluated autumn yield of five cool-season grasses for stockpiling. Reed canarygrass (*Phalaris arundinacea*), orchardgrass (*Dactylis glomerata*), smooth brome grass (*Bromus inermis*), and meadow foxtail (*Alopecurus pratensis*) yielded 10 to 35% less than tall fescue when 269 kg ha<sup>-1</sup> of N was applied. A similar study in Wisconsin examined forage yield from August to March (Riesterer et al., 2000a). This study evaluated the yield of tall fescue, early and late-maturing orchardgrass cultivars, timothy (*Phleum pratense* L. ), reed canarygrass, quackgrass (*Elytrigia repens* L. ), and smooth brome grass for stockpiling. Tall fescue, early-maturing orchardgrass, and reed canarygrass were found best suited for grazing after December, yielding 2790, 2690, and 2020 kg OM ha<sup>-1</sup> respectively (Riesterer et al., 2000a). These experiments suggest that forage species with upright leaf growth pattern, such as reed canarygrass and tall fescue have higher yields as winter progresses.

### ***Waxy Cuticle Layer***

In addition to tall fescue's upright leaf growth pattern, its waxy cuticle layer helps prevent dry matter and forage quality loss. Dry matter loss over time is an important factor in preserving stockpile yield and quality. Dry matter loss is attributed to leaf death and decay caused by a combination of respiration, translocation, leaching of cell contents, and increasing leaf brittleness (Archer and Decker, 1977a,b; Ocumpaugh and Matches, 1977). Leaching of cell contents causes stockpiled tall fescue to decrease in nutritive value and yield.

The cuticle protects the plant from weathering and frost damage which decreases dry matter loss (Gerrish and Peterson, 1993). The waxy layer may also help tall fescue retain its green color throughout winter due to a slower rate of leaf death and decay (Archer and Decker, 1977b). In addition to less deterioration and color loss than other cool-season grasses, tall fescue's forage dry matter yield remains stable or declines slowly from mid-December to mid-March (Collins and Balasko, 1981a; Fribourg and Bell, 1984; Kallenbach et al., 2003).

### ***Dense Sod***

Tall fescue's ability to tolerate season-long grazing is in part due to its ability to form a dense sod (Cowan, 1956; Van Keuren, 1969). Tall fescue's dense sod can help reduce muddiness during the freezing and thawing of winter and facilitates stand persistence. When comparing tall fescue to orchardgrass for winter grazing, Allen et al., (1992a) found that orchardgrass stands thinned overtime and weeds invaded, such that herbicide and reseeding were required. Tall fescue in this study maintained an acceptable stand throughout the experiment with little weed encroachment.

## ENDOPHYTE INFECTION

Tall fescue has many attributes, however the majority of tall fescue (70%) in the transition zone is at least 90% infected (Ball et al., 2002) with a fungal endophyte, *Neotyphodium coenophialum* [(Morgan-Jones and Gams) Glenn, Bacon and Hanlin]. *Neotyphodium coenophialum* grows in the intercellular space in tall fescue plants, and has a mutualistic, symbiotic relationship (Bacon and Siegel, 1988). The plant supplies carbohydrates to the fungus and the fungus increases plant persistence by improving resistance to insect and nematode feeding, and stress and drought tolerance (Sleper and West, 1996). In addition, the endophyte lends antiherbivory characteristics to the plant by synthesizing ergot-like alkaloids (Roberts and Andrae, 2004).

While endophyte infection improves the agronomic aspects of tall fescue, the alkaloids produced by the fungus causes a series of animal health disorders commonly referred to as tall fescue toxicosis. Disorders include reduced weight gains, decreased milk production, increased respiration rates, and failure to shed winter hair coats during the summer (Hemken et. al., 1981; Studemann and Hoveland, 1988; Tucker et. al., 1989; Peters et al., 1992; Beconi et al., 1995; Ball et al., 2003). Symptoms are generally less severe in cooler temperatures (Chestnut et al., 1991), but occasionally sloughing of the tips of the ears, tails, and even entire hooves have been seen during the winter. Because of these health disorders, tall fescue toxicosis cost the United States livestock industry well over \$609 million annually (Hoveland, 1993).

Tall fescue toxicosis has no cure; however, management strategies can decrease its effect on livestock during the growing season. These strategies include clipping pastures in mid- to late-spring, replacing toxic tall fescue with cultivars that are

endophyte-free or that are infected with a novel (non-toxic) endophyte, interseeding other forages such as clover to dilute the toxins, and rotating livestock to non-toxic pastures (Roberts and Andrae, 2004). Clipping pastures in mid- to late-spring is an important management tool because it removes seedheads from the pastures. Toxic alkaloids, such as ergovaline, are most concentrated in the reproductive structures from boot stage until seed maturity which occurs from mid- to late-spring (Rottinghaus et al., 1991).

Replacing endophyte-infected tall fescue with cultivars that are endophyte-free or that contain novel (non-toxic) endophytes can eliminate tall fescue toxicosis. However, endophyte-free tall fescue is generally less persistent (Oliphant, 2005). The other option, planting novel endophyte-infected tall fescue cultivars, has high establishment costs; returns on investment for this option requires 3 to 7 years to become profitable (Gunter and Beck, 2004). Interseeding tall fescue with other forages and rotating livestock to non-toxic pastures are also important tools to help reduce tall fescue toxicosis and improve economic returns to cow-calf operations.

There have been several grazing studies evaluating animal performance on stockpiled tall fescue (Waller et al., 1988; Tucker et al., 1989; Allen et al., 1992a, b; Hitz and Russell, 1998). However, these studies focused on gestating, spring-calving beef cows and stocker calves grazing tall fescue infected with an endemic, toxic endophyte, a novel endophyte, or that are endophyte-free. A study conducted by Tucker et al. (1989) showed that spring-calving cows grazing endophyte-infected tall fescue stands (77% infection rate) had lower pregnancy rates and lost more weight than cows on other forages such as endophyte-infected tall fescue with a low level of infection (21% infection rate) or orchardgrass. During the growing season, for each 10% increase in

endophyte infection rate there is about 0.05 kg depression in ADG over the span of a grazing season (Studemann and Hoveland, 1988).

Grazing data examining the impact of different levels of endophyte infection in stockpiled tall fescue is limited, especially on fall-calving cows and their calves. Research indicates that tall fescue toxicosis should be less severe when grazing autumn saved tall fescue during winter. Autumn growth of tall fescue is characterized by a leafy vegetative growth (Sleper and West, 1996). In addition, Kallenbach et al. (2003) discovered that ergovaline in stockpiled tall fescue declines throughout winter at a faster rate than does forage quality.

A study conducted by Oliphant (2005), showed endophyte-infected tall fescue is less toxic when stockpiled compared to tall fescue during the growing season. She concluded that grazing stockpiled endophyte-infected tall fescue pastures during winter did not affect body condition score (BCS) and progesterone concentrations of gestating beef heifers. In addition, Beconi et al. (1995) reported no carryover effects of grazing endophyte-infected stockpiled tall fescue by steer calves on subsequent feedlot performance. When calves were finished in the feedlot, calves that had previously grazed endophyte-infected tall fescue had higher ADG and gain-to-feed ratios when compared to the calves that had grazed endophyte-free cultivars (Cole et al., 1987; Lusby et al., 1990; Beconi et al., 1995). However, average daily gains (ADG) of steers grazing endophyte-infected stockpiled tall fescue (65% infection rate) was decreased ( $P < 0.05$ ) when compared with endophyte-free cultivars (Beconi et al., 1995).

## **STOCKPILED TALL FESCUE MANAGEMENT**

Although tall fescue is the superior cool-season grass to stockpile, climate has the most control over success of this practice. There are management practices, such as date of stockpile initiation, time of use, and fertilization that can assist in producing stockpiled tall fescue of consistent yield and quality (Ocumpaugh and Matches, 1977; Matches et al., 1973). The importance of each of these management strategies is described in more detail below.

### ***Date of Stockpile Initiation***

The date of initiation, or start of the stockpiling period, greatly influences both yield and quality of forage available for late autumn and winter grazing (Rayburn et al., 1979). In general, the longer the accumulation period is, the greater the yield of stockpiled forage and the lower the forage quality (Fribourg and Bell, 1984). Matches et al. (1973) found that high yields of stockpiled tall fescue could be obtained by accumulating forage over the entire growing season. However, this accumulated growth was low in quality due to mature, reproductive growth, and was inadequate to meet the nutritional requirement for gestating and lactating beef cows.

Research indicates that reproductive growth should be removed by mowing, harvesting, or grazing during the spring and summer (Roberts and Andrae, 2004). In addition to removing poor quality forage, it also removes reproductive growth. Schmitz (2001) states that forage should be clipped to a height of 8 to 10 cm during the last 70-80 days of the growing season (early to mid August) to initiate the stockpiling phase. Research in northern Missouri shows that 2240 kg ha<sup>-1</sup> forage dry matter can be stockpiled over a 70-day period when no N fertilizer is applied (Gerrish et al., 1994).

### *Time of Use*

Since autumn growth of tall fescue is mostly leaf, it is high in nutritive value. The nutritive value slowly declines over winter due to weathering, making the time of use important. A study conducted by Ocumpaugh and Matches (1977) found that between November and February crude protein, in vitro dry matter digestibility (IVDMD), and potassium decreased by 0.1, 1.0, and 0.1 % week<sup>-1</sup>, respectively. Throughout the experiment, crude protein, IVDMD, and potassium averaged 17, 67, and 1.8 percent, respectively. These values were similar to several other experiments (Brown and Blaser, 1965; Wedin et al., 1966; Archer and Decker, 1977). The crude protein level remains adequate throughout winter; however, by January digestibility and potassium may fall below the nutrient requirements for some lactating beef cows (NRC, 2000). Collins and Balasko (1981b) suggested supplementation of energy and potassium may be necessary when utilizing stockpiled tall fescue during January and thereafter.

As the nutritive value of the forage declines, so does the ergovaline concentration of stockpiled tall fescue. A study conducted at the University of Missouri found that ergovaline concentrations decreased by 85 percent from mid-December to mid-March, a much faster rate of decline than crude protein or energy (Kallenbach et al., 2003). This response suggests that producers can benefit by feeding nontoxic forages in early winter and then use infected stockpiled tall fescue in late winter with only minor declines in animal performance.

Time of use may also be important to spring growth. Burns and Chamblee (2000a) showed date of grazing stockpiled tall fescue had no effect on subsequent spring growth. In addition, other studies have shown, if grazed before the growing season



begins, stockpiling does not adversely affect spring growth and botanical diversity (Allen et al., 1992a; Riesterer et al., 2000a). However, an earlier study conducted at the University of Pennsylvania showed the opposite result in spring growth when grazed by sheep (Hall et al., 1998). These different conclusions may have resulted from different allocation and endophyte levels, animal species used to graze, and environmental differences.

### ***Fertilizer Application***

Several researchers have studied the response of tall fescue to N fertilization during autumn (Wedin et al., 1966; Taylor and Templeton, 1976; Balasko, 1977; Fribourg and Bell, 1984; Gerrish et al., 1994). They found applying N increases yield and quality by decreasing the number of senesced leaves and increasing leaf area, number of leaves, tiller density, and concentrations of crude protein (Belesky et al., 1984; Occumpaugh and Matches, 1977). Applying N may also alleviate the need for protein supplementation (Collins and Balasko, 1981a, b; Occumpaugh and Matches, 1977). Archer and Decker (1977b) reported that an application of 100 kg ha<sup>-1</sup> of N increased crude protein concentrations from 13.4 to 16.2 percent after 105 days of stockpiling.

A study conducted in Iowa, showed that tall fescue was more responsive to N fertilizer when compared to reed canarygrass, orchardgrass, smooth bromegrass and meadow foxtail (Wedin et al., 1966). In addition, Taylor and Templeton (1976) also reported that N applications of 100 kg ha<sup>-1</sup> nearly doubled tall fescue production between mid-August and early October compared with no N. A study conducted at the University of Missouri found that tall fescue has a linear response to N rates with forage yield up to 113 kg ha<sup>-1</sup> (Kallenbach and McGraw, 2003). Interestingly, they also reported that N

rates up to 113 kg ha<sup>-1</sup> did not significantly affect red clover stands the following spring. That knowledge could have implications for producers using clover to help dilute the effects of endophyte infection on fescue toxicosis. Another study conducted at the University of Missouri showed N levels of 0, 45, 90, and 135 kg ha<sup>-1</sup> produced dry matter yields of 1896, 2656, 2922, and 3294 kg ha<sup>-1</sup>, respectively (Gerrish et al., 1994). However, the researchers concluded that in many years, due to environmental factors, rates of N greater than 45 kg ha<sup>-1</sup> might not be economically justified.

## **HERD MANAGEMENT**

In addition to stockpiled tall fescue management, herd management is also an important tool when trying to decrease winter feed cost. Herd management, such as calving season, and grazing strategies, such as strip grazing and forage allowance, also play important roles when planning to use stockpiled tall fescue (Matches et al., 1977; Fribourg, 1983; Nelson, 1988;). The importance of each of these herd management practices is described in depth below.

### ***Calving Season***

Calving season plays an important role in determining forage quantity and quality needs. Cow-calf producers must decide which calving season works best with the forage resources available. Lowest feed costs are realized when a cow's most demanding phase of production (usually lactation), occurs on pasture (Waller et al., 1988). Fall-calving is gaining popularity in the lower Midwest, although some researchers suggest that the forage production cycle of tall fescue more closely matches the nutrient requirements of spring-calving cows (Waller et al., 1988; Fribourg, 1983; Matches et al., 1977). However,

with the opportunity to stockpile “forage, fat, and calves”, tall fescue may be better suited for fall-calving cows. The importance of each of these opportunities is described in more detail below.

***Stockpiled Forage.*** Fall-calving cows often have higher feed expenses because of increased nutritional demands during winter (Raleigh, 1970). Stockpiled tall fescue reduces annual feed costs because it lengthens the grazing season and reduces the need for stored feed. There is some question whether stockpiled tall fescue can meet the nutrient requirements of a lactating, fall-calving cow. Fall-calving cows’ nutrient requirements are most critical between calving and breeding because this is when peak lactation occurs (Tucker et al., 1989). Meeting the nutritional requirements for this time period is important for conception rates (Dunn et al., 1969). However, at peak lactation a fall-calving cow’s TDN requirement is 57% (NRC, 2000), which is similar to what stockpiled tall fescue can provide in early December.

***Stockpiled Fat.*** “Stockpiled” fat can be estimated by body condition scores (BCS). BCS is an estimate of the fat content of the animal's body by evaluating the tissue cover over the ribs, spine, pins and hooks, and tail head (Neumann and Lusby, 1986). The scoring system has a range from one to nine, with one representing extremely emaciated cows and nine representing extremely obese cows. A grazing study in Iowa that utilized stockpiled tall fescue in a year-round grazing system with fall (average BCS = 6) and spring-calving (average BCS = 5) cows reported that at similar production stages, fall-calving cows had greater ( $P < 0.03$ ) BCS at all stages except at post-breeding ( $P = 0.13$ ) and post-weaning ( $P = 0.53$ ; Janovick, 2002).

Several researchers have concluded the factor most influencing the cow's ability to rebreed is body condition score at the time of calving (Wiltbank et al., 1962; Richards et al., 1986; Selk et al., 1988; Short et al., 1990; Dunn and Moss 1992; Sinclair et al., 1994; Spitzer et al., 1995). Cows maintaining a condition score between four and six at the time of calving were less affected by a change of one condition score either higher or lower, compared to those who were below four or above a six (Selk et al., 1988). In addition, Houghton et al. (1990) suggested that fleshy (BCS>6) and thin (BCS<4) cows at parturition should be managed to approach moderate body condition (BCS=5) before the breeding season to optimize reproductive performance.

Body weight, then, can decline during winter without adversely affecting reproduction as long as the weight change is fat stores and not lean tissue (Adams et al., 1987). Depositing or depleting of fatty tissue, which varies depending on the season and production stage, increases the efficiency of energy and N use throughout the year (Laurenz, 1992). This is called weight cycling. Weight cycling is natural during a cow's production stages. Jordan et al., (1968) found during winter, body weight loss of up to 1.1 kg d<sup>-1</sup> during lactation did not negatively affect the cow's ability to recover lost body tissue when adequate diet was available the following spring. A study conducted in Iowa found that fall-calving cows can lose over two BCSs between calving and after weaning and then accumulate enough fat stores during the grazing season to reach a BCS of 6.5 to 6.9 (Janovick, 2002).

***Stockpiled Calves.*** Fall-calving herds generally produce more revenue than spring-calving herds (Adams et al., 2001; Nelson, 1988). By calving in the fall, producers may be more flexible in economics and management. Calves born in the fall are exposed

to fewer pathogens because calving occurs on pasture and there is less threat of adverse weather (Adams et al., 2001), thus increasing the number of calves weaned. In addition, weanling calves and cull cows can be marketed at nontraditional times of the year at a premium price (Kreft et al., 1998). Alternatively, calves can be retained as stockers. Retaining or “stockpiling” calves increases the stocking rate when excess spring and summer forage is available. Guretzky et al. (2005) suggest that retention of a fall calf crop is advantageous over retention of a spring calf crop because of lower stored-feed requirements. When compared to retained spring calves, fall calves require 1180 kg hd<sup>-1</sup> less hay (Adams et al., 2001).

### ***Strip Grazing***

Effective grazing management techniques can help optimize pasture utilization. Pasture utilizations decrease due to trampling if cattle are allowed access to large areas of stockpiled tall fescue throughout winter (Gerrish, 2004). Trampling damages the waxy cuticle layer and flattens the erect leaves causing accelerated deterioration. In addition, trampling of pasture by cattle has varying effects on spring yield the following season and soil properties (VanHavern, 1983; Drewry et al., 2001).

To take full advantage of stockpiled forage, it should be strip grazed (Clark, 2003). Strip grazing confines animals to a limited area of pasture with a portable, electric fence. Allocating stockpiled forage in strips extends grazing further into winter and provides more uniform forage quality (Sleper and West, 1996). Researchers at the University of Missouri compared the efficiency of allocating stockpiled forage at three, seven, and 14-day intervals. Strip grazing on a three-day frequency yielded greater than

40 percent more grazing days per hectare than allocating a 14-day forage supply and did not compromise animal gain (Gerrish, 2004).

Using strip grazing is also beneficial to cattle when stockpiled forage is covered by snow and ice. Strip grazing allows access to forage underneath the elements which can be easily grazed. Cattle can graze through accumulations of up to 50 cm of fresh snow and 10 mm of ice as long as un-grazed forage is available (Decker, 1988; Riesterer et al., 2000a).

