Forage Utilization and Nitrogen Management of Tall Fescue Stockpiled for Winter Grazing

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ABSTRACT

The Southeastern United States offers a beneficial environment for stocker and cow-calf production. Abundant tall fescue grass offers a feed source that has been underutilized. These studies evaluated how nitrogen rate and source can affect yield and nutritional quality of fall stockpiled tall fescue, and how grazing methods impact weight gains, forage utilization, and forage nutritive value. The first study evaluated the impact of N rate and source on the yield tall fescue stockpiled for winter grazing. In mid-September, seven N sources (ammonium sulfate (AS), ammonium nitrate (AN), urea + Agrotain @ 2.1 l/Mg (AG2), urea + Agrotain @ 4.2 l/Mg (AG4), urea + Agrotain @ 6.3 l/Mg (AG6), Nutrisphere (NuS), and urea) were applied at 0, 45, 90, and 135 kg N/ha. Ammonium sulfate produced the highest nutritive values of all N sources. Only yield in 2012 was found to be influenced by N volatilization inhibitors; said products had no effect on nutritive value. The second study evaluated how grazing methods impact nutritive value, ADG, and utilization of tall fescue stockpiled for winter grazing. Three treatments (continuous grazing, moved once per week, and moved twice per week) were used. In year one, cattle moved once and twice per week showed significantly higher ADG (P < 0.05) than the continuous treatment. In year two, cattle that continuously grazed had higher ADG (P <0.05), than cattle moved once and twice per week. Cattle moved once and twice per week showed greater forage utilization (P < 0.05) than cattle that continuously grazed.
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CHAPTER 1: INTRODUCTION

With large areas of land ideal for grazing, cattle producers in the Southeastern United States have an opportunity to increase profits. High feed costs have opened the doors for cattle producers of this region to utilize pasture grazing to increase weights of stocker cattle at a fraction of the cost before being sold as feedlot cattle. The ability to utilize low cost, abundant forages to add pounds and profit to cattle is essential to beef production in the Southeastern United States.

Pastures of the Southeastern United States are abundant with tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.)(Paterson et al., 1995), a perennial cool season grass that offers a variety of benefits and challenges. Tall fescue grass is easily established and offers a long growing season. It also is tolerant to drought, pests, and herbivory loss (Ball et al., 2007). These benefits make tall fescue useful as forage for farmers of the Southeast because of its low maintenance and ability to thrive in less than ideal conditions.

Tall fescue is advantageous over other forages for stockpiling, because it grows in the fall, and does not rapidly lose nutrient content after dormancy (Roberts et al., 2009). Fertilization with N is a primary factor impacting both yield and nutritive value of stockpiled tall fescue. Poore and co-workers (2000) observed moderate N inputs (61.59 - 123.18 kg N/ha) can achieve 24.64 - 49.27 kg of forage DM production per kg N. Forage quality tends to be higher as the date of stockpile initiation is delayed until autumn (Gerrish et al., 1994).

Intensive grazing offers a number of benefits to cattle producers in the Southeastern United States. These benefits include increased forage utilization, improved pasture regrowth, and better productivity of pastures (Ball et al., 2008). In an intensive grazing system, after a
certain amount of time or after a certain amount of forage on the paddock is consumed, the animals are moved to another small paddock.

The objective of this study was to evaluate potential options to increase the profitability of stocker cattle operations in the Southeastern United States, where abundant forage is available and a large number of cattle reside. Two experiments were conducted to evaluate how to better stockpile tall fescue for winter grazing and how intensive grazing management can impact cattle performance, forage quality, and pasture utilization. More specifically, the objectives were to evaluate the effect that different nitrogen rates and sources on nutritive value and yield of stockpiled tall fescue, as well as to determine if urease inhibitors are beneficial to stockpiling tall fescue, and to determine how forage utilization and average daily gain are effected by forage allocation.

CHAPTER 2: REVIEW OF LITERATURE

Stocker Production

Stocker production is the practice of growing weaned calves until they are ready to enter the feed lot. This can be accomplished by grazing livestock on high quality pasture or feeding a ration on a dry lot. Usually stocker cattle weigh between 180 and 270 kg when entering stocker production (Allen et al., 2007). These same cattle will be moved to the finishing phase after five to seven months when they weigh 360 to 430 kg (Allen et al., 2007).

Hoveland (1986) stated the greatest opportunity for improving profitability in beef production in the southeastern United States lies in stockering weaned calves. Stocker cattle
producers have some of the lowest demands for facilities and labor of any cattle enterprise (McKinnon and Snodgrass, 2000). To complement this, there is an abundant amount of forage production in the southeastern United States, which gives producers in the region an opportunity to increase profitability of their operations using forages.

Beef production in the southeastern United States mainly consists of cow/calf operations (Hoveland, 1986), but this region also offers the potential to stocker cattle. The rolling topography, climate, and soils of Virginia lend themselves to producing an abundance of lush forages (McKinnon and Snodgrass, 2000). Some stocker cattle operations are able to maintain a stocking rate of one stocker calf per acre of pasture (McKinnon and Snodgrass, 2000), but this requires high degree of management.

When developing a stocker operation, producing abundant and high quality forage throughout the year is very important. During the winter months this can be accomplished through stockpiling, as it offers a lower cost and high nutritional value alternative to feeding hay (Lalman and Smith, 2001). Stockpiling forages reduces the amount of and reliance on stored feeds, and additional labor associated with feeding livestock (Ball et al., 2008). Stockpiling is the practice of removing livestock from pastures in late-summer, fertilizing with nitrogen, and allowing forage to accumulate until the end of the growing season (Roberts et al., 2009). This allows for forage to accumulate that can be grazed in the late fall and winter.

**Tall Fescue**

Tall fescue (*Schedonorus arundinacea* (Schreb.) Dumort., nom. cons.) is an abundant, cool season perennial grass that occupies 14 million hectares in the United States (Bacon and
An estimated 8.5 million beef cows are maintained on tall fescue pastures (Ball, 2007). Tall fescue offers a host of benefits over other cool season perennial grasses. Tall fescue has a long growth period in the fall from mid-September to early December and a spring growth period from early March to late June (Ball et al., 2007). Tall fescue is also tolerant of grazing pressure as well as herbivory loss by animals, insects, and nematodes (Hill et al., 1991). Tall fescue is a deep rooted, high seed producing, low maintenance forage that is highly resistant to drought, insects, and overgrazing (Siegel et al., 1985; Ball et al., 2007). With a crude protein (CP) level that averages 10-15% and a total digestible nutrient (TDN) level that averages 55-60%, tall fescue offers a high quality forage for cow – calf and stocker cattle operations (Ball, 2007).

Tall fescue samples were first collected on the W. M. Suiter farm in Menifee County, Kentucky, in 1931 by Dr. E.N. Fergus of the University of Kentucky (Lacefield and Evans, 1984). In 1943, “Kentucky-31” was commercially released. Its agronomic advantages and adaption to the specific growing conditions of the region known as the “transition zone” (a region which extends from Virginia to Georgia and to the Great Plains) allowed for the widespread acceptance of tall fescue in the region (Siegel et al., 1985).