### ***Forage Allowance***

Forage allowance, an important factor influencing intake, is another aspect of grazing management. “Although much information is available on the nutrient requirements of beef cattle, knowledge of the relationships between animal performance and forage allowance for the grazing animal would be of greater relevance in a pasture situation” (Marsh, 1979). Selecting the appropriate forage allowance will enable the producer to allocate the amount of forage needed for acceptable animal performance. When strip grazing, allocating too much forage decreases utilization and days of grazing, while allowing too little forage limits animal intake and performance. Typically, higher animal gains can be expected with higher allowances than with lower allowances (Matches et al., 1981). By managing stockpiled tall fescue correctly, we can begin to develop management techniques to optimize animal performance and define an economical forage allocation. As defined by Nicoll (1979), the objective may be to determine the minimum weight and condition a beef cow can annually conceive and produce a quality calf.

Most grazing research conducted on stockpiled forage has been related to the maintenance of gestating beef cows (Wilson et al., 1965; Tucker et al., 1989; Allen et al., 1991a, b; Davis, 1996). This research shows that stockpiled tall fescue provides adequate nutrition for gestating beef cows during fall and winter grazing (Baker et al., 1965; Hobbs et al., 1965). However, no few studies have been conducted on forage allocation as a function of body weight for lactating beef cows and their calves.

This study examined the effects of four daily forage allowances (2.50, 3.00, 3.75, and 4.50 percent of the animal's body weight) and three endophyte infection levels (20, 51, and 89 percent infected) of stockpiled tall fescue. Our hypothesis was that cattle allocated high forage allowances and low endophyte infection levels would exhibit higher body condition scores and calf gain compared to the other treatments; however when looking at beef production per hectare, we hypothesized the lower forage allowances would be more economical through least-cost feeding. The objective of this study was to evaluate the impact of different forage allocation and endophyte infection levels of stockpiled tall fescue on the performance of lactating beef cows and their calves, as well as pasture utilization. A secondary objective was to determine if spring growth of pastures was altered by allocating different levels of forage through the winter. Conventional winter hay-feeding practices were also evaluated for a comparison of animal performance with stockpiled tall fescue.

## IMPACT OF FORAGE ALLOWANCE ON LACTATING BEEF COWS STRIP-GRAZING STOCKPILED TALL FESCUE

**ABSTRACT:** A two year study was conducted from December to July of 2004-2005 (Year 1) and 2005-2006 (Year 2) to evaluate the impact of different forage allowances on the performance of lactating beef cows and their calves grazing stockpiled tall fescue. To examine this, forage allowances of 2.25, 3.00, 3.75, and 4.50 percent of body weight (% of BW) were set as experimental treatments. Conventional hay-feeding was also evaluated as a comparison to grazing stockpiled tall fescue. The experimental design was a randomized complete block with three replications. Apparent DM intake of cow-calf pairs grazing stockpiled tall fescue was 32% greater than ( $P < 0.05$ ) for those receiving 4.50% of BW than cows allocated 2.25% of BW. However, as forage allowance increased from 2.25% to 4.50%, pasture utilization fell by 25%. During Year 1, cows in the hay treatment lost 0.50 kg d<sup>-1</sup> compared to 1 kg d<sup>-1</sup> for cows grazing stockpiled tall fescue 3.00, 3.75, and 4.50% of BW, and 1.25 kg d<sup>-1</sup> when allocated 2.25% of BW ( $P < 0.05$ ). However during Year 2, cows receiving 4.50% of BW lost only 0.04 kg d<sup>-1</sup> which was less than ( $P < 0.05$ ) all other treatments, except the 3.75% of BW treatment. Averaged over both years, calf ADG was 0.12 kg d<sup>-1</sup> greater ( $P < 0.05$ ) when forage allowances were above 2.25% BW or when hay was fed. However, calf gain ha<sup>-1</sup> for the 2.25% of BW treatment was nearly 40% greater than the 4.50 % of BW treatment. These results suggest that cow weight and condition loss and suppressed calf average day gain can be easily regained when pasture conditions improve. Individual calf performance is maximized at forage allowances at or above 3.00% of BW, but the most economical



forage allowances may be at 2.25% of BW, since cow weight loss is easily regained, land requirement are decreased and calf gain ha<sup>-1</sup> is increased. In addition, this study shows that stockpiled tall fescue without concentrate supplementation can be fed to lactating, fall calving cows and is a suitable substitute to hay.

**Key Words:** Forage allowance, Allocation level, Fall-calving, Stockpiled tall fescue

## INTRODUCTION

Fall-calving has gained popularity (Bagley and Evans, 2004) due to increased conception rates, decreased calf death loss, decreased heat stress, and marketing advantages (Nelson, 1988). In addition, fall-calving cows typically have higher BCS at similar production stages than do spring-calving cows (Janovick, 2002) and have more energy for weight cycling (Freetly et al., 2000). However, due to lactation demands during winter, the cost to feed a fall-calving cow is approximately 12% greater than the cost to feed a spring-calving cow (Brees and Horner, 2006).

One management technique used to reduce winter feeding costs is to utilize stockpiled tall fescue (*Festuca arundinacea* Schreb). Studies have shown that stockpiled tall fescue can extend the grazing season, reduce labor, and almost eliminate the need for stored feed (Hitz and Russell, 1998; Clark, 2003). However, little is known about the relationship between animal performance and forage allowance of stockpiled tall fescue, especially for lactating, fall-calving beef cows. Researchers in Iowa allotted 4% of BW to gestating, spring calving cows (Hersom, 1999), however lactating cows have higher intake and nutrient requirements (NRC, 2000), and may require higher forage allowances. Selecting the appropriate forage allowance would enable producers to decrease the amount of land required for stockpiling winter forage, while still achieving acceptable animal performance.

We hypothesized that cows allocated more forage would exhibit higher BCS and less BW loss over winter; however, calf gain  $\text{ha}^{-1}$  would be optimal at lower forage

allowances. The objective of this study was to evaluate the impact of different forage allowances of stockpiled tall fescue on the performance of lactating beef cows and their calves, pasture utilization, and subsequent spring growth of tall fescue. Conventional hay-feeding practices were also evaluated for a comparison of animal performance.

## MATERIALS AND METHODS

A 2-year grazing experiment was conducted from 2 December to 18 July in 2004-2005 (Year 1) and from 1 December to 12 July in 2005-2006 (Year 2) at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). The experiment was conducted on a 50 ha block that was divided into 12, four ha pastures and three hay feeding areas (FIGURE 1). The areas used were typical of cool-season grass-legume pastures in the region, with tall fescue as the predominate species. Orchardgrass (*Dactylis glomerata* L.) and Kentucky bluegrass (*Poa pratensis* L.) were subordinate components as were red clover (*Trifolium pretense* L.) and birdsfoot trefoil (*Lotus corniculatus* L.). The soil types were Grundy silt loam (fine, smectitic, mesic Aquertic Argiudolls) on 1-5% slopes, Armstrong loam (fine, smectitic, mesic, Aquertic Hapludalfs) and Lagonda silt loam (fine, smectitic, mesic Aquertic Hapludalfs) on 2-5% slopes, Armstrong clay loam (fine, smectitic, mesic Aquertic Hapludalfs) on 5-9% slopes, and Purdin loam (fine, mixed, superactive, mesic Oxyaquic Hapludalfs) on 9-14% slopes.

### ***Treatments***

The treatments in this experiment were forage DM allowances of 2.25, 3.00, 3.75, and 4.50 percent of cow-calf body weight daily and an additional treatment with cows fed hay *ad libitum*. The experiment was divided into two parts: 1) a grazing phase and 2) a monitoring phase (FIGURE 2). The 84-day grazing phase was divided into four, 21 day periods starting on 2 December 2004 for Year 1 and 1 December 2005 for Year 2.

The monitoring phase was from the end of the grazing phase until mid-July. During the monitoring phase, cows and calves were commingled and managed as a single group. During this phase, animals grazed stockpiled tall fescue until late March, and then were fed hay until they were turned out to cool-season grass/legume pastures in early April. Cattle were not allowed regaze areas used during the grazing phase until mid-May so that residual effects of winter grazing could be measured on pastures.

### ***Pasture Management for Stockpiled Tall Fescue***

Pastures were harvested for hay and/or grazed during the spring and summer prior to stockpiling. In mid-August, pastures were uniformly grazed to a height of approximately 8 cm and then fertilized with 90 kg N ha<sup>-1</sup> as ammonium nitrate. Soils were sampled and tested annually; lime, phosphorus, and potassium were applied in mid-August according to recommendations by the University of Missouri Soil Testing Laboratory. Following fertilization, pasture growth was allowed to accumulate until early December when the grazing phase was initiated. After the end of the grazing phase in late-February, red clover (*Trifolium pretense* L.) and N fertilizer were broadcast across all pastures at 4.48 and 56 kg ha<sup>-1</sup>, respectively, and pastures were allowed to rest until mid-May.

### ***Animal Management***

A total of 75 multiparous cross-bred cows (red Gelbvieh, black Gelbvieh, red Angus, and black Angus) in early lactation and their calves were stratified into fifteen groups of five based on cow weight and age, and calf age and sex, and then groups were randomly assigned to treatments. Water and trace-mineralized salt blocks were available

*ad libitum* to cows and calves. In early-December of Year 1 and Year 2, one red Gelbvieh or black Simmental bull was added to each group to initiate a 45-day breeding season. Each bull passed a breeding soundness examination. The experimental protocol was reviewed and approved by the University of Missouri Animal Care and Use Committee.

***Animal Management for Stockpiled Tall Fescue Treatments.*** Stockpiled tall fescue was allocated every 3.5-days (twice per week) according to treatments by strip grazing. Animals were rotated between pastures within each block at the end of each 21-day period to minimize the impact of pasture variation on animal performance. A back-fence, consisting of portable plastic posts and polywire, was used to prevent access to previously grazed areas of different forage allowance. In the event of a heavy ice (>10 mm) or snowstorm (>50 cm), small square bales of mixed-grass hay were fed to cattle grazing stockpiled tall fescue until animals were able to resume grazing. During Year 1, a total of 58 kg hay was fed per cow-calf pair for five of the 84-days due to excessive ice accumulations. During Year 2, no hay was required.

***Animal Management for Hay Treatment.*** The hay treatment utilized cool-season grass/legume large round bales harvested the previous spring. Bales were stored outside in a well-drained location but uncovered. Cows and calves assigned to the hay feeding treatment were fed hay *ad libitum* and restricted to pasture area of less than one ha. The forage in this area was grazed to 8-cm height prior to the start of the experiment. The amount of hay fed was recorded. Bales were weighed and sampled for dry matter and nutritive value analysis before being fed. Samples were analyzed in duplicate for crude protein and *in-vitro* true digestibility using near infrared (NIR) reflectance spectroscopy (TABLE 1).

### ***Forage Measurements***

Pasture yield during the grazing phase was in each pasture measured by clipping ten, 0.8 x 4.6-m strips to a 2 cm height with a tractor-mounted, flail-type harvester. These harvests are referred as pre harvests (PRE) and were taken from where the cattle were expected to graze within the next 21-day period. At the end of each 21-day period, twelve strips as described above were clipped from the grazed area to determine residual forage yield. These harvests are referred as post harvests (POST). Pasture utilization and apparent intake (pasture disappearance rate) were calculated from the differences in the PRE and POST harvests. During the monitoring phase, five, 0.8 x 4.6-meter strips were harvested in early May from each of the four forage allowance areas in pasture to evaluate the effect of forage allowance on subsequent spring yield (FIGURE 3). Grab-samples collected from each harvest strip were bulked together for an individual pasture area. This grab-sample was then split into two sub-samples of approximately 300 g each. The first sub-sample was analyzed for dry matter by drying in a forced air oven for a minimum of 24 h at 90°C. The second sub-sample was frozen and then freeze-dried. After freeze-drying, samples were ground in a cyclone mill (UDY Corp., Ft. Collins, CO) to pass a 1-mm screen and used to evaluate forage nutritive value.

Crude protein and *in-vitro* true digestibility were measured from ground samples with NIR using the scanning, calibration, and validation methods (TABLE 1). Crude protein for calibration samples was determined by measuring total N content using a LECO FP-428 (LECO Corp., St. Joseph, MI) and then multiplying N values by 6.25. *In-vitro* true digestibility (IVTD) was determined by running a 48-h *in-vitro* digestion followed by washing with neutral detergent fiber solution as described the Ankom Technology

(Ankom Technology, Fairport, NY). Rumen fluid for IVTD was collected from a cannulated cow offered a forage-based diet.

### ***Animal Performance Measurements***

Body condition scores, body weights, birth dates and weights of calves, health records, and pregnancy rates were collected. An experienced technician assigned body condition scores to all cows at the start and end of the grazing phase, at weaning, and the end of the monitoring phase in July. Cow weights were taken on two consecutive mornings to minimize variability due to fluctuations in gastrointestinal fill, without prior removal from water and pasture. This was done at the start and end of the grazing phase, at weaning, and the end of the monitoring phase. On 12 April of Year 1 and 4 April of Year 2, pregnancy determinations were made using rectal palpation and ultrasonography.

Calf weights were also taken on two consecutive mornings without prior removal from water and pasture at the beginning and end of the grazing phase and again at weaning. Calf weaning weights were analyzed both as actual and adjusted 205-d weaning weights. Adjusted weaning weights were adjusted for calf age but not for age of cow. All calves were weaned and sold in mid-April both years.

### ***Statistical Analysis***

Data for forage yield and quality were analyzed as a randomized complete block design with five treatments and three blocks as described by Steel and Torrie (1980). The model was a repeated measures, with year as the main plot, allocation levels as sub-plots, and sampling periods within a year as sub-sub-plots. Main effects and all possible interactions were analyzed as described by Steel and Torrie (1980). Treatment differences



were separated using Fisher's protected LSD ( $\alpha = 0.05$ ). Animal performance data were also analyzed as a randomized complete block using the model described above, except that period was removed from the model. The experimental unit for all measurements in animal performance was the group of five cow-calf pairs on each of the twelve pastures or three hay feeding areas. Animal data were analyzed using the general linear model procedure of SAS version 8.2 (SAS Inst. Inc., Cary, NC). Where applicable, regression analysis was used to explain variable responses using least squares analysis of function and fit (Steel and Torrie, 1980). Except where indicated otherwise, significant differences were defined as  $P \leq 0.05$ .

## RESULTS AND DISCUSSION

### *Apparent Dry Matter Intake and Utilization*

Averaged over the stockpiled forage allowance treatments, apparent DM intake was 3 kg d<sup>-1</sup> and pasture utilization was 14 % greater ( $P < 0.001$ ) for Year 1 than for Year 2 (TABLE 2). However, there were no interactions between treatments and years. The differences between years were attributed to variations in weather conditions; Year 1 was a wet, cold winter, while Year 2 was a dry, cool winter (FIGURE 4). When cattle are cold and wet, DM intake and passage rate increases to help regulate body temperature (NRC, 2000), therefore increasing pasture utilizations.

Throughout the 84-day grazing phase, cow-calf pairs allotted to the hay treatment received 1,632 kg DM of grass hay, giving an apparent DM intake of 18 kg d<sup>-1</sup> (TABLE 2). Apparent DM intake of the stockpiled tall fescue treatments was greatly affected by the different forage allowances ( $P = 0.001$ ). Apparent DM intake was the greatest for cows receiving 4.50% of BW. At 19 kg d<sup>-1</sup>, they apparently consumed 32% more ( $P < 0.05$ ) DM than cows allocated stockpiled tall fescue at 2.25% of BW (TABLE 2). According to the NRC, a beef cow weighing 533 kg in mid-lactation requires approximately 12 kg DM d<sup>-1</sup>, which is 2.25 % of BW. Therefore, cows allocated 2.25% of BW would have to reach pasture utilizations near 100% to meet their DM intake requirements. Baker et al. (1981) concluded at forage allowances below 3.4% of BW reduced the time spent grazing by 2.25 hours and decreased herbage intake by 12%,

making it even harder for cows allotted to the 2.25% of BW treatment to reach DM intake requirements.

Pasture utilization was also affected ( $P = 0.001$ ) by forage allowance. As forage allowance increased from 2.25% to 4.50%, pasture utilization fell from 84% to 59% (FIGURE 5). In addition, pasture utilization responded quadratically to forage allowance ( $R^2 = 0.99$ ; FIGURE 5), with pasture utilization increasing by about 15% for each 1% decrease in forage allowance. Working with lactating dairy cows Virkajarvi et al., (2001), found that when forage allowances increased from 19 to 27 kg DM cow<sup>-1</sup>d<sup>-1</sup>, pasture utilizations declined from 78 to 61%. Marsh (1979) also found that as forage allowance increased, apparent DM intake also increased but pasture utilization decreased; however their study used steers and apparent DM intake did not plateau until the forage allowance in our study were at 10% of BW. These studies suggest that if forage allowances were increased above 4.50% of BW, apparent DM intake would have likely increased.

### ***Animal Performance***

**Cows.** Interactions between years and treatments were significant for all measures of cow performance; thus data are presented by year. A likely reason for the year by treatment interactions were the differences in weather conditions mentioned earlier.

During Year 1, cow BW, BCS, and ADG were greatly influenced by treatments. Cows in the hay treatment lost less weight ( $P < 0.05$ ) and body condition ( $P < 0.05$ ) compared to cows grazing stockpiled tall fescue (TABLE 3, TABLE 4). By the end of the grazing phase, cows in the hay treatment weighed 557 kg, which was 32 kg more ( $P < 0.05$ ) than cows allocated 3.00, 3.75, and 4.50% of BW as stockpiled tall fescue. The cows in the 2.25 treatment weighed 506 kg, which was less ( $P < 0.05$ ) than any other

treatment (TABLE 3). Body condition score also displayed similar results to those of BW. Cows in the hay treatment lost the least ( $P < 0.05$ ) amount of condition and had an average BCS of 5.2, which was at least half a body condition score greater than any of the forage allowance treatments (TABLE 4). A decline in body weight and condition score was also recorded by Janovick et al. (2004). In their study, from November to February, cows lost approximately 30 kg BW and dropped from a BCS of 6 to 4.5, similar to results reported in our experiment.

As a result of the body weight and condition loss, it follows that cow ADG displayed similar results. Cows in the hay treatment lost approximately  $0.50 \text{ kg d}^{-1}$  compared to  $1 \text{ kg d}^{-1}$  for cows that received 3.00, 3.75, and 4.50% of BW as stockpiled tall fescue. Cows allocated only 2.25% of BW lost  $1.25 \text{ kg d}^{-1}$  ( $P < 0.05$ ; TABLE 3). At weaning in mid-April (45 days after the grazing phase ended), all cows averaged 502 kg ( $P = 0.184$ ; TABLE 3). Another interesting result we measured during this part of the monitoring phase was that cows grazing stockpiled tall fescue lost  $0.52 \text{ kg d}^{-1}$  less ( $P < 0.05$ ) than cows fed hay *ad libitum*. It appears that a fall-calving cow's weight declines at a fast rate during winter, but lost body weight and condition are easily regained when spring forage becomes available (Janovick et al. 2004).

Contrary to Year 1, during Year 2, cow BCS for both the grazing and monitoring phase was unaffected ( $P > 0.05$ ) by treatments and averaged 6.2 and 5.8, respectively (TABLE 4). In addition, cows in the hay treatment weighed approximately 30 kg less than ( $P < 0.05$ ) cows at the 4.50% of BW forage allowance (TABLE 3). Treatment effects for ADG approached significance ( $P = 0.063$ ) in Year 2, and was greatest for the 4.50% treatment, averaging  $-0.04 \text{ kg d}^{-1}$  (TABLE 3). Similar to the findings of Gerrish

(2002), the BW of fall-calving cows was practically unchanged when they grazed stockpiled tall fescue from mid-November to mid-February. Another similarity was that from mid-February to late March, cows lost an average of  $0.7 \text{ kg d}^{-1}$ , which was only  $0.1 \text{ kg d}^{-1}$  greater than results report in our experiment (TABLE 3). It is likely that unseasonably mild winters contributed to the similarity in results of these two different experiments.

Even though there were differences in cow performance during the grazing phase, in both years conception rate averaged 93% across all treatments. Conception rate and the ability of a cow to produce a healthy calf on a yearly cycle is one of the major determinants for profitability of cow-calf enterprises (Wiltbank et al., 1962).

**Calves.** Calf performance in Year 2 was greater than year 1; however, there were no year by treatment interactions and thus, data were averaged over both years.

Similar to cow performance in Year 1, calf performance was greater ( $P < 0.05$ ) with forage allowances above  $2.25\% \text{ BW d}^{-1}$  or when hay was fed (TABLE 5). During the grazing phase, calf weight was the same ( $P > 0.05$ ) for the 3.00, 3.75, 4.50, and hay treatments and averaged 173 kg. Calves in the 2.25% of BW treatment gained an average 11 kg less than ( $P < 0.05$ ) the other treatments during the grazing phase. Average daily gain responded quadratically to forage allowance ( $r^2 = 0.92$ ; FIGURE 6), in which ADG increased, with increasing forage allowance.

Our data shows that even though fall-calving beef cows are losing weight over winter, calf performance is not altered until forage allocation is less than 3.0% of BW. As mentioned earlier, at a forage allowance of 2.25% of BW, cows may have had limitations in forage DM intake. Although we did not measure milk production from cows in this

study, it seems likely to us that cows in the 2.25% of BW treatment produced less milk than cows in the other treatments, was nearly equal. Johnson et al. (2003) found that for Brangus cows, a 0.35 kg increase in forage DM intake was associated with about a one kg increase in milk yield. Intake data in conjunction with that of Rutledge et al. (1971), showed that 60% of the variation in calf weaning weight can be attributed to the dam's ability to produce milk. In addition, Lake et al. (2005) found that calf performance was not influenced by the cow's BCS at parturition or diet, but rather it was influenced by milk yield and energy content.

Average daily gain is an important factor for increasing returns to livestock operations; however if land is a limiting component, gain ha<sup>-1</sup> is another valuable index. Even though average daily gain was 20% greater from the highest to the lowest forage allowance, gain ha<sup>-1</sup> for the 2.25% of BW treatment was nearly 40% greater compared the 4.50 % of BW treatment (TABLE 5). These results are similar to those of Virkajavi et al. (2001), which were that a reduction in individual animal performance of 6% led to a 33% increase in animal production per hectare.

There were no differences ( $P > 0.1$ ) in actual weaning weights compared to 205-d adjusted weaning weights; therefore actual weaning weights were used. By weaning, all calves averaged 195 kg ( $P = 0.17$ ; TABLE 5). While calf ADG was greater ( $P < 0.05$ ) for 3.00, 3.75, 4.50% of BW and hay treatments compared to that of the 2.25% of BW treatment during the grazing phase, calf ADG during the monitoring phase was not different ( $P = 0.167$ ). The range of pre-weaning calf ADG for this experiment was approximately 0.2 to 0.3 kg d<sup>-1</sup> less than a similar experiment conducted in Iowa

(Janovick et al., 2004). However no supplements were fed during our experiment, which would be a likely factor influencing calf ADG.

### ***Pre and Post-grazing Yield and Nutritive Value***

***Pre-grazing Yield.*** Ample rainfall during the stockpiling period each year helped to produce approximately 5000 kg ha<sup>-1</sup> of DM. However due to more precipitation during the grazing phase of Year 1 (FIGURE 4), forage yield and quality declined at a faster rate from day 0 to 63 (From 1 December to 13 January; TABLE 6) in Year 1 than in Year 2. Abundant rainfall and warmer temperatures in February of Year 1 (FIGURE 4) caused a slight increase in forage DM yield during the last two forage harvests. Nelson (1996) showed that tall fescue will grow during winter, if temperatures are slightly above freezing.

Contrary to Year 1, during Year 2, forage DM yield remained the same from day 0 to 63 (5,123 kg ha<sup>-1</sup>;  $P > 0.05$ ). However, due to lack of rainfall and cooler temperatures in February (FIGURE 4), forage DM yield declined by 26% by the end of the grazing phase (TABLE 6). These declines in forage DM yield are in accordance with other studies (Ocumpaugh and Matches, 1977; Fribourg and Bell, 1984; Gerrish et al., 1994), which found that the yield of stockpiled tall fescue can decline from almost 0 to 50% over winter. We would also like to note that differences in pre-grazing DM yield could also be attributed to landscape position, as this data was collected from different locations within the pasture.

***Pre-grazing/Feeding Nutritive Value.*** There were year by period interactions for all measures of stockpiled tall fescue nutritive value; therefore data are presented by year.

By the end of the grazing phase during Year 1, crude protein concentration of stockpiled tall fescue declined 5%; however, it remained relatively constant during Year 2 (TABLE 6). Crude protein remained above 12% both years, which was 17% greater concentration than the hay fed in the hay treatment (TABLE 6). Although CP concentrations for stockpiled tall fescue during Year 1 and Year 2 were statistically different, they exceeded the nutrient requirements of lactating beef cows (NRC, 2000). Therefore, the difference in CP reported was likely not biologically important.

For Year 1 and Year 2, IVTD concentrations of the stockpiled tall fescue were 77 and 81%, respectively, at the start of the grazing phase and declined 10 and 6 percentage units, respectively, over the course of the study ( $P < 0.05$ ; TABLE 6). According to the NRC (2000) forage with increased digestibility should have greater DM intake. However, these differences in IVTD concentrations had no impact on apparent DM intake of the cow-calf pairs. For example, during Year 2, IVTD was greater however, apparent DM intake was greater for Year 1 (TABLE 2; TABLE 6) Even though IVTD concentrations did not explain differences in DM intake, and in addition to weather conditions they may explain the difference in calf ADG and cow weight loss.

***Post-grazing Yield.*** Post-grazing forage DM yield was approximately 600 kg ha<sup>-1</sup> greater for Year 2 than Year 1. As discussed earlier, due to wet, cold weather conditions during Year 1, apparent intake was increased and therefore the amount of post-grazing DM decreased. For both years, post-grazing forage DM increased as forage allowance increased, but the responses were curvilinear ( $r^2 = 99$  both years; FIGURE 7). The curvilinear responses were in part due to increased pasture utilizations as forage allowances decreased.



**Post-grazing Nutritive Value.** Post-grazing stockpiled tall fescue CP concentrations were unaffected by forage allowance ( $P > 0.2$ ). However, post-grazing CP concentrations were approximately 6% less than the pre-grazing CP concentrations. Thus it seems likely that cattle selected high quality forage based on the nutritive value of the residual forage. Unlike CP, IVTD was influenced by forage allowance during Year 2 ( $P < 0.001$ ) and slightly during Year 1 ( $P = 0.081$ ). Similar results were found for both years, in which forage allowance positively correlated to IVTD ( $R^2 = 0.99$ ; (FIGURE 8). Additionally, all measure of post-grazing IVTD were lower than pre-grazing IVTD. These post-grazing nutritive value results imply that cattle are selective grazers. These data agree with the finding of Roth et al. (1990), as forage allowances declined from 148 to 9% of BW, grazing selectivity increased. In addition, Roth et al. (1990) documented that cattle select for leaf tissue and leave the stem portion. Cows allocated to 2.25% of BW treatment left a greater portion of stem, therefore IVTD was 67%. In addition cattle at higher forage allowances had more forage to pick through therefore leaving forage at higher IVTD concentrations.

### ***Spring Yield***

There were no year interactions for spring yield ( $P = 0.467$ ) and thus data for both years were combined. Contrary to the findings of Burns and Chamblee (2000), Allen et al. (1992), and Riesterer et al. (2000) spring yield was affected ( $P < 0.05$ ) by winter grazing. However, our results show that the lower the forage allowances during winter, the lower the forage DM yield the following spring. Spring yield was the same for all forage allowances except at the 2.25% treatment, which averaged approximately 4000 kg ha<sup>-1</sup>. However, spring yield was positively correlated ( $R^2 = 0.99$ ) with increasing forage

allowance (FIGURE 9). Kuusela and Khalili (2002) found similar results, noting decreases in pasture regrowth with decreasing forage allowances. They attributed their decline in pasture regrowth to soil compaction from trampling. Soil compaction is known to reduce the availability of N (Younie and Hermansen, 2000). This may have been a factor accounting for some of the decrease in spring yields recorded in our experiment; however more research is needed in this area.

The question needs to be asked, will a decrease in spring DM yield, decrease returns to the land? Even though decreasing forage allowance during winter decreases spring growth the following season, typically spring forage production is in excess of what most beef herds can consume. Many producers harvest this extra forage growth for hay, however, a grazing system that utilizes stockpiled tall fescue the need for hay is virtually eliminated (Clark, 2003).

## IMPLICATIONS

Results from this grazing experiment show that as forage allowance is decreased, cow and calf average daily gain, apparent dry mater intake and subsequent spring growth decrease, but also the amount of land required to over winter a fall-calving herd decreases. Cow weight and body condition loss and suppressed calf average day gain during winter can be easily regained the following spring. Forage allowances may be most economical at 2.25% of BW, since cow weight loss is easily regained, land requirements are decreased and calf gain ha<sup>-1</sup> can be increased by as much as 40%. In addition, when comparing stockpiled tall fescue to hay, cow and calf performance was comparable, concluding that utilization of stockpiled tall fescue for lactating, fall calving beef cows is a suitable substitute for hay.

## LITERATURE CITED

- Allen, V. G., J. P. Fontenot, D. R. Notter and R. C. Hammes, Jr. 1992a. Forage system for beef production from conception to slaughter I. Cow-calf production. *J. Anim. Sci.* 70:576-587.
- Allen, V. G., J. P. Fontenot, and D. R. Notter. 1992b. Forage systems for beef production from conception to slaughter II. Stocker systems. *J. Anim. Sci.* 70:588-596.
- Bagley, C. P. and R. R. Evans. 2004. Questions and answers: beef and forage production. [Online]. Available at [http://msucares.com/pubs/publications/p2023\\_1.htm](http://msucares.com/pubs/publications/p2023_1.htm) (verified 22 June 2006).
- Baker, R. D., F. Alvarez, and Y. L. P. Le Du. 1981. The effect of herbage allowance upon the herbage intake and performance of suckler cows and calves. *Grass and Forage Sci.* 36:189-199.
- Bishop-Hurley, G. J. and R. L. Kallenbach. 2001. The economics of grazing beef cows during winter. p. 274. In *Proc. American Forage and Grassland Council*. 22-25 April, 2001. Springdale, AR. AFGC, Georgetown, TX.
- Brees, M. and J. Horner. 2006 Projected Beef Cow/Calf Annual Budget for Calves Sold in 2006. [Online]. Available at <http://www.agebb.missouri.edu/mgt/budget/annlbeef.htm> (verified 19 June 2006).
- Burns, J. C., and D. S. Chamblee. 2000. Summer accumulation of tall fescue at low elevations in the humid Piedmont: II. Fall and winter changes in nutritive value. *Agron. J.* 92:217-224.
- Clark, J.T. 2003. Evaluating efficacy and limitations of winter grazing systems for beef cattle on animal production and soil properties. Iowa State University, Ames.
- Freetly, H. C., C. L. Ferrell, and T. G. Jenkins. 2000. Timing of realimentation of mature cows that were feed-restricted during pregnancy influences calf birth weights and growth rates. *J. Anim. Sci.* 78:2790-2796.
- Fribourg, H. A. and K. W. Bell. 1984. Yield and composition of tall fescue stockpiled for different periods. *Agron. J.* 76:929-934.
- Gerrish, J. R. 2002. Winter grazing fall-calving cows: first year project summary. *Missouri Agric. Exp. Stn. Forage Systems Update* vol. 11, no. 2 [Online]. Available at <http://aes.missouri.edu/fsrc/news/archives/n102v1n2a.stm> (verified 18 June 2004).

- Gerrish, J. R., P. R. Peterson, C. A. Roberts, and J. R. Brown. 1994. Nitrogen fertilization of stockpiled tall fescue in the Midwestern USA. *J. Prod. Agric.* 7:98-104.
- Hersom, M. J. 1999. Evaluation of year-round forage management systems for beef production. Masters Thesis. Iowa State University, Ames.
- Hitz, A. C. and J. R. Russell. 1998. Potential of stockpiled perennial forages in winter grazing systems for pregnant beef cows. *J. Anim. Sci.* 76:404-415.
- Janovick, N.A. 2002. Evaluation of year-round grazing systems for fall- and spring-calving beef cows. Iowa State University, Ames.
- Janovick, N. A., J. R. Russell, D. R. Strohbahn and D. G. Morrical. 2004. Productivity and hay requirements of beef cattle in a Midwestern year-round grazing system. *J. Anim. Sci.* 82:2503-2515.
- Johnson, C. R., D. L. Lalman, M. A. Brown, L. A. Appeddu, D. S. Buchanan, and R. P. Wettemann. 2003. Influence of milk production potential on forage dry matter intake by multiparous and primiparous Brangus females. *J. Ani. Sci.* 81: 1837-1846.
- Kuusela, E., and H. Khalili. 2002. Effect of grazing method and herbage allowance on the grazing efficiency of milk production in organic farming. *Anim. Feed Sci. and Tech.* 98:87-101.
- Lake, S. L., E. J. Scholljegerdes, R. L. Atkinson, V. Nayigihugu, S. I. Paisley, D. C. Rule, G. E. Moss, T. J. Robinson and B. W. Hess. 2005. Body condition score at parturition and postpartum supplemental fat effects on cow and calf performance. *J. Anim. Sci.* 83:2908-2917.
- Marsh, R. 1979. Effect of herbage SM allowance on the immediate and longer term performance of young Friesian steers at pasture. *N. Z. Agric. Res.* 22:209-219.
- National Research Council. 2000. Nutrient Requirements of Beef Cattle. 7th ed. National Academy Press, Washington, DC.
- Nelson, M. E. 1988. Calving season strategies. Cooperate Extension Service, Manhattan, Kansas.
- Nelson, C. J. 1996. Physiology and developmental morphology. P. 87-125. *In* L.E. Moser et al. (ed.) Cool-season forage grasses. Agron. Monogr. No. 34. ASA, CSSA, and SSSA, Madison, WI.
- Ocuppaugh, W. R., and A. G. Matches. 1977. Autumn-winter yield and quality of tall fescue. *Agron. J.* 69:639-643.

- Riesterer, J. L., and D. J. Undersander, M. D. Casler, and D. K. Combs. 2000. Forage yield of stockpiled perennial grasses in the upper Midwest USA. *Agron. J.* 92: 740-747.
- Roth, L. D., F. M. Rouquette, Jr., and W. C. Ellis. 1990. Effects of Herbage Allowance on Herbage and Dietary Attributes of Coastal Bermudagrass. *J. Anim. Sci.* 68:193-205.
- Rutledge, J. J., O. W. Robison, W. T. Ahlschwede, and J. E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. *J. Animal. Sci.* 33: 563.
- Steel, R. G., and J. H. Torrie. 1980. Principles and procedures of statistics. Second edition. McGraw-Hill. New York, NY.
- Waller, J.C., J.C. Forcherio, H.A. Fribourg, M.C. Smith, and R.J. Carlisle. 1988. Performance of fall-calving cows and their calves grazing fescue-based forage systems. *J. Prod. Agric.* 1:338-342.
- Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory, and R. M. Kock. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. *J. Anim. Sci.* 21:219-225.
- Virkajarvi, P., A. Sairanen, J. I. Nousiainen, H. Khalili. 2001. Effect of herbage allowance on pasture utilization, regrowth and milk yield of dairy cows in early, mid and late season. *Anim. Feed Sci. and Tech.* 97:23-40.
- Younie, D., and J. Hermansen. 2000. The role of grassland in organic livestock. *Grassland Science in Europe* 5:493-511.

FIGURE 1. Map of experimental site: impact of grazing stockpiled tall fescue on lactating beef cows and their calves during the grazing phase (December to February) for Year 1 (2004-2005) and Year 2 (2005-2006). The location was at the University of Missouri Forage Systems Research Center near Linneus, MO (39° 51' N, 93° 6'W).