Shortly after the widespread establishment of tall fescue, producers began to notice poor performance and health in the livestock (Stuedemann and Hoveland, 1988). In the 1970’s, a fungal endophyte, Neotyphodium coenophialum, located within tall fescue, was revealed to be the cause of these shortcomings (Bacon et al., 1977). The endophyte and the tall fescue plant co-habitat in a symbiotic relationship, in which, tall fescue provides the endophyte with nutrients, protection, and dissemination through seed, and the endophyte imparts improved tolerance to drought, pests, and herbivory loss to the host plant (Ball et al., 2007).
The endophyte in wild-type tall fescue produces highly toxic ergot alkaloids. Over 90% of the tall fescue fields tested in the United States are infested with an endophytic fungus (Sleper and West, 1996). Over 400,000 hectares of hay and pasture in Virginia are planted with tall fescue (Smith et al., 2002).

**Tall Fescue Toxicosis**

Consumption of wild-type endophyte infected (E+) tall fescues, such as Kentucky-31, can lead to a plethora of disorders that are collectively known as “tall fescue toxicosis”. Tall fescue toxicosis in cattle is characterized by poor weight gain, impaired reproductive performance, depressed milk production, retention of rough (winter) hair coats into the summer months, low serum prolactin, restricted blood flow to peripheral tissues and heat intolerance (Schmidt and Osborn 1993; Strickland et al., 1993; Thompson and Stuedemann 1993).

A study by Yates (1985) reported that detection of alkaloids in toxic pastures and their absence in nontoxic pastures implied they may be the cause of tall fescue toxicity in cattle. Yates (1985) also stated that ergovaline, which is an ergopeptide and known dopamine agonist produced by the endophyte, is the primary cause of toxicosis. However, subsequent research has indicated that multiple alkaloids may be partially responsible for toxicosis symptoms (Browning and Leite-Browning, 1997; Browning et al., 1998); both ergonovine and ergotamine can alter plasma concentrations of various pituitary hormones and thermoregulation.

The fungus is located between the cell walls of the E+ tall fescue (Bacon, 1995). Ergot alkaloids produced by wild-type *N. coenophialum* are ergopeptides and lysergic acid and its derivatives (Bush and Fannin., 2009). Ergot alkaloids counter insect herbivory but are the only
endophyte-derived alkaloids that serve as mycotoxins that counter mammalian herbivory (Strickland et al., 2011).

Aiken et al. (2009) concluded that the concentration levels of endophyte infestation play a pivotal role in the severity of toxicity. As the level of E+ tall fescue decreases, symptoms of tall fescue toxicosis decrease. Inversely, average daily gains (ADG) in cattle increase (Fribourg et al., 1991).

Three maladies have been continually associated with tall fescue toxicosis: summer slump, fescue foot, and fat necrosis (Ball, 2007). These three ailments collectively represent the majority of disorders livestock producers encounter when grazing animals on E+ tall fescue (Stuedemann and Hoveland, 1988).

**Summer Slump**

The summer months are when cattle are most noticeably affected by tall fescue toxicosis. “Summer slump” has become the most common and economically important syndrome of cattle grazing endophyte infected tall fescue (Ball, 2007). Though more visible in warm areas, summer slump occurs throughout all tall fescue regions in the U.S. (Ball, 2007). Economic loss in the United States has been estimated to be greater than $600 million annually to the beef industry (Hoveland, 1993).

Symptoms accompanying summer slump include decreased feed intake, increased respiration rates, elevated body temperatures, excessive salivation, and decreased time spent grazing with more time spent in shade or standing in ponds (Schmidt and Osborn, 1993; Thompson and Stuedemann, 1993). Reduced average daily gains, conception rates, heat
tolerance, serum prolactin, weaning weights, as well as nervousness and rough hair coats are associated with summer slump (Stuedemann and Hoveland, 1988).

Consumption of endophyte-infected diets during a constant heat challenge at 32°C has been shown to result in a 50% reduction in skin vaporization (Aldrich et al., 1993). Research has shown that endophyte-infected tall fescue can reduce blood flow to the skin causing an increase in energy expenditure (Zanzalari et al., 1989) and decreased productivity during summer months. Cattle grazing E- fescue pastures compared to E+ fescue have been recorded having weight gain increases from 30% to over 100% (Hoveland, 1993). Decreased blood flow to the core as well as periphery tissue has been recorded when ambient temperature exceeds 32°C (Hemken et al., 1981).

**Fescue Foot**

The most severe form of tall fescue toxicosis, fescue foot, can result in lameness, gangrene, sloughing of hooves, and loss of the tips of the ears or the tail. First reported in New Zealand on cattle grazing tall fescue pastures, fescue foot can be an acute and costly problem (Cunningham, 1949).

Cunningham (1949) was the first to describe fescue foot, stating that it is a condition characterized by extreme lameness that can progress to peripheral necrosis of the affected limb. Cunningham (1949) reported signs of fescue foot in cattle placed on endophyte infected pastures as early as 14 days.

Generally, fescue foot appears in livestock grazing in cold regions of fescue production and develops in the late fall and winter (Bacon, 1995). Research in Australia found removal of cattle from E+ pastures before permanent damage occurs is the only way to treat fescue foot.
(Pulsford, 1950). If allowed to graze E+ tall fescue lameness develops as swelling of the coronary band above the hoof becomes evident (Fletcher et al., 1990). If cattle are not removed from E+ stands, then gangrene, followed by hoof sloughing, can occur (Jacobson et al., 1970). Even after being removed from E+ fescue, cattle may never recover completely from lameness (Yates et al., 1985). Fescue foot can be a costly problem, it is however considered less of a concern compared to other disorders associated with E+ tall fescue (Ball, 1997).

**Fat Necrosis**

Fat necrosis is characterized by hard masses of adipose tissue, mostly in the abdominal cavity (Ball, 2007). The presence of these abnormal deposits of fat can upset digestion, cause difficulties in birth, renal failure, and death (Thompson and Stuedemann, 1993). Animals with fat necrosis commonly exhibit anorexia, constipation, lethargy, and bloat (Smith et al., 2004).

The role of endophyte toxins in fat necrosis is still not fully understood (Bacon, 1995). It is believed to be associated with high rates of nitrogen fertilization on E+ fescue. This can also lower blood cholesterol as Stuedemann (1985) found in his research with brood cows. Stuedemann (1985) also found that intestinal constriction by hard fat, as well as fat encompassing the omasum, led to death in cows. Fat necrosis is not specific to cattle, it has also been found in pigs, horses, Eld’s deer, and pygmy goats (Smith et al., 2004).

**Alleviation of Tall Fescue Toxicosis**

A multitude of solutions have been proposed in to order to increase profitability and control negative health effects since the discovery of E+ tall fescue problems in cattle. Removal
of the endophyte, replacing the endophyte with an animal safe novel endophyte, planting of nitrogen fixing legumes and clovers, and stricter management practices have all become popular in the control of tall fescue toxicosis. All these options, however, are aimed at preventing the onset of toxicosis and less at treating existing conditions. The use of a D2 dopamine receptor antagonist has been shown to treat tall fescue toxicosis in horses and cattle (Redmond et al., 1994), but the treatment is costly and not economically feasible for beef cattle.