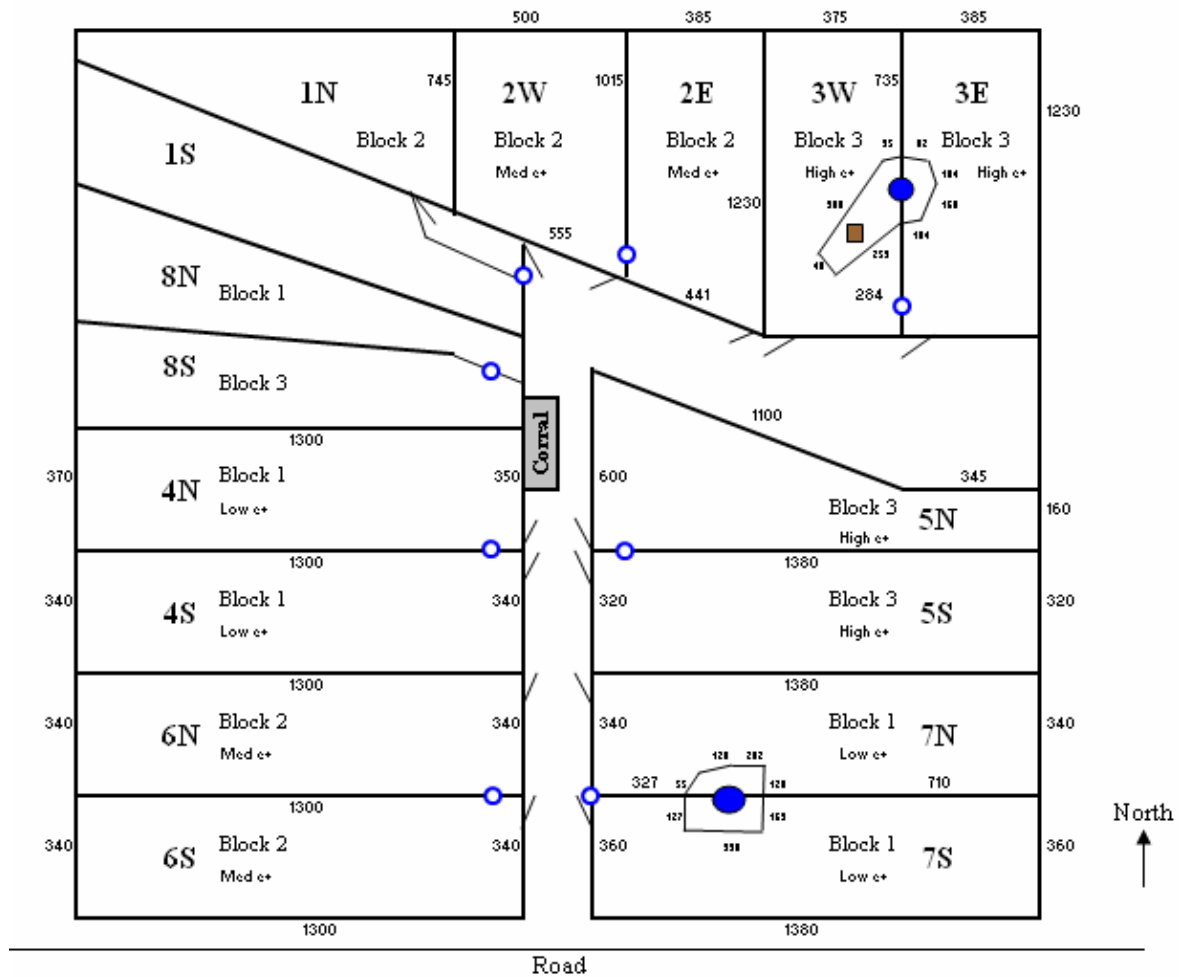


FIGURE 2. Experimental timeline for forage allowance and hay feeding treatments for lactating beef cows and their calves from August to the end of July for Year 1 (2004-2005) and Year 2 (2005-2006). The experiment was conducted at the University of Missouri Forage Systems Research Center (39° 51' N, 93° 6'W).

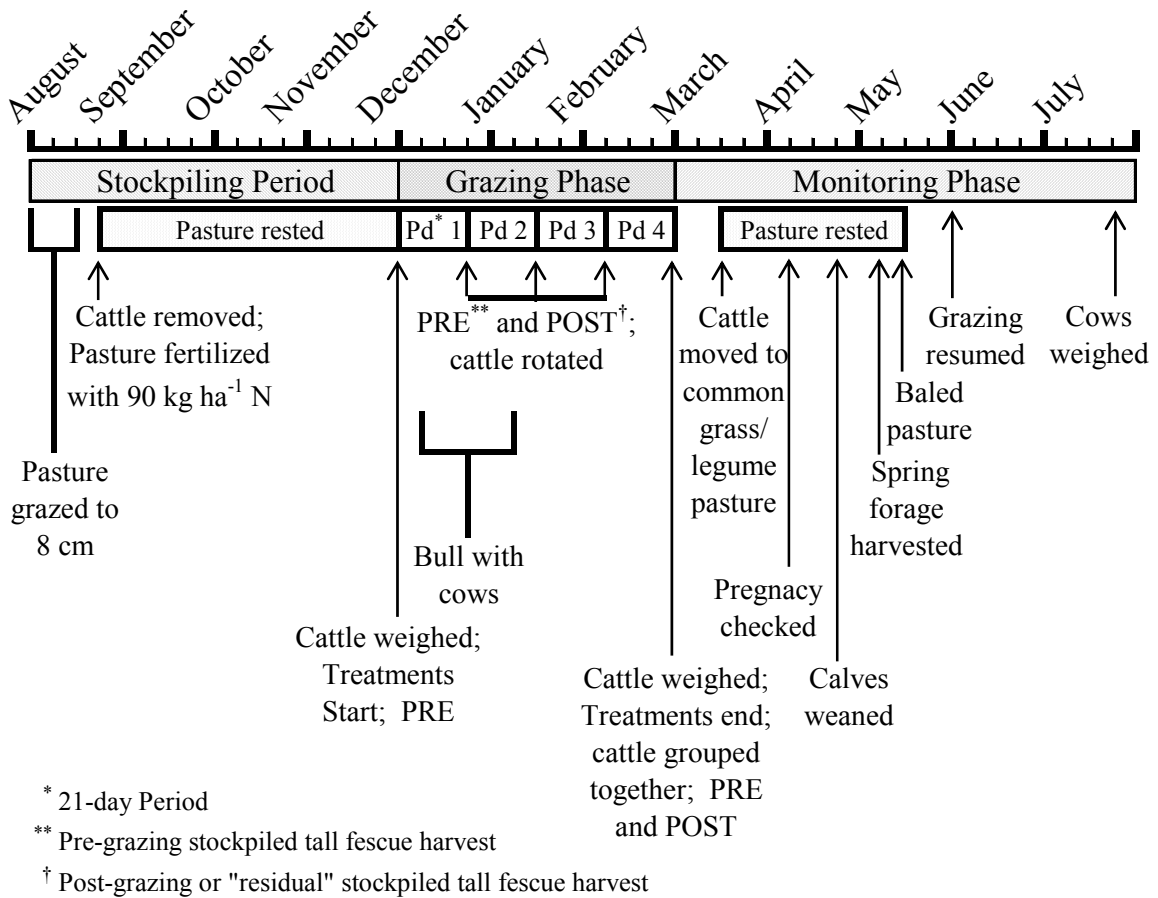




FIGURE 3. Experimental map of grazing stockpiled tall fescue forage allowance treatments located at the University of Missouri Forage Systems Research Center (39° 51' N, 93° 6' W) for Year 1 (2004-2005) and Year 2 (2005-2006). The May forage harvest was collected to evaluate the impact of different forage allowances on subsequent spring growth.

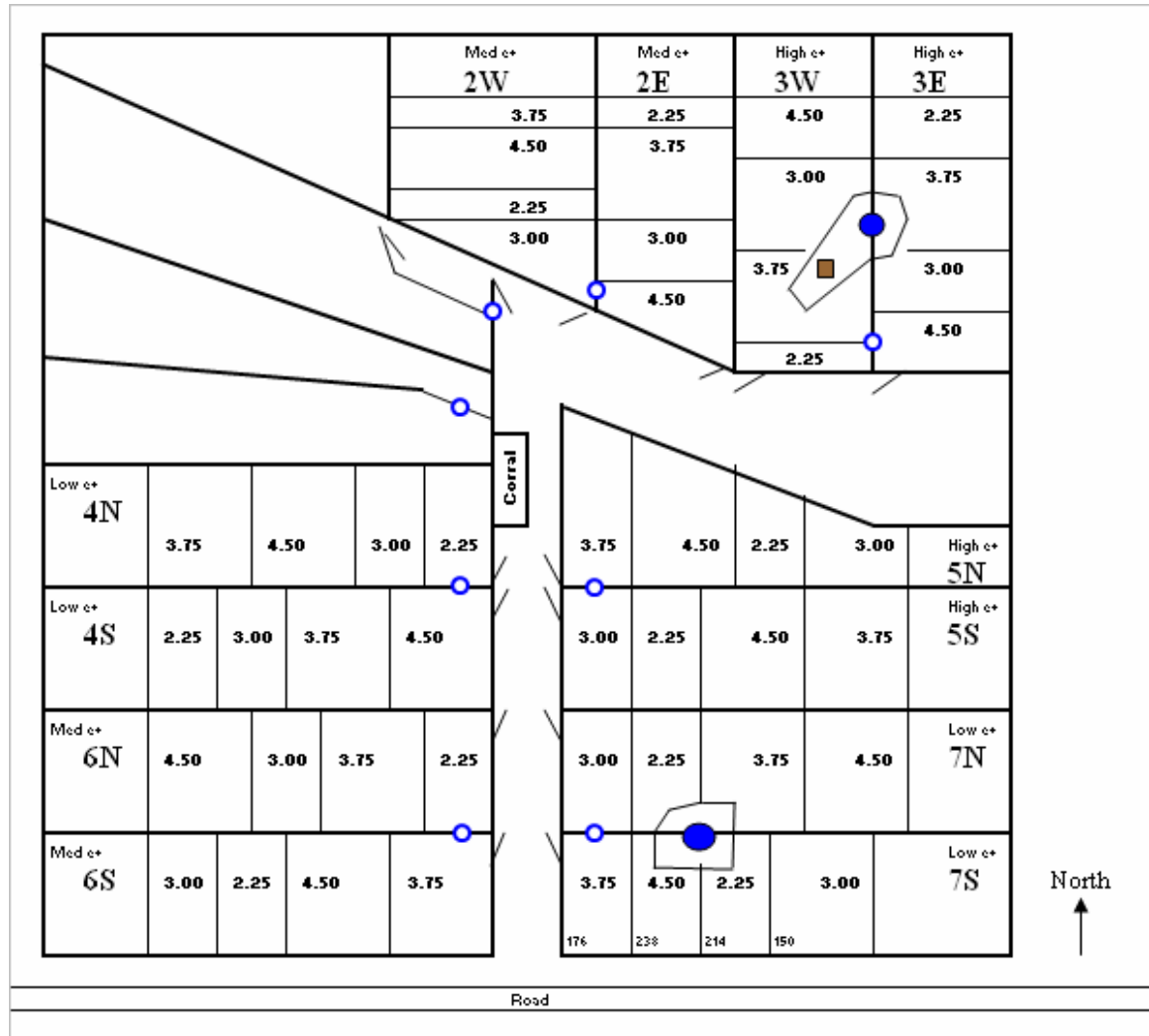


FIGURE 4. Temperature and precipitation data from August to February for Year 1 (2004-2005) and Year 2 (2005-2006), in comparison to the 30 year average. Data were collected from the University of Missouri Forage Systems Research Center Weather Station near Linneus, Missouri (39° 51' N, 93° 6' W). No precipitation was received in February of Year 2 therefore it is not shown.

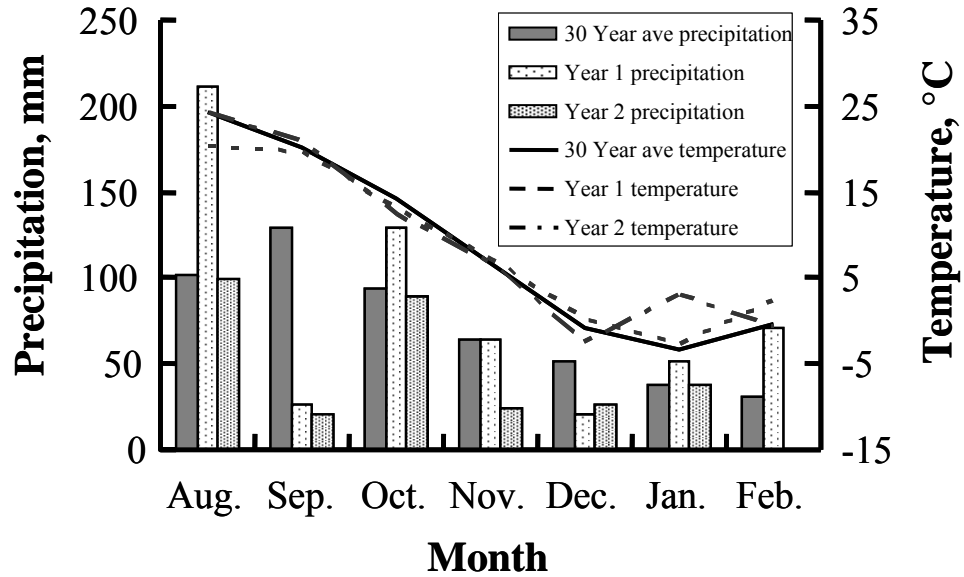


FIGURE 5. Correlation between pasture utilization and forage allowance treatments for Year 1 (2004-2005) and Year 2 (2005-2006) combined. Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). The error bars represent two times the standard error. Treatments represent forage allowances based on percent of body weight (BW).

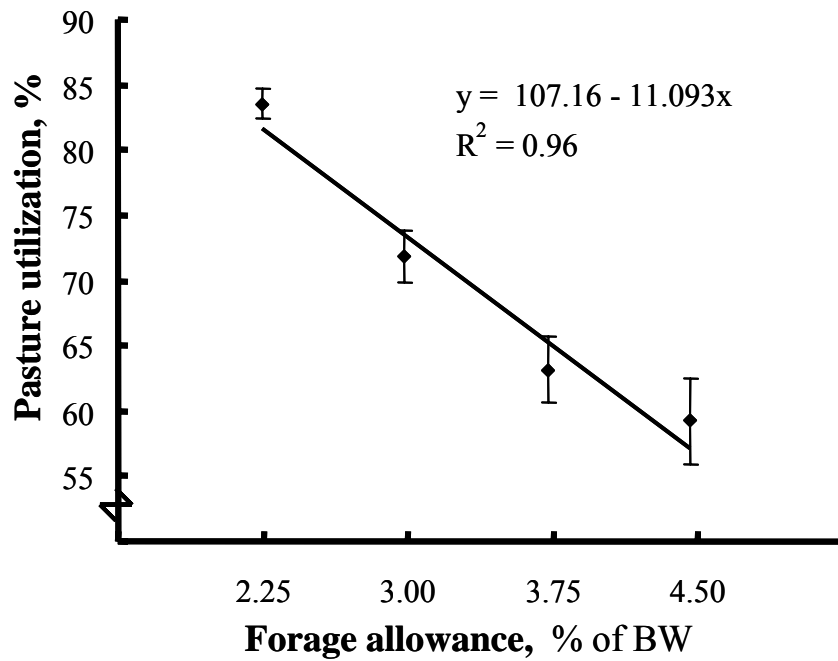


FIGURE 6. Relationship between calf daily gain and forage allowance treatments with inclusion of the hay treatment for comparison for Year 1 (2004-2005) and Year 2 (2005-2006) combined. Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error. Treatments, with the exclusion of hay, represent forage allowances based on percent of body weight.

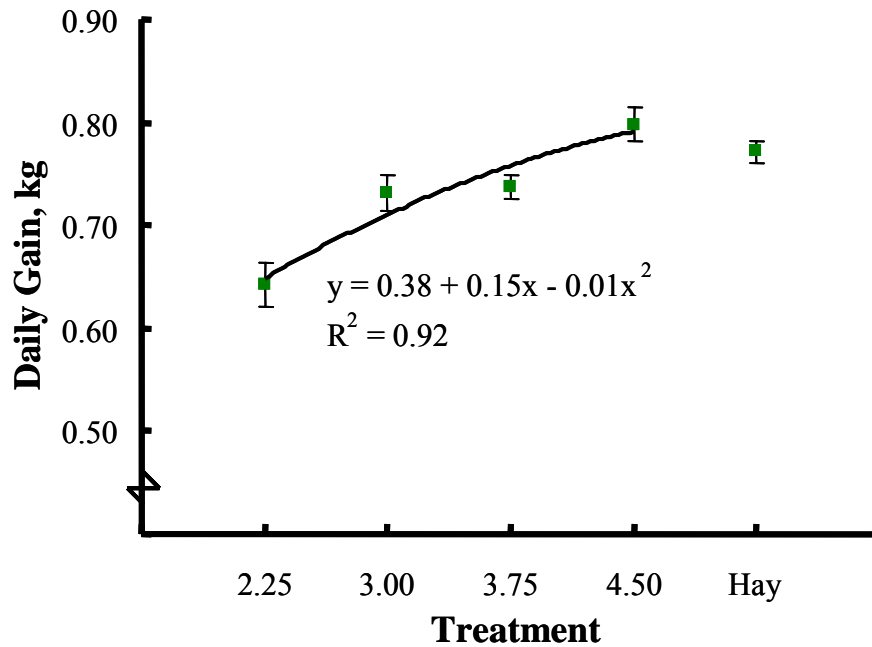


FIGURE 7. Correlation between post-grazed, “residual,” forage dry matter yield and forage allowance treatments for Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error. Treatments represent forage allowances based on percent of body weight (BW).

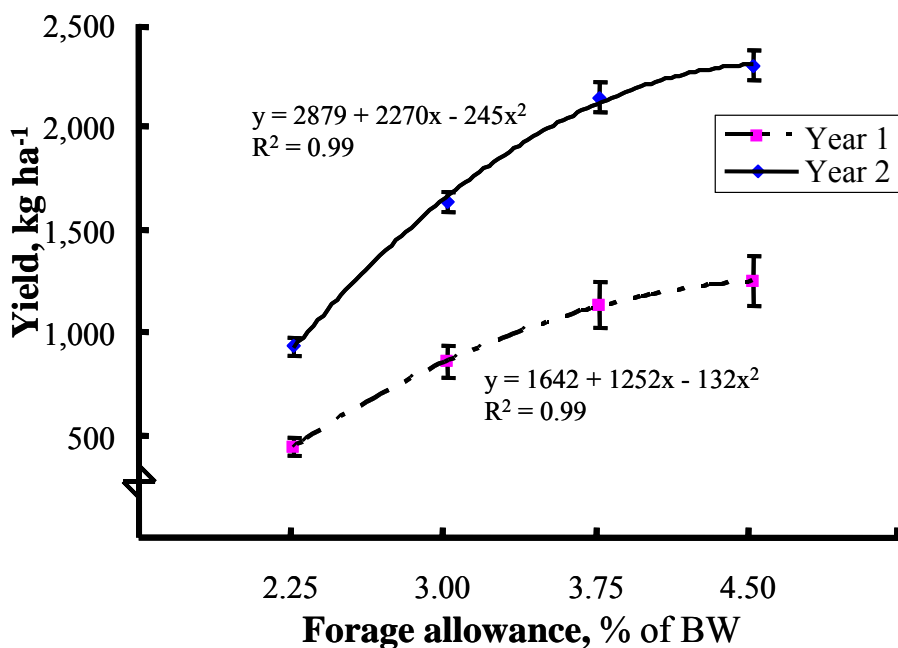


FIGURE 8. Correlation between forage allowance treatments and *in-vitro* true digestibility (IVTD) of post-grazed forage for Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected during the grazing phase of the experiment at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error. Treatments represent forage allowances based on percent of body weight (BW).

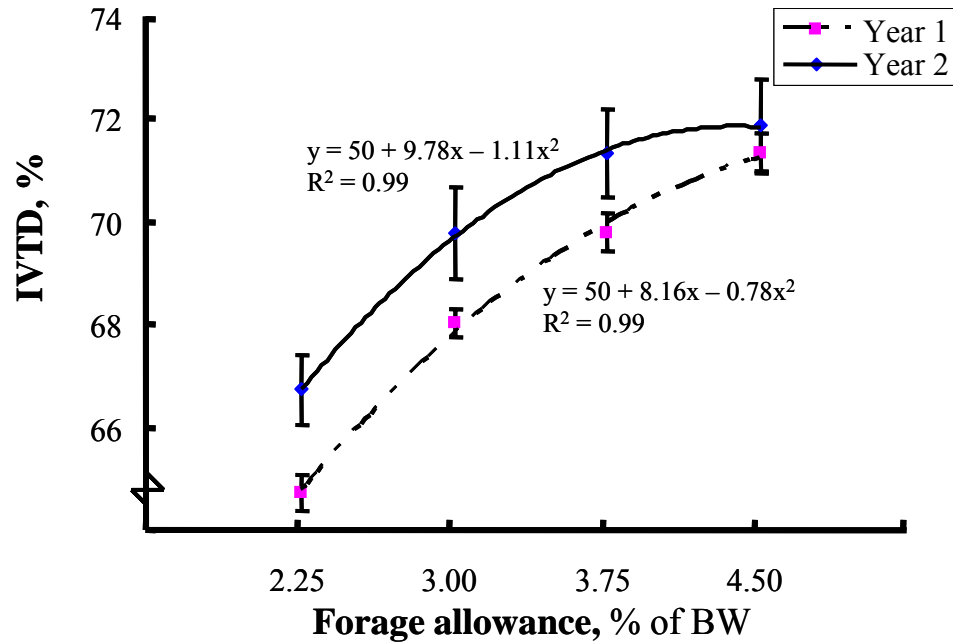


FIGURE 9. Relationship between spring forage dry matter yields and forage allowance treatments. Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error. Treatments represent forage allowances based on percent of body weight (BW).

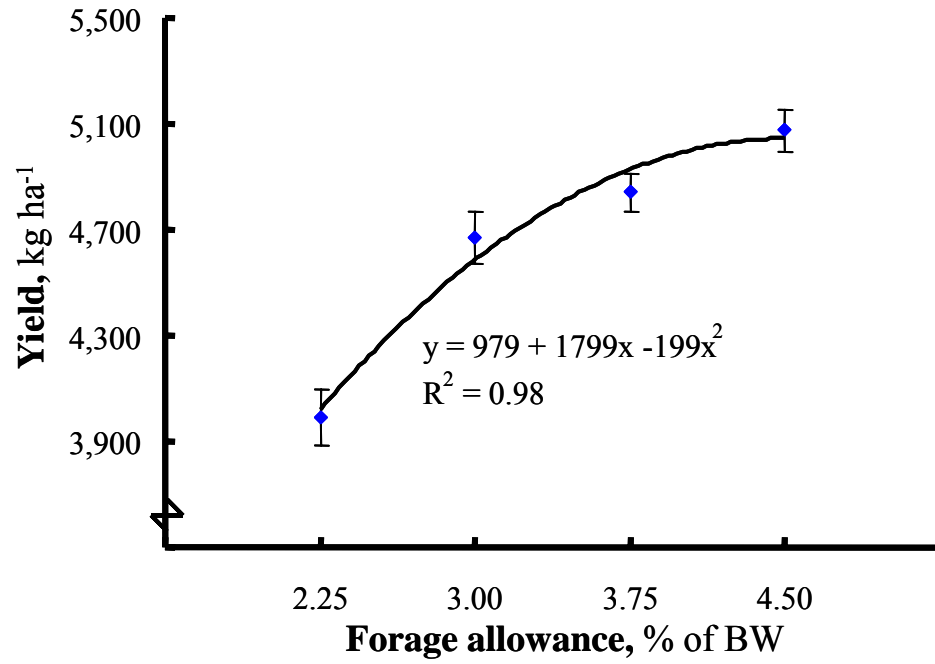


TABLE 1. Calibration statistics for near-infrared spectroscopic determination of crude protein and *in-vitro* true digestibility content in stockpiled tall fescue.

Population	N	R <sup>2</sup>	Mean	SEC <sup>†</sup>	SECV <sup>‡</sup>	1 – VR <sup>*</sup>
Crude protein, %	60	0.95	12	0.29	0.39	0.91
<i>In-vitro</i> true digestibility, %	50	0.98	76	1.27	1.99	0.95

<sup>†</sup> SEC, standard error of calibration calculated in modified partial least squares regression

<sup>‡</sup> SECV, standard error of cross validation calculated in modified partial least squares regression

<sup>\*</sup> 1 – VR, 1 minus variance ratio calculated in cross validation in modified partial least squares regression



TABLE 2. Forage offered, apparent dry matter (DM) intake, and hectares used for each treatment during 84 days of grazing (grazing phase) starting in December. Data were averaged across Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Treatments labeled 2.25, 3.00, 3.75, and 4.50 represent forage allowances based on a percent of body weight. Hay represents the hay feeding treatment in which forage was offered *ad libitum*. Cow-calf pairs in the stockpiled tall fescue forage allowance treatments were fed hay only when weather conditions did not permit grazing.

Item	Treatment				Hay	SE	P
	2.25	3.00	3.75	4.50			
<i>Forage Offered</i>							
Stockpiled tall fescue, kg pair <sup>-1</sup>	1,380	1,840	2,300	2,759	-	-	-
Hay, kg pair <sup>-1</sup>	42	58	58	58	1,632	-	-
Apparent DM intake, kg d <sup>-1</sup>	13 <sup>d</sup>	16 <sup>c</sup>	17 <sup>cb</sup>	19 <sup>a</sup>	18 <sup>ab</sup>	1.33	<0.001
Hectares used, ha	0.35	0.46	0.58	0.70	-	-	-

<sup>a,b,c,d</sup> Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

TABLE 3. Body weight and average daily gain of cows during 84 days of grazing during winter (grazing phase) and monitoring phase for Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Daily gain under the grazing phase heading accounts for the average daily gain between early-December and late-February (84 days). Daily gain under the monitoring phase heading accounts for the daily gain from the end of the grazing phase to weaning (45 days). Treatments labeled 2.25, 3.00, 3.75, and 4.50 represent forage allowances based on a percent of body weight. Hay represents the hay feeding treatment in which forage was offered *ad libitum*.

Item	Treatment				Hay	SE	P
	2.25	3.00	3.75	4.50			
<b>YEAR 1</b>	—kg—						
<i>Grazing Phase</i>							
Initial weight	611	611	611	599	600	9	0.298
Final weight	506 <sup>c</sup>	517 <sup>bc</sup>	533 <sup>b</sup>	524 <sup>bc</sup>	557 <sup>a</sup>	11	0.006
Daily gain	-1.25 <sup>c</sup>	-1.03 <sup>b</sup>	-0.93 <sup>b</sup>	-0.97 <sup>b</sup>	-0.51 <sup>a</sup>	0.10	<0.002
<i>Monitoring Phase</i>							
Weight at weaning	492	505	510	496	509	10	0.184
Daily gain	-0.26 <sup>a</sup>	-0.35 <sup>a</sup>	-0.41 <sup>a</sup>	-0.42 <sup>a</sup>	-0.88 <sup>b</sup>	0.16	0.009
<b>YEAR 2</b>							
<i>Grazing Phase</i>							
Initial weight	610	612	610	615	608	3	0.128
Final weight	586 <sup>b</sup>	591 <sup>b</sup>	597 <sup>ab</sup>	612 <sup>a</sup>	583 <sup>b</sup>	10	0.044
Daily gain	-0.30 <sup>b</sup>	-0.25 <sup>b</sup>	-0.16 <sup>ab</sup>	-0.04 <sup>a</sup>	-0.30 <sup>b</sup>	0.10	0.063 <sup>*</sup>
<i>Monitoring Phase</i>							
Weight at weaning	550 <sup>b</sup>	550 <sup>b</sup>	551 <sup>b</sup>	566 <sup>a</sup>	531 <sup>c</sup>	8	0.007
Daily gain	-0.70	-0.80	-0.89	-0.90	-1.02	0.15	0.209

<sup>a,b,c</sup> Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

<sup>\*</sup> Means within this row within a grouping with different superscripts differ by  $P < 0.1$

TABLE 4. Body condition score (BCS) of cows during the 84 days of winter grazing (grazing phase) and the first 45 days of the monitoring phase of Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Body condition score change under the grazing phase heading accounts for the change in BCS during the grazing phase. Body condition score change under the monitoring phase heading accounts for the change in BCS from the end of the grazing phase to weaning (late-February to mid-April). Treatments labeled 2.25, 3.00, 3.75, and 4.50 represent forage allowances based on a percent of body weight. Hay represents the hay feeding treatment in which forage was offered *ad libitum*.

Item	Treatment					SE	P
	2.25	3.00	3.75	4.50	Hay		
<b>YEAR 1</b>	<b>BCS</b>						
<i>Grazing Phase</i>							
Initial BCS	6.0	5.9	5.7	5.9	5.7	0.15	0.215
Final BCS	4.1 <sup>c</sup>	4.6 <sup>b</sup>	4.7 <sup>b</sup>	4.5 <sup>b</sup>	5.2 <sup>a</sup>	0.18	<0.001
BCS change	-1.9 <sup>d</sup>	-1.3 <sup>bc</sup>	-1.0 <sup>b</sup>	-1.4 <sup>c</sup>	-0.5 <sup>a</sup>	0.19	<0.001
<i>Monitoring Phase</i>							
BCS at weaning	4.9 <sup>b</sup>	4.9 <sup>b</sup>	5.0 <sup>b</sup>	5.0 <sup>b</sup>	5.4 <sup>a</sup>	0.13	0.008
BCS change	0.9 <sup>a</sup>	0.3 <sup>b</sup>	0.3 <sup>b</sup>	0.5 <sup>ab</sup>	0.2 <sup>b</sup>	0.23	0.047
<b>YEAR 2</b>							
<i>Grazing Phase</i>							
Initial BCS	6.6	6.5	6.5	6.7	6.5	0.21	0.680
Final BCS	6.2	6.1	6.0	6.3	6.2	0.21	0.500
BCS change	-0.4	-0.4	-0.5	-0.4	-0.4	0.16	0.887
<i>Monitoring Phase</i>							
BCS at weaning	5.9	5.8	5.6	5.9	5.6	0.20	0.275
BCS change	-0.3	-0.3	-0.3	-0.3	-0.5	0.12	0.206

<sup>a,b,c</sup> Means within a row with different superscripts differ ( $P < 0.05$ )

TABLE 5. Body weight and daily gain of calves allotted four different allowances of stockpiled tall fescue or hay during 84 days of grazing in winter (grazing phase) and a subsequent monitoring phase over two years. Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Daily gain under the grazing phase heading accounts for the daily gain during the grazing phase. Daily gain under the monitoring phase heading accounts for the daily gain from the end of the grazing phase to weaning (late-February to mid-April). Gain hectare<sup>-1</sup> accounts for the calf body weight gain per hectare for each treatment. Treatments labeled 2.25, 3.00, 3.75, and 4.50 represent forage allowances based on a percent of body weight. Hay represents the hay feeding treatment in which forage was offered *ad libitum*.

Item	Treatment					SE	P
	2.25	3.00	3.75	4.50	Hay		
	-----kg-----						
<i>Grazing Phase</i>							
Initial weight	108	110	112	107	110	6	0.688
Final weight	162 <sup>b</sup>	171 <sup>a</sup>	174 <sup>a</sup>	174 <sup>a</sup>	174 <sup>a</sup>	7	0.055
Daily gain	0.64 <sup>b</sup>	0.73 <sup>a</sup>	0.73 <sup>a</sup>	0.80 <sup>a</sup>	0.77 <sup>a</sup>	0.05	0.009
Gain hectare <sup>-1</sup>	155 <sup>a</sup>	132 <sup>b</sup>	107 <sup>c</sup>	97 <sup>c</sup>	-	9	<0.001
<i>Monitoring Phase</i>							
Weaning weight	187	194	196	197	200	8	0.207
Daily gain	0.48	0.44	0.43	0.40	0.48	0.06	0.167

<sup>a,b</sup> Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

TABLE 6. Pre-grazing dry matter (DM) yield, crude protein (CP) and *in-vitro* true digestibility (IVTD) for 84 days in the winter (grazing phase) of Year 1 (2004-2005) and Year 2 (2005-2006). Nutritive value of forage used in hay treatment is also included. Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). The forage harvest collected on day 21 of Year 1 was not included in this analysis, due to inability to accurately harvest forage under snow and ice cover. Treatments labeled 2.25, 3.00, 3.75, and 4.50 represent forage allowances based on a percent of body weight. Hay represents the hay feeding treatment in which forage was offered *ad libitum*.

Item	Day of Experiment					HAY*	SE	P
	0	21	42	63	84			
<b>YEAR 1</b>								
DM yield, kg ha <sup>-1</sup>	4,875 <sup>a</sup>	-	4,471 <sup>a</sup>	3,975 <sup>b</sup>	4,468 <sup>a</sup>	-	557	0.009
CP, %	13 <sup>a</sup>	-	13 <sup>ab</sup>	13 <sup>bc</sup>	12 <sup>c</sup>	9	0.5	0.007
IVTD, %	77 <sup>a</sup>	-	72 <sup>c</sup>	74 <sup>b</sup>	69 <sup>d</sup>	70	1.7	<0.001
<b>YEAR 2</b>								
DM yield, kg ha <sup>-1</sup>	5,144 <sup>a</sup>	5,029 <sup>a</sup>	5,198 <sup>a</sup>	4,602 <sup>b</sup>	3783 <sup>c</sup>	-	359	<0.001
CP, %	13	13	13	13	13	11	0.5	0.403
IVTD, %	81 <sup>a</sup>	81 <sup>a</sup>	75 <sup>bc</sup>	73 <sup>c</sup>	76 <sup>b</sup>	74	2.1	<0.001

\* Hay nutritive value data is not included in mean separation  
a,b,c,d Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

## IMPACT OF ENDOPHYTE LEVEL ON LACTATING BEEF COWS STRIP-GRAZING STOCKPILED TALL FESCUE

**ABSTRACT:** A study was conducted to examine the effect of endophyte infection level of stockpiled tall fescue on the performance of lactating, fall-calving beef cows and their calves. To examine this, three endophyte infection levels of tall fescue at 20 (LOW), 51, (MEDIUM) and 89% (HIGH) were set as experimental treatments. The experimental design was a randomized complete block replicated four times and repeated over two years. Five cow-calf pairs grazed in experimental pasture (n = 120 cow-calf pairs) for 84 days starting on 2 December 2004 (Year 1) and 1 December 2005 (Year 2). Animal performance data including cow BW, ADG, and BCS and calf BW and ADG were collected as well as pre-grazed and post-grazed forage DM yield to estimate apparent intake. Apparent intake of stockpiled tall fescue was constant across all treatments at 16 kg d<sup>-1</sup> for each cow-calf pair. In addition, nutritive value was constant across all treatments; therefore, changes in animal performance are attributed to endophyte infection levels. Cows allotted to the LOW treatment averaged 547 kg by the end of the grazing phase, losing 16 and 32 kg less than ( $P < 0.05$ ) cows grazing MEDIUM and HIGH treatments, respectively. Furthermore, cow ADG was 0.22 kg d<sup>-1</sup> greater ( $P < 0.05$ ) for the LOW treatment, averaging -0.47 kg d<sup>-1</sup>, when compared to either the MEDIUM or HIGH treatments. However, after being commingled for 45 days after the completion of the experiment, cows that had grazed the HIGH and MEDIUM treatment gained 0.28 kg d<sup>-1</sup> more ( $P = 0.015$ ) weight than the LOW treatment and by weaning, all cows weighed the same (528 kg;  $P = 0.137$ ). In contrast to cow performance, calf ADG

and BW were unaffected ( $P = 0.134$ ) by endophyte level, averaging  $0.73 \text{ kg d}^{-1}$  ( $P = 0.134$ ) and  $170 \text{ kg}$  ( $P = 0.215$ ), respectively. Our data suggest that to maximize calf weaning weight for fall calving herds, renovation of endophyte-infected pastures is unneeded.

**Key Words:** Endophyte, Fall-calving, Stockpiled tall fescue

## INTRODUCTION

Winter is the most expensive time to feed cattle, especially for fall-calving beef cows. Fall-calving herds are in lactation over winter and thus their nutritional demands and feed costs increase (NRC, 2000). While spring-calving is more common in the lower Midwest, there are advantages frequently cited for fall-calving. Perhaps foremost are increased pregnancy rates because there is no heat stress during breeding in December. Marketing advantages are another reason fall-calving is gaining popularity (Nelson, 1988). Waller et al. (1988) and Janovick et al. (2004) evaluated the use of stockpiled tall fescue (*Festuca arundinacea* Schreb) to decrease winter feed costs for fall-calving herds and found that it was an adequate winter feed source.

More than 90% of tall fescue (Ball et al., 2002) is infected with the fungal endophyte *Neotyphodium coenophialum* [(Morgan-Jones and Gams) Glenn, Bacon and Hanlin]. While endophyte infection improves many agronomic aspects of tall fescue (Sleper and West, 1996), it also produces ergot-like alkaloids known to cause a series of animal health disorders collectively known as “fescue toxicosis”. Symptoms are generally less severe in cooler temperatures, but occasionally sloughing of the tips of the ears, tails, and even entire hooves occurs during the winter (Chestnut et al., 1991). Since fall-calving cows are lactating during winter, they may be more vulnerable to fescue toxicosis. In addition, little is known about how calf performance is affected when calves are suckling dams grazing stockpiled, endophyte-infected tall fescue.



Our hypothesis was beef cows grazing tall fescue with a low endophyte infection level would exhibit higher body condition scores and increased calf gain compared to highly infected tall fescue. The objective of this study was to examine the effects of three endophyte infection levels of 20, 51, and 89 percent in stockpiled tall fescue on forage yield and nutritive value as well as animal performance.

## MATERIALS AND METHODS

A 2-year grazing experiment was conducted from 2 December to 23 February in 2004-2005 (year 1) and from 1 December to 22 February in 2005-2006 (year 2) at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). The experiment was conducted on a 48 ha block that was divided into 12, four ha pastures. The areas used were typical of cool-season grass-legume pastures in the region, with tall fescue as the predominate species. Orchardgrass (*Dactylis glomerata* L.) and Kentucky bluegrass (*Poa pratensis* L.) were subordinate components as were red clover (*Trifolium pretense* L.) and birdsfoot trefoil (*Lotus corniculatus* L.). The soil types were Grundy silt loam (fine, smectitic, mesic Aquertic Argiudolls) on 1-5% slopes, Armstrong loam (fine, smectitic, mesic, Aquertic Hapludalfs) and Lagonda silt loam (fine, smectitic, mesic Aquertic Hapludalfs) on 2-5% slopes, Armstrong clay loam (fine, smectitic, mesic Aquertic Hapludalfs) on 5-9% slopes, and Purdin loam (fine, mixed, superactive, mesic Oxyaquic Hapludalfs) on 9-14% slopes.

### ***Experimental Design and Treatments***

The experimental design was a randomized complete block with three treatments replicated four times. The treatments in this experiment were endophyte levels of 20, 51, and 89%, which will be referred to as LOW, MEDIUM, and HIGH, respectively. The experiment was conducted for 84 days from December to February, which was divided into four, 21-day periods. Upon completion of the grazing experiment, cows and calves

were commingled and managed as a single group so residual effects of grazing endophyte-infected tall fescue could be documented.