In a study by Nihsen (2004), ADG of cattle grazing E+ tall fescue were lower than that of cattle grazing novel endophyte tall fescue, by 0.34 kg/d and 0.60 kg/d, respectively. Cattle on novel tall fescue had similar ADG of cattle grazing E- tall fescue, 0.61 kg/d (Nihsen et al., 2004). Cattle grazing E+ stands also displayed increased respiration and rectal temperatures when compared to novel endophyte tall fescue (Nihsen et al., 2004).

**Endophyte Free**

Removal of the endophyte from tall fescue in order to create an endophyte-free (E-) tall fescue can either be accomplished by treating the seed with a fungicide to kill the endophyte or by storing the seed at an ambient temperature for at least one year before planting (Barker et al., 2009). The benefits of E- tall fescue include ADG improvement from 30 to 100%, normal conception rates, and normal milk production when compared to E+ tall fescue (Hoveland, 1993).

Early in its introduction, E- tall fescue was accepted as the answer to E+ tall fescue’s short comings, but the lack of endophyte led to other problems. The ability for tall fescue to thrive in
harsh environments was greatly impaired and producers were left with reduced forage yields and costly re-establishment practices (Read and Camp, 1986; Waller, 2009).

Non-Toxic Endophyte

Due to the shortcomings of E- tall fescue, the need for an endophyte that did not pose a threat to livestock but could protect the grass from environmental stressors and intensive grazing became more apparent. Selection of endophytes with low to no levels of ergovaline production could improve animal performance (Agee and Hill, 1994).

Jesup MaxQ was released (Bouton et al., 2002) in 2000. Jesup MaxQ was created by researchers from Georgia and New Zealand by combining the adapted tall fescue cultivar Jesup with the non-ergot alkaloid producing endophyte MaxQ. At the University of Arkansas, a combination of HiMag tall fescue (Sleper et al., 2002) and Strain 4 novel endophyte has also shown promise as an answer to the shortcomings of E+ tall fescue (Gunter and Beck, 2004).

Studies done by Gunter and Beck (2004) showed that established stands of tall fescues infected with novel endophytes can allow for rates of gain by stocker cattle that are superior to those attained by cattle grazing E+ tall fescues. Fall and winter research by Beck (2008) reported average daily gains of cattle grazing Kentucky-31 compared MaxQ to were 0.55 kg to 0.78 kg, respectively. Beck (2008) reported that in the spring, average daily gains of cattle on KY-31 was 0.45 kg compared to 0.92 kg for cattle on novel endophyte pastures.

Re-establishing pastures with novel endophyte tall fescue takes an investment of time and capital. When replacing E+ with another cool-season grass the process called spray-smother spray commonly used (Roberts and Andrae, 2004). Initially, old tall fescue is sprayed with a systemic, non-selective herbicide. The field is then quickly no-till drilled into an annual smother
crop that is grazed or cut for hay, and then the field is sprayed again prior to planting the new cool-season grass. Pastures with over a 20 to 35% infection rate of E+ will find it beneficial to replant pastures with another grass or a novel endophyte tall fescue (Roberts and Andrae, 2004).

**Legumes**

The process of interseeding legumes such as alfalfa or clover can dilute E+ tall fescue and improve ADG (Ball, 2007). White clover (*Trifolium repens* L.) is the most common legume seeded with tall fescue, but red clover (*Trifolium pretense* L.) is also used (Campbell, 2008). Steers grazing a high endophyte clover mix had similar feedlot gains as steers grazing a low endophyte and also had higher finishing weights (Lusby et al., 1990).

Management is crucial when establishing and maintaining adequate legume stands. Legumes tend to have trouble persisting in E+ infected tall fescue (Fribourg et al., 1991) because tall fescues tends to grow faster and smother less aggressive plants. Grazing management that favors legumes should be used.

Legumes are naturally have the ability of trapping elemental nitrogen from the atmosphere (Lalitha and Santhaguru, 2010). This process, known as nitrogen fixation, is possible because of an symbiotic relationship legumes have with bacteria in the genus *Rhizobium* (Ball, 2007). The *Rhizobium* infects the roots of legumes and produces the enzyme nitrogenase that in the presence of molybdenum reduces nitrogen gas into ammonia (Ball, 2007). Once the *Rhizobium* are inside the root, nitrogen is accumulated in appendages called nodules (Ball, 2007). Nodules function by importing sugar from the plant shoot via the phloem and exporting nitrogen-rich metabolic products of nitrogen fixation back to the shoot via the xylem (Steward, 1983). The amount of N transferred 'below-ground', predominantly through decomposition of
legume roots and nodules, has been estimated at 3 to 102 kg N/ha per year or 2 to 26% of biologically fixed nitrogen (Ledgard and Steele, 1992). In grazed pasture, N is also transferred 'above-ground' via return in animal excreta and this can be of a similar magnitude to 'below-ground' transfer (Ledgard and Steele, 1992).

Management

Grazing management is a key factor in minimizing the effect of E+ on cattle performance (Paterson et al., 1995). The endophytic fungus is concentrated in the seed head at maturity, therefore by closely grazing seed heads off producers can keep tall fescue in the boot stage, and should reduce the impact of the toxins on the animal (Paterson et al., 1995).

Daily gain from E+ either improved or remained the same as stocking rate increased, compared with increased stocking rate on E- pastures that resulted in decreased average daily gain (Bransby et al., 1988). Grazing and/or clipping that keeps plants young and vegetative will result in better animal performance (Ball et al., 1987).

Stockpiling Tall Fescue

Stockpiling is accomplished by allowing forage to accumulate growth before grazing (Roberts et al., 2009). The practice of stockpiling tall fescue can be beneficial in E+ management. When tall fescue is used in cool weather, the cattle are less subject to heat stress and perform better than when it is used in warm weather (Rayburn, 1993). The longer these stockpiles are left ungrazed; the more reduced the levels of ergovaline will be for cattle (Kallenbach et al., 2003). After tall fescue has been successfully stockpiled, grazing can begin in late fall or winter. Leaves of tall fescue have a waxy cuticle that allows it to resist frost damage.
and weathering (Ball et al., 2008). Stable herbage mass, slow declining nutritive value, and low
toxicity levels of ergovaline in late winter (Kallenbach et al., 2003) are all benefits of tall fescue
stockpiling. Stockpiling allows an economic and efficient option to stored winter forage (Waller
et al., 1988). In studies done by Wedin (1966), it was determined that autumn-grown tall fescue
had higher forage quality than orchard grass (Dactylis glomerata L.), smooth bromegrass
(Bromus inermis Leyss.), or reed canary grass (Phalaris arundinacea L.).

Nitrogen application greatly affects DM and CP. Early application increases yields but
lowers quality as shown by Rayburn and coworkers (1979). Rayburn and coworkers (1979)
reported that with June and August applications of 112 kg N/ha yields were 4580 kg/ha and 3730
kg/ha of dry matter respectively. Meanwhile, CP was 8.2% and 9.8% for June and August
respectively. Gerrish and coworkers (1994) concluded that early-August nitrogen fertilization of
tall fescue produced yields of 3277 kg/ha, a 724 kg/ha increase compared to late-August nitrogen
fertilization, for late season grazing in the Midwest.

The amount of nitrogen that can be applied economically to tall fescue will depend on
many factors, including the procedures used for harvesting the forage, the presence or absence of
legumes, and the current and expected future moisture conditions (Roberts et al., 2009). For
stockpiling operations in the Upper South, nitrogen should be added between mid-August and
mid-September, six to nine weeks before the end of the growing season (Roberts et al., 2009).
Recommendations for stockpiling fescue vary depending on the latitude and elevation of the
farm. The farther north in the fescue belt and the higher the elevation, the earlier the nitrogen
should be applied.

Stockpiling is one of tall fescue’s strongest yet most under-utilized attributes (Teutsch et
al., 2005). The ability to feed cattle on low cost forages offers the potential to decrease winter
feed costs. Stockpiled tall fescue is a high-quality forage that can be grazed during the late fall and early winter to reduce both hay and supplemental feed amounts needed for livestock (Caldwell et al., 2009).

Stockpiled forages are a cost-effective alternative to feeding hay during winter (Jennings et al., 2009) where stockpiled forages can reduce winter feed costs over $20/AU compared to feeding hay and supplement. By grazing stockpiled forage, cows were fed 14.4 kg of dry matter less supplement per cow per day than was fed to cows consuming hay (Schoonmaker et al., 2003).

Winter grazing of stockpiled tall fescue and alfalfa reduced the amount of stored hay required to maintain cows by as much as 1,069 kg of DM when compared to cows fed in a drylot (Hitz and Russell, 1998). Heifers consumed 13.6 kg of hay dry matter per heifer and 0.8 kg of DM corn gluten feed per heifer in dry lots, while heifers grazing stockpiled forage were supplemented with only 0.1 kg of corn gluten feed per heifer (Driskill et al., 2007). With proper management, stockpiling can provide many economic benefits to cattle production.

When grazing stockpiled forages, instituting a form of grazing management such as rotational, strip, or mob grazing, can allow for better utilization of forages. Uncontrolled grazing may waste about 50 to 60% of the forage because of trampling and manure dropping on unused forage (Lemus, 2007).

**Strip Grazing**

Strip grazing is where pastures are subdivided into several blocks or paddocks usually using portable electric fencing (Ball, 2007). Livestock are allocated from paddock to paddock.
based on forage growth and utilization. The number of paddocks and frequency of allocations depends upon many factors, including the class of livestock and production goals of the manager.

Strip grazing in type of intensive or controlled grazing method. These grazing methods allows producers better control over pastures, reduces forage waste, and improves total production of grazing days (Ball, 2007). Some intensive grazing practices such as, rotational grazing, have been shown to increase the amount of beef produced per acre by as much as 61% (Henning et al., 2000) compared to a continuous grazing operation. In intensive grazing systems, manure is more evenly distributed in paddocks and weed control is better, as animals are usually forced to eat everything in a paddock.

A major factor affecting forage quality of an individual plant is the physiological age of plant tissue (Cogswell and Kamstra, 1976). Live tissue was generally higher in CP and organic matter digestibility (OMD) than dead senesced tissue (Heitschmidt et al., 1987). Declines in quality were generally associated with periods of slow or no growth while increases were generally associated with periods of rapid growth (Heitschmidt et al., 1987). Heitschmidt (1987) also stated that intensive grazing systems tend to maintain an active growing state, therefore producing higher quality forage.

In grass-legume mixed pastures that utilize rotational grazing, legumes tend to have an advantage (Henning et al., 2000). Non-selective grazing in mixed stands allows for a more uniform height among grasses and legumes, while grass regrowth tends to be faster than legumes when grazing heights are high (Henning et al., 2000).

One metric ton (Mg) of legume forage harvested as hay removes 22 to 28 kg. of nitrogen, 5.5 to 8.25 kg. of phosphorus pentoxide (P₂O₅), and 22 to 28 kg. of potassium oxide (K₂O) from the soil (Henning et al., 2000). Grazing animals excrete 70 to 90% of the nitrogen, phosphorus,
and potassium they consume from forage in the form of feces and urine (Henning et al., 2000). Intensive grazing allows for a more even distribution of manure (Henning et al., 2000) thus improving soil fertility.
Literature Cited


CHAPTER 3: NITROGEN RATE AND SOURCE EFFECTS ON TALL FESCUE STOCKPILED FOR WINTER GRAZING

Abstract

There has been increased interest in the use of products that reduce the volatilization of urea N. However, the use of these products for stockpiling cool-season grasses for winter grazing has not been studied. This study was designed to evaluate the impact of N rate and source, and the use of products designed to reduce N volatilization, on yield and nutritional quality of stockpiled tall fescue. In 2012 and 2013, trials were conducted on a farm near Crewe, VA. In mid-Sep, seven N sources (ammonium sulfate (AS), ammonium nitrate (AN), urea + Agrotain @ 2 l/Mg (AG2), urea + Agrotain @ 4.2 l/Mg (AG4), urea + Agrotain @ 6.3 l/Mg (AG6), Nutrisphere (NuS), and urea) were applied at 0, 45, 90, and 135 kg N/ha. Forage growth was accumulated until harvest in mid-Jan. Yields increased linearly with N fertilization (P < 0.05) ranging from 1663 to 2820 kg DM/ha in 2012 and 1976 to 3161 kg DM/ha in 2013. Crude protein (CP) increased linearly with N fertilization, from 9.4 to 12.4% (P < 0.05). The fiber in the forage decreased with N fertilization from 35.9 to 32.7% and 59.8 to 55.9% for acid and neutral detergent fiber, respectively (P < 0.05). Ammonium sulfate was found to produce the highest nutritive values of all N sources examined. Although products to protect N from volatilization may work under specific conditions, they only impacted the yield of stockpiled tall fescue in 2012 and they had no effect on nutritive value.
**Introduction**

Tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.) is an abundant cool season perennial grass that covers over 14 million hectares in the United States (Bacon and Siegel, 1988). An estimated 8.5 million beef cows are maintained on tall fescue pastures in this region (Poore et., 2000; Ball, 2007). Tall fescue is advantageous over other forages for stockpiling because it grows in the fall and does not rapidly lose nutrient content after dormancy (Roberts et al., 2009). Fertilization with N is a primary factor impacting both yield and nutritive value of stockpiled tall fescue. Poore and co-workers (2000) observed moderate N inputs (61.6 - 123.2 kg N/ha) can achieve 24.6 - 49.3 kg/ha of forage DM production per kg N. Forage quality tends to be higher as the date of stockpile initiation is delayed until autumn (Gerrish et al., 1994). Environmental conditions can greatly influence tall fescue response to N application.

The use of urease inhibitors has become a potential approach to reducing N loss when urea is applied. Urease inhibitors reduce the probability of volatilization losses of N and delay urea hydrolysis by 1-2 weeks (Blennerhassett et al., 2006). A New Zealand study on established irrigated dairy pastures, Agrotain treated urea produced 327 kg/ha more pasture dry matter than standard urea (Martin et al., 2008). With N fertilization sources becoming more costly, and the reduced availability of ammonium nitrate, the use of a urease inhibitor could provide beneficial results to producers.