### ***Pasture Management***

In mid-August, pastures were uniformly grazed to a height of approximately 8 cm and then fertilized with 90 kg ha<sup>-1</sup> of N as ammonium nitrate. Soils were sampled and tested annually; lime, phosphorus, and potassium were applied in mid-August according to recommendations by the University of Missouri Soil Testing Laboratory. Following fertilization, pasture growth was allowed to accumulate until early December when grazing was initiated. On 2 November 2004 and 11 May 2006, twenty-five tall fescue tillers were collected from each pasture in order to document endophyte infection status using the immunoblot assay described by Hiatt and Hill (1997).

### ***Animal Management***

A total of 60 multiparous cross-bred cows (red Gelbvieh, black Gelbvieh, red Angus, and black Angus) in early lactation and their calves were stratified into twelve groups of five based on cow weight and age, and calf age and sex and then groups were randomly assigned to treatments. Water and trace-mineralized salt blocks were available *ad libitum* to cows and calves. In early-December of year 1 and year 2, one red Gelbvieh or black Simmental bull was added to each group to initiate a 45-day breeding season. The experimental protocol was reviewed and approved by the University of Missouri Animal Care and Use Committee.

Stockpiled tall fescue was allocated every 3.5-day (twice per week) at 3.375 % BW d<sup>-1</sup> in DM by strip grazing. In the event of a heavy ice (>10 mm) or snowstorm (>50

cm), small square bales of mixed grass hay were fed until animals were able to resume grazing. Over the two years of experimentation, hay was fed for a total of 5 days.

### ***Forage Measurements***

Pasture yield was measured by clipping ten, 0.8 x 4.6-m strips to a 2 cm height with a tractor-mounted, flail-type harvester from each pasture. These harvests are referred to as pre harvests (PRE) and were taken from where the cattle were expected to graze within the next 21-day period. At the end of each 21-day period, twelve strips as described above were clipped from the grazed area to determine residual forage yield. These harvests are referred to as post harvests (POST). Apparent intake (pasture disappearance rate) was calculated from the differences in the PRE and POST harvests.

Grab-samples collected from each harvest strip were bulked together for an individual pasture. This grab-sample was then split into two sub-samples of approximately 300 g each. The first sub-sample was analyzed for dry matter by drying in a forced air oven for a minimum of 24 h at 90°C. The second sub-sample was frozen, freeze-dried, and then ground in a cyclone mill (UDY Corp., Ft. Collins, CO) to pass a 1-mm screen. This sample was used to evaluate forage nutritive value.

Crude protein (CP) and *in-vitro* true digestibility (IVTD) were measured from ground samples with near infrared reflectance spectroscopy (NIR) using the scanning, calibration, and validation methods (TABLE 7). Crude protein for calibration samples was determined by measuring total N content using a LECO FP-428 nitrogen analyzer (LECO Corp., St. Joseph, MI) and then multiplying N values by 6.25. *In-vitro* true digestibility (IVTD) was determined by running a 48-h *in-vitro* digestion, followed by washing with neutral detergent fiber solution as described by Ankom Technology

(Ankom Technology, Fairport, NY). Rumen fluid was collected from one cannulated cow offered a forage based diet. Total ergot alkaloid content was determined by using a phytoscreen ergot alkaloid ELISA kit purchased from Agrinostics Ltd. Co. (Watkinsville, GA).

### ***Animal Performance Measurements***

Body condition scores, hip heights, body weights, birth dates, birth weights, health records, and pregnancy rates were collected. An experienced technician assigned body condition scores to all cows at the start and end of the grazing experiment, weaning, and late-July. Hip-height measurements obtained during February of each year were used to determine weight-to-height ratios as a second indicator of body condition. Cow weights were taken on two consecutive mornings to minimize variability due to fluctuations in gastrointestinal fill, without prior removal from water and pasture. This was done at the start and end of the grazing experiment, weaning, and late-July. On 12 April of year 1 and 4 April of year 2, pregnancy determinations were made using rectal palpation and ultrasonography. Throughout the experiment, health records were recorded on both cows and calves. Calf weights were also recorded on two consecutive mornings without prior removal from water and pasture at the beginning and end of the grazing experiment and again at weaning. Calf weaning weights were analyzed as actual weaning weights. All calves were weaned and sold in mid-April both years.

### ***Statistical Analysis***

Data for forage yield and quality was analyzed as a randomized complete block design with three treatments and four blocks as described by Steel and Torrie (1980). The

model was a repeated measures with year as the main plot, endophyte levels were sub-plots, and periods were sub-sub-plots. Main effects and all possible interactions were analyzed as described by Steel and Torrie (1980). Mean separation was performed using Fisher's protected LSD. Animal performance data was also analyzed as a randomized complete block using the model described above except that period was removed from the model. The experimental unit for all measurements in animal performance was the group of five cow-calf pairs on each of the twelve pastures. Data were analyzed using the general linear model procedure of SAS version 8.2 (SAS Inst. Inc., Cary, NC). Significant differences were defined as  $P \leq 0.05$ , except where indicated otherwise.

## RESULTS AND DISCUSSION

### *Apparent Intake*

Apparent DM intake of stockpiled tall fescue was 2 kg d<sup>-1</sup> greater for Year 1 compared to Year 2, however there were no year by treatment interactions, thus data were averaged by year. In addition, apparent DM intake was unaffected by endophyte infection level, with apparent DM intake remaining constant across all treatments at 16 kg d<sup>-1</sup> for each cow-calf pair. Pasture utilizations were significantly different ( $P = 0.03$ ) for Year 1 when compared to Year 2, and averaged 77 and 63%, respectively. These year differences in apparent intake and pasture utilization are attributed to differences in weather; Year 1 was a wet, cold winter, while Year 2 was a dry, cool winter (FIGURE 10). When cattle are exposed to wet, cold temperatures, metabolic rates increase to regulate body temperature. As a result, DM intake and passage rate increases, which increase the amount of heat produced (NRC, 2000).

### *Stockpiled Tall Fescue Forage Production*

**Forage Yield.** Stockpile tall fescue DM yield had year by treatment interactions; therefore, forage yield data are presented by year.

From 2 December to 23 February of Year 1, yield differences in endophyte infection level approached significance ( $P = 0.06$ ). When alpha equaled 0.10, the HIGH treatment yielded 4,910 kg ha<sup>-1</sup> which was 11% greater than the MEDIUM treatment and 17% greater than the LOW treatment. Similarly, during Year 2, the HIGH treatment yielded the most ( $P = 0.02$ ; 4976 kg ha<sup>-1</sup>) which was 337 kg ha<sup>-1</sup> greater than the LOW

and MEDIUM treatments (FIGURE 11). These results are similar to those of Kallenbach et al. (2003) where forage DM yield of endophyte-infected tall fescue was 20% greater than that of endophyte-free cultivars.

**Forage Nutritive Value.** Stockpiled tall fescue nutritive value was unaffected by endophyte infection level ( $P > 0.10$ ); however, nutritive value was slightly greater for Year 2 when compared to Year 1. Year by period interactions were documented for all measures of nutritive value, therefore data were presented by year. Crude protein concentration of stockpiled tall fescue declined by just one percentage unit from the beginning of grazing until the end of grazing in Year 1; during Year 2, CP was constant at 13% (TABLE 8). During both years, CP remained above 12% (TABLE 8), which exceeds nutrient requirements for lactating beef cows (NRC, 2000).

For Year 1 and Year 2, IVTD concentrations of the stockpiled tall fescue started at 77 and 81%, respectively, and by late February declined by 10 and 6%, respectively (TABLE 8). However, these yearly differences in IVTD concentrations had no impact of apparent DM intake of the cow-calf pairs. For instance, Year 2 IVTD was numerically greater than for Year 1; however, apparent DM intake was greater for Year 1. According to the NRC (2000) forage with increased digestibility should have greater DM intake.

**Total Ergot Alkaloid Concentrations.** Similar to Kallenbach et al. (2003) findings with ergovaline, total ergot alkaloid concentration declined at faster rates than did energy and protein. Total ergot alkaloid concentrations for the HIGH treatment started out at 918 ppb and quickly declined to 450 ppb between early December and late February (FIGURE 12). Similar to the HIGH treatment, the MEDIUM treatment declined 52%, ending at 168 ppb (FIGURE 12). The LOW treatment throughout the grazing experiment



contained 0 ppb total ergot alkaloid concentration even though standing forage had an endophyte infection level of 20%. Since total ergot alkaloid concentration declined relatively fast over winter, there may be implications drawn. Producers could utilize pastures with low levels of endophyte infection first and then move to higher infected pastures in late winter. To accomplish this management though, endophyte testing of tall fescue paddocks would have to be implemented.

### ***Animal Performance***

All measures of animal performance were significantly greater for year 2 than for year 1; however there were no year by treatment interactions. Thus, animal performance data was averaged across years.

***Cow performance.*** Cow performance at the end of the 84-day grazing phase was greatly ( $P = 0.005$ ) influenced by endophyte infection level. The significance of the difference was surprising to us because forage data from Sleper and West (1996), Kallenbach et al. (2003), Oliphant (2005), and that which we have reported suggest that alkaloids produced by endophyte-infected tall fescue are less concentrated in stockpiled tall fescue compared to the growing season. Cow BW for the LOW treatment was 574 kg, while the MEDIUM and HIGH weighed 16 and 32 kg less, respectively (TABLE 9). Body condition score and ADG for the cows in the LOW treatment were 0.4 and 0.22 kg d<sup>-1</sup> greater than for cows on the HIGH and MEDIUM treatments (TABLE 9, TABLE 10). In addition, Tucker et al. (1989) reported similar results when gestating, spring calving cows grazed 77 and 21% endophyte-infected tall fescue during the growing season. In another experiment which was a comparison of a leader-follower system, Waller et al. (1988) found that fall-calving cows grazing stockpiled tall fescue after their calves likely

consumed more endophyte infected tall fescue and had lower average daily gains than cows that did not follow calves.

Even though these studies documented declines in cow BW and ADG, they concluded that stockpiling tall fescue for lactating, fall-calving beef cows was “a practical forage system.” In addition, during our study when all cows were grouped together from late February to weaning in mid-April, cows that had grazed the HIGH and MEDIUM treatment gained  $0.28 \text{ kg d}^{-1}$  more ( $P = 0.015$ ) weight than the LOW treatment and by weaning, all cows weighed the same (528 kg;  $P = 0.137$ ; TABLE 9). This increase in ADG may be classified as compensatory gain, which is defined as “a period of faster or more efficient rate of growth following periods of nutritional or environmental stress” (NRC, 2000). Since they all received the same diet, our data show that cows that had grazed HIGH and MEDIUM treatments during winter had higher efficiency of energy use when compared to the LOW treatment cows. In addition, Carstens et al. (1991) concluded that reduced energy requirements and changes in gut fill accounted for most of the compensatory growth response exhibited in growing steers. However more research is needed to examine the cause for compensatory gain in mature beef cows.

Contrary to Chestnut et al. (1991) findings that visual signs of tall fescue toxicosis are less severe in cool weather, four cows in the HIGH treatment displayed symptoms of fescue toxicosis during Year 1 and Year 2. In Year 2, one cow was removed from the experiment in mid-February due to sloughing of the hoof. However it appears that cow fertility was unaffected by endophyte infection level. Even with visible signs of fescue toxicosis during the 84 days of winter grazing, natural service conception rate was still 93% across all treatments. This excellent conception rate is contradictory to the results

reported by Boling (1985), in which increased levels of endophyte infection resulted in a decline in conception rates. In addition, during the growing season, Porter and Thompson (1992) reported that conception rates decreased 3.5% for each 10% increase in endophyte infection. Since conception rates averaged 93% across all treatments, this may imply that alkaloids produced by endophyte-infected tall fescue are less toxic when stockpiled; even though EA concentrations were as high as 900 ppb during the breeding season (FIGURE 12).

***Calf Performance.*** In contrast to cow performance, calf performance was unaffected by endophyte level. Average daily gain and BW averaged 0.73 kg d<sup>-1</sup> ( $P = 0.134$ ) and 170 kg ( $P = 0.215$ ), respectively (TABLE 11). In addition, by weaning calves still averaged the same weight at 193 kg ( $P = 0.526$ ; TABLE 11). In a similar study, Waller et al. (1988) found that gain of suckling calves was not affected by their dams grazing endophyte-infected tall fescue (30-50% endophyte-infected) during winter. Our data, along with this report, show that to maximize calf weaning weight for fall calving herds, renovation of endophyte-infected pastures is unneeded. In Arkansas, Gunter and Beck (2004) found that calves grazing endophyte infected tall fescue gained 47% less than steers grazing endophyte-infected tall fescue. This difference between the Arkansas study and our study is likely because the calves on our study received the greatest portion of their diet from milk and not forage.

Even though research commonly cites decreased milk production as an effect of grazing endophyte-infected tall fescue (Paterson et al., 1995); surprisingly, calf performance was unaffected by endophyte infection level. In addition, Rutledge et al. (1971) discovered that the dam's milking ability describes 60% of the variation in calf

weaning weight. Since there was no variation in calf weaning weight, a likely conclusion would be that the dam's milking ability was unaffected by grazing stockpiled, endophyte-infected tall fescue.

## IMPLICATIONS

Even though it is suggested that endophyte-infected tall fescue is less toxic when stockpiled, cow performance at the end of the 84-day grazing phase was greatly ( $P = 0.005$ ) influenced by endophyte level. However when looking at calf performance at the three levels of endophyte infection (20, 51, and 89% endophyte-infected), body weight and average daily gain was unaffected. Based upon our results for calf gain and weaning weight, renovation of endophyte-infected tall fescue pasture would not be needed in most cases. Our results also reiterate the importance of knowing endophyte infection level of tall fescue pasture. Thus, if cattlemen have fields with different levels of endophyte infection, cattle can graze less infected pastures earlier in the winter and can take advantage of the decline in toxic alkaloids in pastures with a greater level of endophyte. Doing so should help to minimize the weight loss of lactating cows on stockpiled tall fescue.

## LITERATURE CITED

- Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 2002. Fescue toxicity. In: Southern Forages, Modern Concepts for Forage Crop Management, 3rd Edition. Graphic Communications Corporation. Lawrenceville, GA.
- Boling, J. A. 1985. Endophytic fungus and tall fescue utilization by ruminants. *Prof. Anim. Sci.* 1:19.
- Carstens, G.E., D. E. Johnson, M. A. Ellenberger, and J. D. Tatam. 1991. Physical and chemical components of the empty body during compensatory growth in beef steers. *J. Anim. Sci.* 69:3251-3264.
- Chestnut, A. B., H. A. Fribourg, K. D. Gwinn, P. D. Anderson, and M. A. McCann. 1991. Effect of ammoniation on toxicity of *Acremonium coenophialum* infested tall fescue. *Anim. Feed Sci. Tech.* 35:227-236.
- Gunter, S.A., and P.A. Beck, 2004. Novel endophyte-infected tall fescue for growing beef cattle. *J. Anim. Sci.* 82(E. Suppl.):E75-E82.
- Hiatt, E.E., III, and N.S. Hill. 1997. *Neotyphodium coenophialum* mycelial protein and herbage mass effects on ergot alkaloid concentration in tall fescue. *J. Chem. Ecol.* 23:2721-2736.
- Janovick, N. A., J. R. Russell, D. R. Strohbahn and D. G. Morrill. 2004. Productivity and hay requirements of beef cattle in a Midwestern year-round grazing system. *J. Anim. Sci.* 82:2503-2515.
- Kallenbach, R. L., G. J. Bishop-Hurley, M. D. Massie, G. E. Rottinghaus, and C. P. West. 2003. Herbage mass, nutritive value, and ergovaline concentration of stockpiled tall fescue. *Crop Sci.* 43:1001-1005.
- National Research Council. 2000. *Nutrient Requirements of Beef Cattle*. 7th ed. National Academy Press, Washington, DC.
- Nelson, M. E. 1988. *Calving season strategies*. Cooperate Extension Service, Manhattan, Kansas.
- Oliphant, E. J. 2005. Performance of beef heifers grazing stockpiled endophyte-infected, endophyte-free or non-toxic endophyte-infected tall fescue. Masters Thesis. [Online] Available at <http://www.lib.ncsu.edu/theses/available/etd-11302004-222906/unrestricted/etd.pdf> (verified 18 June 2004).

- Paterson, J., C. Forcherio, B. Larson, M. Samford, and M. Kerley. 1995. The effects of fescue toxicosis on beef cattle productivity. *J. Anim. Sci.* 73:889-898.
- Porter, J. K. and F. N. Thompson, Jr. 1992. Effects of fescue toxicosis on reproduction in livestock. *J. Anim. Sci.* 70:1594-1603.
- Rutledge, J. J., O. W. Robison, W. T. Ahlschwede, and J. E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. *J. Animal. Sci.* 33: 563.
- Sleper, D.A. and C.P. West. 1996. Tall Fescue. P 471-502. In L.E. Moser et al. (ed.) Cool-season forage grasses. Agron. Monogr. No. 34 ASA, CSSA, and SSSA, Madison, WI.
- Steel, R. G., and J. H. Torrie. 1980. Principles and procedures of statistics. Second edition. McGraw-Hill. New York, NY.
- Tucker, C. A., R. E. Morrow, J. R. Gerrish, C. J. Nelson, G. B. Garner, V. E. Jacobs, W. G. Hires, J. J. Shinkle, and J. R. Forwood. 1989. Forage systems for beef cattle: effect of winter supplementation and forage systems on reproductive performance of cows. *J. Prod. Agric.* 2:217-221.
- Waller, J.C., J.C. Forcherio, H.A. Fribourg, M.C. Smith, and R.J. Carlisle. 1988. Performance of fall-calving cows and their calves grazing fescue-based forage systems. *J. Prod. Agric.* 1:338-342.

FIGURE 10. Temperature and precipitation data reported from December to February for Year 1 (2004-2005) and Year 2 (2005-2006) in comparison to the 30 year average. Data were collected at the University of Missouri Forage Systems Research Center weather station near Linneus, Missouri (39° 51' N, 93° 6'W).