**Materials and Methods**

The experimental design was a randomized complete block with a 2 factor (N rate and N source) treatment arrangement and four replications. Plot size was 3 x 6.1 m. Nitrogen treatments
include four rates of N (0, 45, 90, and 135 kg/ha) supplied as seven nitrogen sources (ammonium sulfate (AS), ammonium nitrate (AN), urea + Agrotain @ 2 l/Mg (AG2), urea + Agrotain @ 4.2 l/Mg (AG4), urea + Agrotain @ 6.3 l/Mg (AG6), Nutrisphere (NuS), and urea). Plots were fertilized with N in mid-September and allowed to accumulate herbage until mid to late January.

Plots were harvested on 23 Jan 2012 and 9 Jan 2013 by clipping a 1.5 m strip through the center of each plot at a height of 7 to 10 cm using a self-propelled forage harvester (Wintersteiger, Inc., Salt Lake City, UT). A 250 g subsample was collected from each plot for dry matter and nutritive value determinations. Forage samples were weighed immediately and then dried for three days at 60°C. Samples were then weighed a second time to determine dry matter content. All forage samples were ground through Wiley (Thomas Scientific, Swedesboro, NJ) and Cyclone (Udy Corporation, Fort Collins, CO) sample mills utilizing 2 and 1mm screens, respectively. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP) were estimated using near infrared spectroscopy (Foss North America, Eden Prairie, MN). Total digestible nutrients (TDN) were calculated using the following equation: TDN = 100.32 – 1.118 x ADF.

Data were analyzed using general linear model procedure from SAS (SAS Institute, Cary, NC). Main effects and interactions included in the model were replication, N rate, N source, and N source x N rate. The linear regression was performed using SigmaPlot 11.0 (Systat, San Jose, Ca) to examine the impact of N rate for both yield and nutritive value.

Results and Discussion

Rainfall and Temperature Data
The rainfall was below the 30 year-average for most of the growing season in both years of the study (Table 1). In 2012, the rainfall was greater than 0.25 cm within 5 days of application, which is adequate for N source incorporation (Havlin et al., 2005). In 2013, there was no rainfall within five days of N application. Killing frosts (-2.2°C) occurred on 25 Nov and 13 November of 2012 and 2013, respectively.

**Nitrogen Rate and Source Effects on Dry Matter Yield**

A year x treatment interaction was observed (P < 0.05) for DM yields, therefore results will be presented by year. There was no N rate x N source interaction in either year, therefore the main effects of N rate and N source will be presented. In both years, N rate significantly influenced yields (P < 0.05). The yield of stockpiled tall fescue increased linearly with N rate for both years (Fig 1). This increase in yield from nitrogen is to be expected and agrees with what others have published (Teutsch et al., 2005). Yields linear response to N rate produced equations with relatively low \( r \)-squared values for 2012 and 2013, 0.11 and 0.09, respectively. These low \( r \)-squares suggest that other factors are also impacting yields.

Nitrogen rate showed lower response to DM yields in year one and two compared to other studies such as Poore and co-workers (2000). A response of 8.57 kg DM for kg N added was observed in year one and only 3.38 kg DM for kg N added was recorded in year two. In contrast, Poore and co-workers (2000) found a much higher response to N fertilization. These low responses to N rate call into question the economics of additional N fertilizing.

In year one, only urea treated with Nutrisphere and Agrotain produced yields greater than urea alone (P <0.05) (Fig 2). In fact, NuS and AG4 produced 890 and 800 kg/ha more DM than urea alone, respectively. The additional cost of using NuS and AG4 was $10.49 and $11.24/ha,
respectively. When hay is at a value of $132/Mg, the use of NuS and AG4 adds an additional $117 and $105 of forage per ha, respectively. The additional cost associated with N volatilization inhibitors proved to be economic when stockpiling tall fescue in the fall in 2012.

There was no difference in forage yield based on the source of the nitrogen applied for year two (P > 0.05) (Fig 3). The prolonged lack of rainfall after N application may have caused N volatilization (Havlin et al., 2005), resulting in a loss of available N to forage in year two. In contrast to 2012, the additional cost associated with N volatilization inhibitors was not economical. These data indicate that use of N volatilization inhibitors could be economical in some years.

_Nitrogen Rate and Source Effects on the Nutritive Value_

A year x treatment interaction was observed (P < 0.05) for nutritive value; therefore results will be presented by year. There was no N rate x N source interaction in either year, therefore the main effects of N rate and N source will be presented.

Nitrogen rate was shown to have an impact on nutritive value. Both ADF and NDF decreased linearly as the N rate increased (Fig 4) (Fig 6). This is consistent with other research which has reported a positive correlation between nitrogen fertilization and nutrient content in forage tissue (Gerrish et al., 1994). The r-squared values for ADF and NDF response were 0.16 and 0.12, respectively. These low r-squares suggest that other factors are also impacting yields.

Crude protein increased linearly with N rate. Crude protein applied at a rate of 135 kg N/ha was 23% higher than the control (Fig 8). Only when fertilizing tall fescue with 135 kg/ha of N did we observe CP values above 12%. Cru/de protein above 12% is necessary for steers
weighing 204 kg to potentially gain 0.68 kg/day. At 90 kg/ha of N, lactating beef cows could be maintained on stockpiled tall fescue alone. The CP requirements of dry beef cows could be met on unfertilized stockpiled tall fescue.

Total digestible nutrients increased with nitrogen rate which would be expected. All N rates produced TDN levels above 60%, therefore both lactating and dry beef cows could be maintained on stockpiled tall fescue at any N rate (Fig 10). No N rate tested was found to produce a TDN level of 65%. Without a higher TDN, one would expect to have ADG below 0.68 kg for steers weighing 204 kg.

Nitrogen source was found to have varied effects on forage nutritive value. For ADF, AG2, AG4, NS, AG6, AN, and urea all had similar (P < 0.05) values. Ammonium sulfate showed the lowest ADF, which was similar to AG6 and AN (Fig 5). Ammonium sulfate was found to produce the lowest NDF of any of the N source treatments (Fig 7) Urea, NS, AN, and AG6 all had similar NDF values to AS, while AG2 and AG4 were found to have significantly different (P > 0.05) values.

Similar to as what was found for ADF and NDF, ammonium sulfate produced the highest CP values in stockpiled tall fescue. Ammonium sulfate had similar CP values to AN and AG6. Ammonium nitrate and AG6 had similar (P < 0.05) CP values as AG2, AG4, NS, and urea (Fig 9). Only AS was found to produce adequate CP values to potentially have an ADG of 0.68 kg/for steers weighing 204 kg. All N sources produced forage that was adequate in nutritive value to maintain beef cows, both at lactation and dry. Only dry beef cows had low enough CP requirements to be maintained on only unfertilized tall fescue.
None of the N sources used produce adequate TDN levels capable of producing an ADG of 0.68 kg for steer calves weighing 204 kg (Fig 11). Beef cows, both at lactation and dry, could be maintained on stockpiled tall fescue at the TDN values documented in this study.