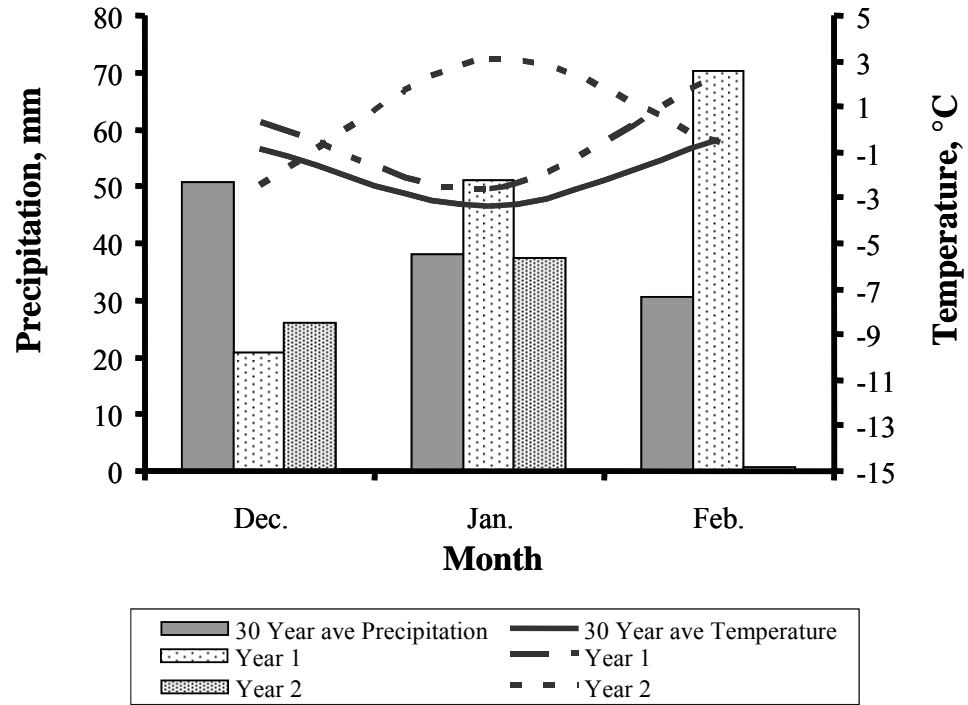




FIGURE 11. Pre-grazing stockpiled tall fescue dry matter yield for the three endophyte infection levels 20 (LOW), 51 (MEDIUM), and 89 (HIGH). Year 1 represents December 2004 to February 2005 and Year 2 represents December 2005 to February 2006. Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error.

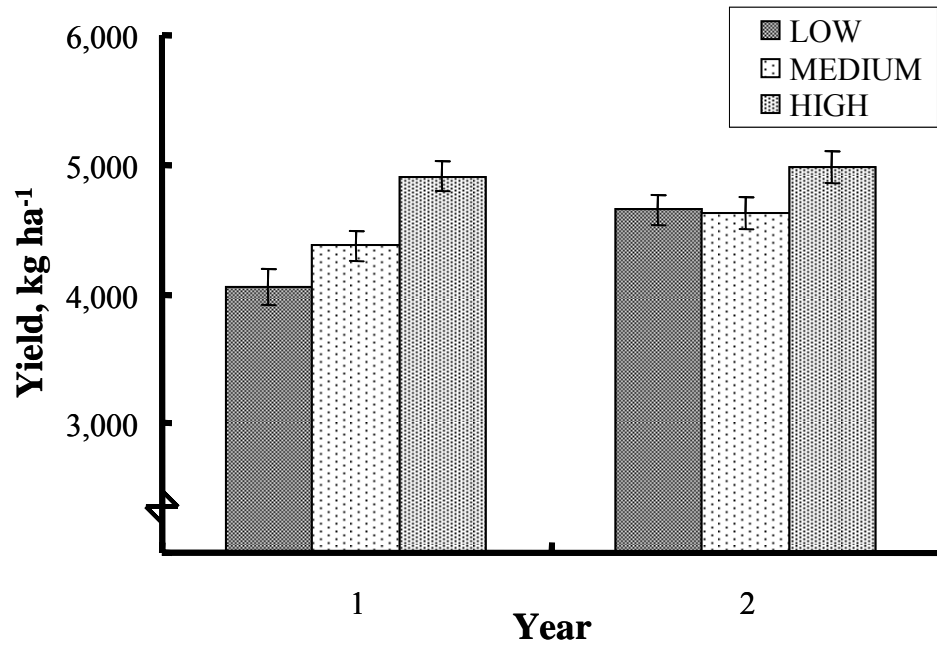


FIGURE 12. Total ergot alkaloid (EA) concentrations of pre-grazed forage by endophyte level and day of experiment for Year 1 (2004-2005) and Year 2 (2005-2006). Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Error bars represent two times the standard error. Day of experiment 0 represents the EA concentration of the harvest collected on 2 December 2004 and 1 December 2005. NOTE: the LOW endophyte infected tall fescue treatment was not plotted because all points equaled zero.

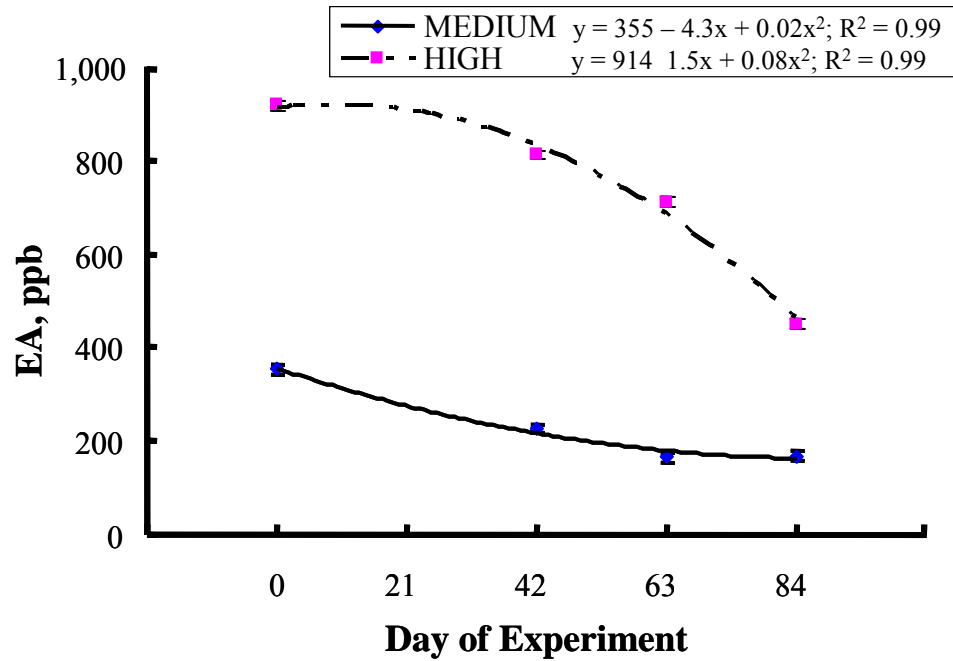


TABLE 7. Calibration statistics for near-infrared spectroscopic determination of crude protein and *in-vitro* true digestibility content in stockpiled tall fescue.

Population	N	R <sup>2</sup>	Mean	SEC <sup>†</sup>	SECV <sup>‡</sup>	1 – VR <sup>*</sup>
Crude protein, %	60	0.95	12	0.29	0.39	0.91
<i>In-vitro</i> true digestibility, %	50	0.98	76	1.27	1.99	0.95

<sup>†</sup> SEC, standard error of calibration calculated in modified partial least squares regression

<sup>‡</sup> SECV, standard error of cross validation calculated in modified partial least squares regression

<sup>\*</sup> 1 – VR, 1 minus variance ratio calculated in cross validation in modified partial least squares regression

TABLE 8. Crude protein (CP) and *in-vitro* true digestibility (IVTD) recorded for each harvest by Year 1 (2004-2005) and Year 2 (2005-2006). Data were collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). The forage harvest collected on day 21 of Year 1 was not included in this analysis, due to inability to accurately harvest forage under snow and ice cover.

Item	Day of Experiment					SE	P
	0	21	42	63	84		
<b>YEAR 1</b>							
CP, %	13 <sup>a</sup>	-	13 <sup>ab</sup>	13 <sup>bc</sup>	12 <sup>c</sup>	0.5	0.007
IVTD, %	77 <sup>a</sup>	-	72 <sup>c</sup>	74 <sup>b</sup>	69 <sup>d</sup>	1.7	<0.001
<b>YEAR 2</b>							
CP, %	13	13	13	13	13	0.5	0.403
IVTD, %	81 <sup>a</sup>	81 <sup>a</sup>	75 <sup>bc</sup>	73 <sup>c</sup>	76 <sup>b</sup>	2.1	<0.001

a,b,c,d Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

TABLE 9. Body weight and average daily gain for cows grazing stockpiled tall fescue at three endophyte infection rates of 20 (LOW), 51 (MEDIUM), and 89% (HIGH) for Year 1 (2004-2005) and Year 2 (2005-2006). Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Daily gain under the December to February heading accounts for the average daily gain over 84 days from early-December and late-February, daily gain under the February to April heading accounts for the daily gain from April to weaning.

Item	Treatment			SE	P
	LOW	MEDIUM	HIGH		
	-----kg-----				
<i>December to February</i>					
Initial weight	613	612	605	8	0.118
Final weight	574 <sup>a</sup>	558 <sup>b</sup>	542 <sup>c</sup>	12	0.005
Daily gain	-0.47 <sup>a</sup>	-0.64 <sup>b</sup>	-0.74 <sup>b</sup>	0.13	0.014
<i>February to April</i>					
Weight at weaning	534	529	521	11	0.137
Daily gain	-0.78 <sup>b</sup>	-0.57 <sup>a</sup>	-0.43 <sup>a</sup>	0.17	0.015

<sup>a,b,c</sup> Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

TABLE 10. Body condition score (BCS) for fall-calving cows grazing stockpiled tall fescue at three endophyte infection rates of 20 (LOW), 51 (MEDIUM) and 89% (HIGH) during Year 1 (2004-2005) and Year 2 (2005-2006). Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W).

Item	Treatment			SE	P
	LOW	MEDIUM	HIGH		
	kg				
<i>December to February</i>					
Initial BCS	6.4	6.2	6.1	0.23	0.182
Final BCS	5.6 <sup>a</sup>	5.2 <sup>b</sup>	5.2 <sup>b</sup>	0.26	0.042
<i>February to April</i>					
BCS at weaning	5.6 <sup>a</sup>	5.3 <sup>b</sup>	5.3 <sup>b</sup>	0.20	0.054

<sup>a,b,c</sup> Means within a row within a grouping with different superscripts differ ( $P < 0.05$ )

TABLE 11. Body weight and average daily gain of calves grazing stockpiled tall fescue at three endophyte infection rates of 20 (LOW), 51 (MEDIUM) and 89% (HIGH) during Year 1 (2004-2005) and Year 2 (2005-2006). Data collected at the University of Missouri Forage Systems Research Center near Linneus, Missouri (39° 51' N, 93° 6' W). Daily gain under the December to February heading accounts for the average daily gain over 84 days from early-December and late-February, daily gain under the February to April heading accounts for the daily gain from April to weaning.

Item	Treatment			SE	P
	LOW	MEDIUM	HIGH		
	-----kg-----				
<i>December to February</i>					
Initial weight	111	109	109	6	0.776
Final weight	174	168	197	8	0.215
Daily gain	0.76	0.71	0.70	0.05	0.134
<i>February to April</i>					
Weaning weight	196	194	191	9	0.526
Daily gain	0.39	0.48	0.44	0.06	0.080

## GENERAL CONCLUSIONS

Cow performance results show that as forage allowance of stockpiled tall fescue decreases and endophyte infection level increases, body condition score, body weight, and average daily gain decrease. However, a fall-calving cow's weight and body condition loss can be easily regained when pasture conditions improve. In addition, calf performance is unaffected by endophyte infection level of stockpiled tall fescue. On the other hand, calf average daily gain is decreased when dams were allocated 2.25% of BW. We conclude that this decrease in calf average daily gain is a result of dams not receiving adequate dry matter intake, therefore reducing milk production. Even though calves gain less weight when allocated 2.25% of BW, gain  $\text{ha}^{-1}$  can be increased by as much as 40% compared to allocating at 4.50% of BW. One down fall to allocating forage at 2.25% of BW is a decline in subsequent spring growth, however fall-calving operations that utilize stockpiled tall fescue may be unaffected by decreased spring yield, since virtually no hay is required to over winter cattle. Despite increased cow weight loss, reduced individual calf gain, and decreased spring yield, forage allowances may be most economical at 2.25% of BW, since cow weight loss is easily regained, land requirement are decreased, and calf gain  $\text{ha}^{-1}$  is increased. In addition, when comparing the use of stockpiled tall fescue to hay, cow-calf performance was comparable, concluding that utilization of stockpiled tall fescue for lactating, fall calving beef cows is a suitable substitute and will decrease winter feed costs (Bishop-Hurley and Kallenbach, 2001). And when faced with the question of whether to renovate endophyte-infected tall fescue pastures for fall-calving operations, based upon our results for calf gain and weaning weight, renovation



of endophyte-infected tall fescue pasture would not be needed in most cases. Our results also reiterate the importance of knowing endophyte infection level of pasture. Thus if cattle producers have fields with different levels of endophyte infection, cattle can graze less infected pastures earlier in the winter and can take advantage of the decline in toxic alkaloids in pastures with a greater level of endophyte.

## REFERENCES

- Adams, D. C., R. E. Short, and B. W. Knapp. 1987. Body size and body condition effects on performance and behavior of grazing beef cows. *Nutrition Reports International*. 35:269-277.
- Adams, D. C., D. Clark, R. Sahdberg, G. Carriker, T. Klopfenstein, and T. Milton. 2001. June vs. March calving in the Nebraska sandhills: production traits. *Nebraska Beef Report*. 2001.
- Allen, V. G., J. P. Fontenot, D. R. Notter and R. C. Hammes, Jr. 1992a. Forage system for beef production from conception to slaughter I. Cow-calf production. *J. Anim. Sci.* 70:576-587.
- Allen, V. G., J. P. Fontenot, and D. R. Notter. 1992b. Forage systems for beef production from conception to slaughter II. Stocker systems. *J. Anim. Sci.* 70:588-596.
- Archer, K. A. and A. M. Decker. 1977a. Autumn-accumulated tall fescue and orchardgrass. I. Growth and quality as influenced by nitrogen and soil temperature. *Agron. J.* 69:601-605.
- Archer, K. A. and A. M. Decker. 1977b. Autumn-accumulated tall fescue and orchardgrass. II. Effects of leaf death on fiber components and quality parameters. *Agron. J.* 69:605-609.
- Bacon, C. W. and M. R. Siegel. 1988. Endophyte parasitism of tall fescue. *J. Prod. Agric.* 1: 45-55.
- Bagley, C. P., J. C. Carpenter, Jr., J. I. Feazel, F. G. Hembry, D. C. Huffman, and K. L. Koonce. 1987. Influence of calving season and stocking rate on beef cow-calf productivity. *J. Anim. Sci.* 64:687-694.
- Baker, H. K., J. R. A. Chard, and W. E. Hughes. 1965. A comparison of cocksfoot- and tall fescue –dominant sward for out of season production. *J Br. Grassl. Soc.* 20:84-90.
- Balasko, J. A. 1977. Effects of N, P, and K fertilization on yield and quality of tall fescue forage in winter. *Agron. J.* 69:425-428.
- Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 2002. Fescue toxicity. In: *Southern Forages, Modern Concepts for Forage Crop Management*, 3rd Edition. Graphic Communications Corporation. Lawrenceville, GA.

- Ball, D. M., S. P. Schmidt, G. D. Lacefield, C. S. Hoveland, and W. C. Young III. 2003. Tall Fescue/Endophyte Concepts. Oregon Tall Fescue Commission Special Publication 1-03, Salem, OR.
- Beconi, M. G., M. D. Howard, T. D. A. Forbes, R. B. Muntifering, N. W. Bradley, and M. J. Ford. 1995. Growth and subsequent feedlot performance of estradiol-implanted vs nonimplanted steers grazing fall-accumulated endophyte-infested or low-endophyte tall fescue. *J. Anim. Sci.* 73:1576-1584.
- Belesky, D. P., S. R. Wilkinson, and F. McHan. 1984. Yield, composition and quality of tall fescue as influenced by N fertility and soil water availability. *Commun. Soil. Sci. Plant Anal.* 15:945-968.
- Berry, R. F., and C. S. Hoveland. 1969. Summer defoliation and autumn-winter production of *Phalaris* species and tall fescue varieties. *Agron. J.* 61: 493-494.
- Bishop-Hurley, G. J. and R. L. Kallenbach. 2001. The economics of grazing beef cows during winter. p. 274. In *Proc. American Forage and Grassland Council.* 22-25 April, 2001. Springdale, AR. AFGC, Georgetown, TX.
- Brees, M and J. Horner. 2006. Projected Beef Cow/Calf Annual Budget for Calves Sold in 2006. [Online]. Available at <http://www.agebb.missouri.edu/mgt/budget/annlbeef.htm> (verified 19 June 2006).
- Brown, R. H., and R. E. Blaser. 1965. Relationship between reserve carbohydrate accumulation and growth rate in orchardgrass and tall fescue. *Crop Sci.* 5:577-582.
- Boling, J. A. 1985. Endophytic fungus and tall fescue utilization by ruminants. *Prof. Anim. Sci.* 1:19.
- Bryan, W. B., W. F. Wedin, and R. L. Vetter. 1970. Evaluation of reed canarygrass and tall fescue as spring-summer and fall-saved pasture. *Agron. J.* 62:75-80.
- Buckner, R. C., and L. P. Bush. Tall Fescue. *Agron. Monogr.* 20. ADA, CSSA, and SSSA, Madison, WI.
- Burns, J. C., and D. S. Chamblee. 2000a. Summer accumulation of tall fescue at low elevations in the humid Piedmont: I. Fall yield and nutritive value. *Agron. J.* 92:211-216.
- Burns, J. C., and D. S. Chamblee. 2000b. Summer accumulation of tall fescue at low elevations in the humid Piedmont: II. Fall and winter changes in nutritive value. *Agron. J.* 92:217-224.
- Carstens, G.E., D. E. Johnson, M. A. Ellenberger, and J. D. Tatam. 1991. Physical and chemical components of the empty body during compensatory growth in beef steers. *J. Anim. Sci.* 69:3251-3264.