**Economics**

Breakeven analyses of stockpiled tall fescue compared to hay based on total digestible nutrients at three different N prices are displayed in Tables 3 and 4. Values in Table 3 and 4 are presented by year and are based on the assumption: 1) hay has a TDN value of 55%; 2) livestock producer has established pastures ready to be stockpiled; and 3) N application costs are $20/ha. Tables show the breakeven sensitivity to changes in N price and yield.

The conditions of the study showed that in 2012 N should be applied at a rate of 45 kg/ha if hay costs more than $224/ Mg TDN (Table 2). At a rate of 90 kg N/ha hay becomes a better feed option if it cost below $150/ Mg TDN. Response for N applied at 135 kg N/ha resulted in stockpiling tall fescue to breakeven with hay at $222/Mg TDN. In 2012, TDN yield response to additional N showed that applying additional N was beneficial since hay prices general are above the additional costs associated with stockpiling tall fescue. Nitrogen fertilization in 2012 produced TDN yields high enough to be economic even if a fluctuation in N price or yield occurred. The addition of 90 kg N/ha proved to be economic even if TDN yields decreased by 15% and if N prices increased by 25%

In 2013, yield response to additional was much lower than 2012. The addition cost associated with adding 45 kg N/ha was only economic if hay cost more than $1,475/Mg (Table 3). At rates of 90 and 135 kg N/Mg, the use additional N when stockpiling tall fescue also
proved to be uneconomic with breakevens of $799 and $568/Mg, respectively. Lower TDN yield response in 2013 made the application of additional N uneconomic. It would be more cost effective to stockpile tall fescue without the use of additional N and then purchase hay to meet any additional nutrient requirements. A producer grazing animals on well managed pastures with adequate legume stands along with an organic N source, may have higher yields than observed in this study with stockpiled tall fescue without additional N. This would make it necessary to further evaluate said operation to make more profitable choices when applying N. The difference in TDN yields between 2012 and 2013 also suggest in years with little rainfall, such as 2013, the addition of N to stockpiled pastures will only produce miniscule yield (Table 3). Even with lower N prices and the use of additional N does not produce economic TDN yields.

**Conclusion**

Yields increased linearly with N fertilization (P < 0.05) in both years. The reduced yields and N response in 2013 were likely due to lower rainfall during the stockpiling period. Crude protein (CP) increased linearly with N fertilization (P < 0.05). The fiber in the forage decreased with N fertilization for acid and neutral detergent fiber (P < 0.05). Ammonium sulfate was found to produce the highest nutritive values of all N sources examined. Products designed to reduce N from volatilization work under specific conditions. Nitrogen volatilization inhibitors were shown to influence only yield of stockpiled tall fescue in 2012, but did not impact the yield or nutritive value of stockpiled tall fescue in 2013.

As expected applying additional N in years without adequate precipitation in the stockpiling phase was not economical. At N rates of 135 kg of N/ha hay prices would need to be above $568/Mg, in a year without adequate precipitation, in order to make the additional N
feasible. Finding less expensive N sources is needed to make additional N fertilization practical. The practice of stockpiling tall fescue without the addition of N and then purchasing hay seems to be a more profitable approach to having adequate winter feed sources in some years.
**Literature Cited**


### Table 1. Rainfall for years of study and deviation from 63 year average\(^1\)

<table>
<thead>
<tr>
<th>Month</th>
<th>2012</th>
<th>DEV(^2)</th>
<th>2013</th>
<th>DEV(^2)</th>
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<tr>
<td>JAN</td>
<td>5.28</td>
<td>-3.12</td>
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<td>-4.80</td>
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<td>DEC</td>
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<td>97.94</td>
<td>-13.79</td>
<td>152.17</td>
<td>40.03</td>
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</table>

\(^1\)Rainfall was calculated in (cm)
\(^2\)Deviation from 63 year average (cm)
### Table 2. Break-even analysis of stockpiled tall fescue compared to hay based on total digestible nutrients (2012)\(^1,2,3,4\)

<table>
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<tr>
<th>Percent Change in Price of Nitrogen(^5)</th>
<th>25%</th>
<th>15%</th>
<th>10%</th>
<th>5%</th>
<th>0%</th>
<th>-5%</th>
<th>-10%</th>
<th>-15%</th>
<th>-25%</th>
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<td>$211</td>
<td>$203</td>
<td>$196</td>
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<td>$211</td>
<td>$202</td>
<td>$192</td>
<td>$183</td>
<td>$164</td>
</tr>
<tr>
<td>0%</td>
<td>$271</td>
<td>$251</td>
<td>$241</td>
<td>$232</td>
<td>$222</td>
<td>$212</td>
<td>$202</td>
<td>$192</td>
<td>$172</td>
</tr>
<tr>
<td>-5%</td>
<td>$285</td>
<td>$265</td>
<td>$254</td>
<td>$244</td>
<td>$233</td>
<td>$223</td>
<td>$213</td>
<td>$202</td>
<td>$181</td>
</tr>
<tr>
<td>-10%</td>
<td>$301</td>
<td>$279</td>
<td>$268</td>
<td>$257</td>
<td>$246</td>
<td>$235</td>
<td>$224</td>
<td>$213</td>
<td>$191</td>
</tr>
<tr>
<td>-15%</td>
<td>$319</td>
<td>$296</td>
<td>$284</td>
<td>$272</td>
<td>$261</td>
<td>$249</td>
<td>$238</td>
<td>$226</td>
<td>$203</td>
</tr>
</tbody>
</table>

\(^1\)Total digestible nutrients (TDN) calculated as 100.32 – 1.118 x ADF; where ADF = acid detergent fiber

\(^2\)Hay has a TDN value of 55%

\(^3\)Nitrogen application costs are $19.76/ha

\(^4\)Expressed on a TDN basis

\(^5\)Nitrogen price expressed as $/kg N

\(^6\)Yield expressed as Mg/ha
Table 3. Breakeven analysis of stockpiled tall fescue compared to hay based on total digestible nutrients (2013)\(^1,2,3,4\)