- Chestnut, A. B., H. A. Fribourg, K. D. Gwinn, P. D. Anderson, and M. A. McCann. 1991. Effect of ammoniation on toxicity of *Acremonium coenophialum* infested tall fescue. *Anim. Feed Sci. Tech.* 35:227-236.
- Clark, J. T. 2003. Evaluating efficacy and limitations of winter grazing systems for beef cattle on animal production and soil properties. Masters Thesis. Iowa State University, Ames.
- Clark, J. T., J. R. Russell, D. R. Strohbehn, J. D. Lawrence, and D. G. Morrical. 2004. Iowa State University Animal Industry Report. Effects of stocking rate and corn gluten feed supplementation on growth and intake of bred heifers grazing stockpiled tall fescue-red clover forages during winter [Online]. Available at <http://www.ans.iastate.edu/AIR/2004pdf/AS1879.pdf> (verified 1 July 2004).
- Coffey K., D. Hubbell, C. Rosenkrans, Jr., W. Coblenz, Z Johnson, and K. Harrison. 1999. Performance of fall-calving cow fed zeolite while grazing fescue during winter. Arkansas Anim Sci Dept Report [Online]. Available at <http://www.uark.edu/depts/agripub/Publications/researchseries/470.pdf> (verified 19 June 2006).
- Cole, N. A., J. A. Stuedemann, C. W. Purdy, and D. P. Hutcheson. 1987. Influence of endophyte in tall fescue pastures on the feedlot performance of beef steers. *J. Anim. Sci.* 65(Suppl. 1): 331.
- Collins, M., and J. A. Balasko. 1981a. Effects of N fertilization and cutting schedules on stockpiled tall fescue I. Forage yield. *Agron. J.* 73:803-807.
- Collins, M., and J. A. Balasko. 1981b. Effects of N fertilization and cutting schedules on stockpiled tall fescue II. Forage quality. *Agron. J.* 73:821-826.
- Cowan, J. R. 1956. Tall Fescue. *Adv. Agron.* 8:283-320.
- Davis, B. W. 1996. Changes in stockpiled tall fescue quality over the grazing season and period. Master thesis. University of Missouri, Columbia.
- Decker, A. M. 1988. Maximizing the grazing season. Pages 31-42 in *Pasture in northeast region of the United States*. J. B. Cropper, ed. Northeast Regional Agricultural Engineering Serv., Ithica, NY.
- Drewry, J. J., K. C. Cameron, and G. D. Buchan. 2001. Effect of simulated dairy cow-treading on soil physical properties and ryegrass pasture yield. *NZ J. Agric. Res.* 44:181-190.
- Dunn, T. G., J. E. Ingalls, D. R. Zimmerman, and J. N. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. *J. Anim. Sci.* 29:719.
- Dunn, T. G. . and G. E. Moss. 1992. Effects of nutrient deficiencies and excesses on reproductive efficiency of livestock. *J. Anim. Sci.* 70:1580-1593.

- Freetly, H. C., C. L. Ferrell, and T. G. Jenkins. 2000. Timing of realimentation of mature cows that were feed-restricted during pregnancy influences calf birth weights and growth rates. *J. Anim. Sci.* 78:2790–2796.
- Fribourg, H. A. 1983. Computer program for teaching forage management and utilization: Beef-forage management system (BFMS). Tennessee Agric. Exp. Stn. Res. Rep. 83-10.
- Fribourg, H. A. and K. W. Bell. 1984. Yield and composition of tall fescue stockpiled for different periods. *Agron. J.* 76:929-934.
- Gerrish, J. R. 2004. Management-Intensive Grazing: The Grassroots of Grass Farming. Green Park Press.
- Gerrish, J. R. 2002. Winter grazing fall-calving cows: first year project summary. Missouri Agric. Exp. Stn. Forage Systems Update vol. 11, no. 2 [Online]. Available at <http://aes.missouri.edu/fsrc/news/archives/n102v1n2a.stm> (verified 18 June 2004).
- Gerrish, J. R. and P. R. Peterson. 1993. Rate and timing of nitrogen fertilization impact yield and quality of stockpiled tall fescue. p. 195-169. In Proc. American Forage and Grassland Council. 29-31 April, 1993. Des Moines, IA. AFGC, Georgetown, TX.
- Gerrish, J. R., P. R. Peterson, C. A. Roberts, and J. R. Brown. 1994. Nitrogen fertilization of stockpiled tall fescue in the Midwestern USA. *J. Prod. Agric.* 7:98-104.
- Gunter, S. A., and P. A. Beck, 2004. Novel endophyte-infected tall fescue tall fescue for growing beef cattle. *J. Anim. Sci.* 82(E. Suppl. ):E75-E82.
- Guretzky, N. A. J., J. R. Russell, D. R. Strohbehn and D. G. Morrical. 2005. Grazing and feedlot performance of yearling stocker cattle integrated with spring- and fall-calving beef cows in a year-round grazing system. *J. Anim. Sci.* 83:2696-2704.
- Hall, M. H., P. J. Levan, E. H. Cash, H. W. Harpster, and S. L. Fales. 1998. Fall-grazing management effects on production and persistence of tall fescue, perennial ryegrass, and prairie grass. *J. Prod. Agric.* 11:487-491.
- Hanson, A. A. 1979. The future of tall fescue. P. 341-344. In R. C. Buckner and P. P. Bush (ed. ) Tall fescue. Agron. Monogr. 20. ASA, CSSA, SSSA, Madison, WI.
- Hemken, R. W., J. A. Boling, L. S. Bull, R. H. Hatton, R. C. Buckner, and L. P. Bush. 1981. Interaction of environmental temperature and anti-quality factors on the severity of summer fescue toxicosis. *J. Anim. Sci.* 52:710.
- Hersom, M. J. 1999. Evaluation of year-round forage management systems for beef production. Masters Thesis. Iowa State University, Ames.

- Hiatt, E. E., III, and N. S. Hill. 1997. Neotyphodium coenophialum mycelial protein and herbage mass effects on ergot alkaloid concentration in tall fescue. *J. Chem. Ecol.* 23:2721–2736.
- Hitz, A. C. and J. R. Russell. 1998. Potential of stockpiled perennial forages in winter grazing systems for pregnant beef cows. *J. Anim. Sci.* 76:404-415.
- Hobbs, C. S., T. W. High, Jr., and I. Dyer, Jr. 1965. Orchardgrass and fescue pastures for producing yearling slaughter steers. *Tennessee Agric. Exp. Sta. Bull.* p386.
- Houghton, P. L., R. P. Lemeager, K. S. Hendrix, G. E. Moss, and T. S. Stewart. 1990. Effects of body composition, pre- and postpartum energy level and stage of production on energy utilization by beef cows. *J Anim. Sci.* 68: 1447-1456.
- Hoveland, C. S. 1993. Importance and economic significance of the Acremonium endophytes to performance of animals and grass plant. *Agric. Ecosyst. Environ.* 44:3-12.
- Janovick, N. A. 2002. Evaluation of year-round grazing systems for fall- and spring-calving beef cows. Masters Thesis. Iowa State University, Ames.
- Janovick, N. A., J. R. Russell, D. R. Strohbahn and D. G. Morrical. 2004. Productivity and hay requirements of beef cattle in a Midwestern year-round grazing system. *J. Anim. Sci.* 82:2503-2515.
- Johnson, C. R., D. L. Lalman, M. A. Brown, L. A. Appeddu, D. S. Buchanan, and R. P. Wettemann. 2003. Influence of milk production potential on forage dry matter intake by multiparous and primiparous Brangus females. *J. Ani. Sci.* 81: 1837-1846.
- Jordan, W. A., E. E. Lister, and G. J. Rowlands. 1968. Effects of planes of nutrition on wintering pregnant beef cows. *Can. J. Anim. Sci.* 51:432-438.
- Kallenbach, R. L., G. J. Bishop-Hurley, M. D. Massie, G. E. Rottinghaus, and C. P. West. 2003. Herbage mass, nutritive value, and ergovaline concentration of stockpiled tall fescue. *Crop Sci.* 43:1001-1005.
- Kallenbach, R. L., and R. L. McGraw. 2003. Influence of nitrogen rate and pasture composition on toxicity, quality and yield of stockpiled tall fescue. University of Missouri: Forage Systems Update Vol 12, No. 3.
- Kreft, B., J. Kreft, R. Cargo, D. Schmidt. 1998. Fall-calving in North Dakota. North Dakota State University Central Grasslands Research Extension Center. [Online] Available at: <http://www.ag.ndsu.nodak.edu/streeter/98report/fall98.htm> (verified 18 June 2004).

- Kuusela, E., and H. Khalili. 2002. Effect of grazing method and herbage allowance on the grazing efficiency of milk production in organic farming. *Anim. Feed Sci. and Tech.* 98:87-101.
- Lake, S. L., E. J. Scholljegerdes, R. L. Atkinson, V. Nayigihugu, S. I. Paisley, D. C. Rule, G. E. Moss, T. J. Robinson and B. W. Hess. 2005. Body condition score at parturition and postpartum supplemental fat effects on cow and calf performance. *J. Anim. Sci.* 83:2908-2917.
- Laurenz, J. C., F. M. Byers, G. T. Schelling, and L. W. Greene. 1992. Periodic changes in body composition and in priorities for tissue storage and retrieval in mature beef cows. *J. Anim. Sci.* 70:1950-1956.
- Lusby, K. S., W. E. McMurphy, C. A. Strasia, S. C. Smith, and S. H. Muntz. 1990. Effects of fescue endophyte and interseeded clovers on subsequent finishing performance of steers. *J. Prod. Agric.* 3:103.
- Marsh, R. 1979. Effect of herbage SM allowance on the immediate and longer term performance of young Friesian steers at pasture. *N. Z. Agric. Res.* 22:209-219.
- Matches, A. G., F. A. Martz, D. A. Sleper, and M. T. Krysowaty. 1981. Selecting levels of herbage allowance to compare forages for animal performance. P331-339. In *Proceeding of XIV International Grassland Congress*. DSIRO, Australia.
- Matches, A. G. J. B. Tevis, and F. A. Martz. 1973. Yield and quality of tall fescue stockpiled for winter grazing. p54-57. In *Research in agronomy 1973*. Univ. of Missouri Misc. Publ. 73-75.
- Matches, A. G., S. Bell, M. Mitchell, and F. A. Martz. 1977. Pasture systems for season-long grazing. Res. Rep. Coop. UMC-Southwest Missouri Center.
- Minson, D. J., and P. C. Whiteman. 1989. A standard livestock unit (SLU) for defining stocking rate in grazing studies. In *Proc. XVI International Grassland Congress*, Nice, France, 4-11 Oct. p. 1117.
- Morrow, R. E., J. A. Stricker, G. B. Garner, V. E. Jacobs, and W. G. Hires. 1988. Cow-calf production on tall fescue-ladino clover pastures with and without nitrogen fertilization or creep feeding: fall calves. *J. Prod. Agric.* 1:145-148.
- National Research Council. 2000. *Nutrient Requirements of Beef Cattle*. 7th ed. National Academy Press, Washington, DC.
- Nelson, C. J. 1996. Physiology and developmental morphology. P. 87-125. In L.E. Moser et al. (ed.) *Cool-season forage grasses*. Agron. Monogr. No. 34. ASA, CSSA, and SSSA, Madison, WI.
- Nelson, M. E. 1988. *Calving season strategies*. Cooperate Extension Service, Manhattan, Kansas.

- Neumann, A. L., and K. S. Lusby. 1986. Beef cattle (8th Ed. ). Wiley, New York, NY.
- Nichols, J. T., P. E. Reece, G. W. Hergert, and L. E. Moser. 1990. Yield and quality response of subirrigated meadow vegetation to nitrogen, phosphorous and sulfur fertilizer. *Agron. J.* 54:47-52.
- Nicoll, G. B. 1979: Influence of pre-and post-calving pasture allowance on hill country beef cow and calf performance. *New Zealand Journal of Agricultural Research* 22: 417-424.
- Ocuppaugh, W. R., and A. G. Matches. 1977. Autumn-winter yield and quality of tall fescue. *Agron. J.* 69:639-643.
- Oliphant, E. J., 2005. Performance of beef heifers grazing stockpiled endophyte-infected, endophyte-free or non-toxic endophyte-infected tall fescue. Masters Thesis. [Online] Available at <http://www.lib.ncsu.edu/theses/available/etd-11302004-222906/unrestricted/etd.pdf> (verified 18 June 2004).
- Paterson, J., C. Forcherio, B. Larson, M. Samford, and M. Kerley. 1995. The effects of fescue toxicosis on beef cattle productivity. *J. Anim. Sci.* 73:889-898.
- Peters, C. W., K. N. Grigsby, C. G. Aldrich, J. A. Paterson, R. J. Lipsey, M. S. Kerley, and G. B. Garner. 1992. Performance, pasture utilization, and ergovaline consumption by beef cows grazing endophyte fungus infected tall fescue, edophy fungus-free tall fescue, or orchardgrass pastures. *J. Anim. Sci.* 70(1550-1561).
- Porter, J. K. and F. N. Thompson, Jr. 1992. Effects of fescue toxicosis on reproduction in livestock. *J. Anim. Sci.* 70:1594-1603.
- Raleigh, R. J. 1970. Symposium on pasture methods for maximum production in beef cattle: Manipulation of both livestock and forage management to give optimum production. *J. Anim. Sci.* 30: 108-114.
- Rayburn, E. C., R. R. Blaser, and D. D. Wolf. 1979. Winter tall fescue yield and quality with different accumulation periods and N rates. *Agron. J.* 71:959-963.
- Richards, M. W., J. C. Spitzer, and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. *J. Anim. Sci.* 62:300-306.
- Riesterer, J. L., and D. J. Undersander, M. D. Casler, and D. K. Combs. 2000a. Forage yield of stockpiled perennial grasses in the upper Midwest USA. *Agron. J.* 92: 740-747.
- Riesterer, J. L., M. D. Casler, D. J. Undersander, and D. K. Combs. 2000b. Seasonal yield distribution of cool-season grasses following winter defoliation. *Agron. J.* 92:974-980.



- Roberts, C., and Andrae, J. 2004. Tall fescue toxicosis and management Crop Management. [Online]. Available at <http://www.plantmanagementnetwork.org/feature/fescue/> (verified 28 October 2004).
- Roth, L. D., F. M. Rouquette, Jr., and W. C. Ellis. 1990. Effects of Herbage Allowance on Herbage and Dietary Attributes of Coastal Bermudagrass. *J. Anim. Sci.* 68:193-205.
- Rottinghaus, G. E., G. B. Garner, C. N. Cornell, and J. L. Ellis. 1991. An HPLC method for quantitating ergovaline in endophyteinfected tall fescue: seasonal variation of ergovaline levels in stems with leaf sheaths, leaf blades and seed heads. *J. Agric. Food Chem.* 39:112.
- Rutledge, J. J., O. W. Robison, W. T. Ahlschwede, and J. E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. *J. Animal. Sci.* 33: 563.
- SAS Institute. 1999. OnlineDoc, Version 8. 0 [Online]. SAS Inst., Cary, NC. Available at <http://v8doc.sas.com/sashtml/> (verified 31 March 2005).
- Schmitz, Gene. 2001. Fall grazing programs utilizing cool-season forages. University Outreach and Extension – Mercer County.
- Selk, G. E., R. P. Wettermann, K. S. Lusby, J. W. Oltje, S. L. Mobley, R. J. Rasby and J. C Garmendia. 1988. Relationships among weight change, body condition and reproductive performance of range beef cows. *J. Anim. Sci.* 66:3153-3159.
- Short, R. E., R. A. Bellows, R. B. Staigmiller, J. G. Berardinelli, and E. E. Custer. 1990. Physiological mechanisms controlling anestrus and idfertility in postpartum beef cattle. *J. Anim. Sci.* 68:799-816.
- Sinclair, K. D., P. J. Broadbent, and J. S. M. Hutchinson. 1994. The effect of pre-and-postpartum energy and protein supply on the blood metabolites and reproductive performance of single-and twin-suckling beef cows. *Anim. Prod.* 59:391-400.
- Sleper, D. A., and R. C. Buckner. 1995. The fescues. In forages: an introduction to grassland agriculture, vol. 1, 5th edition, pp. 345-356 Iowa State University Press, Ames.
- Sleper, D. A. and C. P. West. 1996. Tall Fescue. P 471-502. In L. E. Moser et al. (ed. ) Cool-season forage grasses. Agron. Monogr. No. 34 ASA, CSSA, and SSSA, Madison, WI.
- Spitzer, J. C., D. G. Morrison, R. P. Wettermann, and L. C. Faulkner. 1995. Reproductive responses and calf birth and weaning weights as affected by body condition at parturition and postpartum weight gain in primiparous beef cows. *J. Anim. Sci.* 73:1251-1257.

- Steel, R. G., and J. H. Torrie. 1980. Principles and procedures of statistics. Second edition. McGraw-Hill. New York, NY.
- Strohbehn, D. R. 2001. 2000 Beef Cow Business Record ISU-IRM-SPA. Iowa State Summary. [Online]. Available at <http://www.iowabeefcenter.org/Publications/spa00.pdf> (verified 21 June 2006).
- Stuedemann, J. A. and C. S. Hoveland. 1988. Fescue endophyte: history and impact on animal agriculture. *J. Prod. Agric.* 1:39-44.
- Taylor, T. H, and W. C. Templeton, Jr. 1976. Stockpiling Kentucky bluegrass and tall fescue forage for winter pasturage. *Agron. J.* 68:235-239.
- Tucker, C. A., R. E. Morrow, J. R. Gerrish, C. J. Nelson, G. B. Garner, V. E. Jacobs, W. G. Hires, J. J. Shinkle, and J. R. Forwood. 1989. Forage systems for beef cattle: effect of winter supplementation and forage systems on reproductive performance of cows. *J. Prod. Agric.* 2:217-221.
- VanHavern, B. P. 1983. Soil bulk density as influenced by grazing intensity and soil type on shortgrass prairie site. *J. Range Manag.* 36(5):586-588.
- Van Keuren, R. W. 1969. All-season pastures for beef cows. *Beef Cattle.* p27-31. Ohio Agric. Res. Dev. Cent. Res. Summary B.
- Van Keuren, R. W. 1970. All-season grazing for beef cows. Ohio Agric. Res. Dev. Cent. Res. Summary. 43:1-6.
- Waller, J. C., J. C. Forcherio, H. A. Fribourg, M. C. Smith, and R. J. Carlisle. 1988. Performance of fall-calving cows and their calves grazing fescue-based forage systems. *J. Prod. Agric.* 1:338-342.
- Wedin, W. F., I. T. Carlson, and R. L. Vetter. 1966. Studies on nutritive value of fall-saved forage, using rumen fermentation and chemical analysis. p. 424-428. In *Proc. 10th Int. Grassl. Congr., Helsinki, Finland.* Valtioneuvoston Kirjapaino.
- Wilson, L., R. C. Peterson, M. E. Heath, and R. E. Erb. 1965. Restricted vs unrestricted winter grazing of round fescue bales and aftermath for a beef cow herd on the forage farm. *Purdue Univ. Agric. Exp. Stn. Res. Progr. Rep.* 189.
- Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory, and R. M. Kock. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. *J. Anim. Sci.* 21:219-225.
- Wolf, D. D., R. H. Brown, and R. R. Blaser. 1979. Physiology of growth and development. P. 92 In R. C. Buckner and P. P. Bush (ed. ) *Tall fescue.* Agron. Monogr. 20. ASA, CSSA, SSSA, Madison, WI.

- Virkajarvi, P., A. Sairanen, J. I. Nousiainen, H. Khalili. 2001. Effect of herbage allowance on pasture utilization, regrowth and milk yield of dairy cows in early, mid and late season. *Anim. Feed Sci. and Tech.* 97:23-40.
- Younie, D., and J. Hermansen. 2000. The role of grassland in organic livestock. *Grassland Science in Europe* 5:493-511.