<table>
<thead>
<tr>
<th>(\text{Percent Change in Price of Nitrogen}^5)</th>
<th>25%</th>
<th>15%</th>
<th>10%</th>
<th>5%</th>
<th>0%</th>
<th>-5%</th>
<th>-10%</th>
<th>-15%</th>
<th>-25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 kg N/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td>$1,518</td>
<td>$1,424</td>
<td>$1,377</td>
<td>$1,330</td>
<td>$1,283</td>
<td>$1,236</td>
<td>$1,189</td>
<td>$1,142</td>
<td>$1,048</td>
</tr>
<tr>
<td>10%</td>
<td>$1,587</td>
<td>$1,488</td>
<td>$1,439</td>
<td>$1,390</td>
<td>$1,341</td>
<td>$1,292</td>
<td>$1,243</td>
<td>$1,194</td>
<td>$1,096</td>
</tr>
<tr>
<td>5%</td>
<td>$1,662</td>
<td>$1,559</td>
<td>$1,508</td>
<td>$1,456</td>
<td>$1,405</td>
<td>$1,354</td>
<td>$1,302</td>
<td>$1,251</td>
<td>$1,148</td>
</tr>
<tr>
<td>0%</td>
<td>$1,745</td>
<td>$1,637</td>
<td>$1,583</td>
<td>$1,529</td>
<td>$1,475</td>
<td>$1,421</td>
<td>$1,367</td>
<td>$1,313</td>
<td>$1,205</td>
</tr>
<tr>
<td>-5%</td>
<td>$1,837</td>
<td>$1,723</td>
<td>$1,667</td>
<td>$1,610</td>
<td>$1,553</td>
<td>$1,496</td>
<td>$1,439</td>
<td>$1,382</td>
<td>$1,269</td>
</tr>
<tr>
<td>-10%</td>
<td>$1,939</td>
<td>$1,819</td>
<td>$1,759</td>
<td>$1,699</td>
<td>$1,639</td>
<td>$1,579</td>
<td>$1,519</td>
<td>$1,459</td>
<td>$1,339</td>
</tr>
<tr>
<td>-15%</td>
<td>$2,053</td>
<td>$1,926</td>
<td>$1,863</td>
<td>$1,799</td>
<td>$1,736</td>
<td>$1,672</td>
<td>$1,608</td>
<td>$1,545</td>
<td>$1,418</td>
</tr>
<tr>
<td>90 kg N/ha</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>15%</td>
<td>$841</td>
<td>$782</td>
<td>$753</td>
<td>$724</td>
<td>$694</td>
<td>$665</td>
<td>$636</td>
<td>$606</td>
<td>$548</td>
</tr>
<tr>
<td>10%</td>
<td>$879</td>
<td>$818</td>
<td>$787</td>
<td>$757</td>
<td>$726</td>
<td>$695</td>
<td>$665</td>
<td>$634</td>
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<tr>
<td>5%</td>
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<td>$825</td>
<td>$793</td>
<td>$760</td>
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<td>$696</td>
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<td>$600</td>
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<tr>
<td>0%</td>
<td>$967</td>
<td>$900</td>
<td>$866</td>
<td>$832</td>
<td>$799</td>
<td>$765</td>
<td>$731</td>
<td>$697</td>
<td>$630</td>
</tr>
<tr>
<td>-5%</td>
<td>$1,018</td>
<td>$947</td>
<td>$912</td>
<td>$876</td>
<td>$841</td>
<td>$805</td>
<td>$769</td>
<td>$734</td>
<td>$663</td>
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<tr>
<td>-10%</td>
<td>$1,075</td>
<td>$1,000</td>
<td>$962</td>
<td>$925</td>
<td>$887</td>
<td>$850</td>
<td>$812</td>
<td>$775</td>
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<tr>
<td>-15%</td>
<td>$1,138</td>
<td>$1,059</td>
<td>$1,019</td>
<td>$979</td>
<td>$939</td>
<td>$900</td>
<td>$860</td>
<td>$820</td>
<td>$741</td>
</tr>
<tr>
<td>135 kg N/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td>$604</td>
<td>$560</td>
<td>$538</td>
<td>$516</td>
<td>$494</td>
<td>$472</td>
<td>$450</td>
<td>$428</td>
<td>$384</td>
</tr>
<tr>
<td>10%</td>
<td>$631</td>
<td>$585</td>
<td>$562</td>
<td>$539</td>
<td>$516</td>
<td>$493</td>
<td>$470</td>
<td>$447</td>
<td>$401</td>
</tr>
<tr>
<td>5%</td>
<td>$661</td>
<td>$613</td>
<td>$589</td>
<td>$565</td>
<td>$541</td>
<td>$517</td>
<td>$493</td>
<td>$469</td>
<td>$420</td>
</tr>
<tr>
<td>0%</td>
<td>$695</td>
<td>$644</td>
<td>$619</td>
<td>$593</td>
<td>$568</td>
<td>$543</td>
<td>$517</td>
<td>$492</td>
<td>$441</td>
</tr>
<tr>
<td>-5%</td>
<td>$731</td>
<td>$678</td>
<td>$651</td>
<td>$625</td>
<td>$598</td>
<td>$571</td>
<td>$545</td>
<td>$518</td>
<td>$465</td>
</tr>
<tr>
<td>-10%</td>
<td>$772</td>
<td>$715</td>
<td>$687</td>
<td>$659</td>
<td>$631</td>
<td>$603</td>
<td>$575</td>
<td>$547</td>
<td>$490</td>
</tr>
<tr>
<td>-15%</td>
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<td>$728</td>
<td>$698</td>
<td>$668</td>
<td>$638</td>
<td>$609</td>
<td>$579</td>
<td>$519</td>
</tr>
</tbody>
</table>

\(^1\)Total digestible nutrients (TDN) calculated as \(100.32 - 1.118 \times \text{ADF}\); where ADF = acid detergent fiber

\(^2\)Hay has a TDN value of 55%

\(^3\)Nitrogen application costs are $19.76/ha

\(^4\)Expressed on a TDN basis

\(^5\)Nitrogen price expressed as $/kg N

\(^6\)Yield expressed as Mg/ha
Figure 1. Yield of stockpiled tall fescue as impacted by nitrogen rate in 2012 and 2013\(^1,2\)

\(^1\) 0 = 0 kg/ha of nitrogen added; 45 = 45 kg/ha of nitrogen added; 90 = 90 kg/ha of nitrogen added; 135 = 135 kg/ha of nitrogen added

\(^2\) Expressed on a dry matter basis
Figure 2. Yield of stockpiled tall fescue as impacted by nitrogen source in 2012\(^{1,2,3,4,5}\)

\(^1\)AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere

\(^2\)Standard error = 475.48

\(^3\)Bars where letters differ are significantly different (P < 0.05)

\(^4\)Expressed on a dry matter basis
Figure 3. Yield of stockpiled tall fescue as impacted by nitrogen source in 2013\textsuperscript{1,2,3,4,5}

\textsuperscript{1}AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere
\textsuperscript{2}Standard error = 270.13
\textsuperscript{3}Bars where letters differ are significantly different (P < 0.05)
\textsuperscript{4}Expressed on a dry matter basis
Figure 4. Acid detergent fiber of stockpiled tall fescue as impacted by nitrogen rate\textsuperscript{1,2}
\textsuperscript{1}0 = 0 kg/ha of nitrogen added; 45 = 45 kg/ha of nitrogen added; 90 = 90 kg/ha of nitrogen added; 135 = 135 kg/ha of nitrogen added
\textsuperscript{2}Expressed on a dry matter basis

\begin{equation}
y = 35.51 - 0.022x
\end{equation}

$r^2 = 0.16$  \( P < 0.0001 \)
Figure 5. Acid detergent fiber of stockpiled tall fescue as impacted by nitrogen source$^{1,2,3,4}$

$^1$AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere

$^2$Standard error = 0.61

$^3$Bars where letters differ are significantly different (P < 0.05)

$^3$Expressed on a dry matter basis
Figure 6. Neutral detergent fiber of stockpiled tall fescue as impacted by nitrogen rate\textsuperscript{1,2}

\textsuperscript{1}0 = 0 kg/ha of nitrogen added; 45 = 45 kg/ha of nitrogen added; 90 = 90 kg/ha of nitrogen added; 135 = 135 kg/ha of nitrogen added

\textsuperscript{2}Expressed on a dry matter basis
Figure 7. Neutral detergent fiber of stockpiled tall fescue as impacted by nitrogen source\textsuperscript{1,2,3,4}

\textsuperscript{1}AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere

\textsuperscript{2}Standard error = 0.83

\textsuperscript{3}Bars where letters differ are significantly different (P < 0.05)

\textsuperscript{4}Expressed on a dry matter basis
Figure 8. Crude protein of stockpiled tall fescue as impacted by nitrogen rate\(^1,2\)
\(^1\)0 = 0 kg/ha of nitrogen added; 45 = 45 kg/ha of nitrogen added; 90 = 90 kg/ha of nitrogen added; 135 = 135 kg/ha of nitrogen added
\(^2\)Crude protein determined by % nitrogen of stockpiled tall fescue times 6.25 expressed on a dry matter basis
**Figure 9.** Crude protein of stockpiled tall fescue as impacted by nitrogen source\(^1\,\,2\,\,3\,\,4\)

\(^1\)AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere

\(^2\)Standard error = 0.45

\(^3\)Bars where letters differ are significantly different (P < 0.05)

\(^4\)Crude protein determined by % nitrogen of stockpiled tall fescue times 6.25 expressed on a dry matter basis
Figure 10. Total digestible nutrients of stockpiled tall fescue as impacted by nitrogen rate\textsuperscript{1,2,3}
\textsuperscript{1}0 = 0 kg/ha of nitrogen added; 45 = 45 kg/ha of nitrogen added; 90 = 90 kg/ha of nitrogen added; 135 = 135 kg/ha of nitrogen added
\textsuperscript{2}Total digestible nutrients calculated as 100.32 $- 1.118 \times$ ADF; where ADF = acid detergent fiber
\textsuperscript{3}Expressed on a dry matter basis
Figure 11. Total digestible nutrient of stockpiled tall fescue as impacted by nitrogen source.  

AG2 = urea + Agrotain @ 2.1 l/Mg; AG4 = urea + Agrotain @ 4.2 l/Mg; AG6 = urea + Agrotain @ 6.3 l/Mg; AN = ammonium nitrate; AS = ammonium sulfate; NuS = Nutrisphere  

Standard error = 0.68  
Bars where letters differ are significantly different (P < 0.05)  
Total digestible nutrients calculated as 100.32 – 1.118 x ADF; where ADF = acid detergent fiber  
Expressed on a dry matter basis
Abstract

The Southeastern United States offers a unique environment that is beneficial to stocker cattle production. Abundant forage in the form of tall fescue offers a feed source that has not been utilized to its fullest potential. The objective of this study was to determine how grazing methods impact animal performance, forage quality, and forage utilization. Trials were conducted near Blackstone, VA in 2013 and 2014. Three treatments (continuous grazing, moved once per week, and moved twice per week) were used on established tall fescue pastures. Pastures were fertilized with 67.19 kg N/ha in late August and allowed to accumulate growth until December. In early December cattle were randomly selected for each treatment and remained on pastures until late February in year one and early February in year two. In year one, cattle that were moved once and twice per week showed significantly higher (P < 0.05) ADG than the continuous treatment. In year two, cattle in the treatment with full access to pasture had the highest ADG (0.59 kg/d) and cattle in allocated once per week and twice per week had significantly lower (P < 0.05) gains of 0.30 kg/d and 0.36 kg/d, respectively. Forage quality (ADF, NDF, CP, and TDN) benefited from moving cattle once or twice a week; whereas pastures where animals were allowed full access to forage showed a more rapid deterioration of nutrient content. Cattle moved once and twice per week showed greater forage utilization (P < 0.05) than cattle with full access to pasture.
Introduction

With large areas of land ideal for grazing, domestic cattle producers in the Southeastern United States have an opportunity to increase profits. High feed costs have opened the doors for cattle producers of this region to utilize pasture grazing to increase weights of stocker cattle at a fraction of the cost before being sold as feedlot cattle. The ability to utilize low cost, abundant forages to add pounds and profit to cattle is essential to beef production in the Southeastern United States.

Currently, cattle production in the Southeastern United States consists mainly of cow/calf operations (Hoveland, 1986) where upon reaching a certain weight calves are sent to feedlots. In feedlots, calves are fed high grain diets in order to rapidly increase weight gains before market. Most of these feedlots are located in the Midwest, where grain is more abundant and cost efficient to feed. Cattle producers in the Southeast cannot utilize grains as efficiently as Midwestern producers due to poorer quality land and lower crop yields. Southeastern producers do, however, have large amounts of pastureland that could easily be used to increase stocker operations (McKinnon and Snodgrass, 2000).

Hoveland (1986) stated the greatest opportunity for improving profitability in beef production in the Southeastern United States lies in stockering weaned calves. In stocker operations, cattle are fed from the weaning stage until the onset of the finishing stage. Stocker calves in the Southeastern United States are generally fed forages or allowed to graze on stockpiled forage. This provides a cost efficient way for Southeastern producers to add pounds to calves before selling them as finishers.
Intensive grazing offers many benefits over other forms of land management. Intensive grazing involves the grazing of a group of animals on a small paddock of pasture. After a certain amount of time or after a certain amount of forage on the paddock is consumed, the animals are moved to another small paddock. Intensive grazing allows for greater utilization of pasture forages and an increase in grazing days (Ball et al., 2007). Intensive grazing allows for stocker cattle to have access to inexpensive, high quality, and abundant forage at all times.

Pastures of the Southeastern United States are abundant with tall fescues (Paterson et al., 1995), a perennial cool season grass that offers a variety of benefits and challenges. Tall fescue grass is easily established and offers a long growing season. It also is tolerant to drought, pests, and herbivory loss (Ball et al., 2007). These benefits, along with its low maintenance and ability to thrive in less than ideal conditions, make tall fescue useful as forage for farmers of the Southeast.

The majority of tall fescue in the Southeast is infected with an endophytic fungus (*Neotyphodium coenophialum*). This endophyte, when consumed by cattle, causes a host of problems including poor weight gain, impaired reproductive performance, depressed milk production, retention of rough (winter) hair coats into the summer months, low serum prolactin, restricted blood flow to peripheral tissues and heat intolerance (Schmidt and Osborn, 1993; Thompson and Stuedemann, 1993). Collectively, these signs are known as “tall fescue toxicity”.

The objective of this study was to determine how grazing methods impact animal performance, forage quality, and utilization of tall fescue stockpiled for winter grazing.
Materials and Methods

Nine 2 ha pastures located at the Virginia Tech Southern Piedmont Agricultural Research and Extension Center near Blackstone, VA (37.1 N, 78.0 W) were used in this study. The experiment design was a random complete block with three replications for each treatment. The study was repeated. Treatments included: 1) cattle moved once per week; 2) cattle moved twice per week; and 3) cattle allowed to continuously graze. All pastures consisted of Jesup MaxQ tall fescue, which is a tall fescue containing a novel endophyte that does not produce alkaloids that induce tall fescue toxicosis. In late August of each year, all pastures were clipped and fertilized with 67 kg of nitrogen per ha and allowed to stockpile until December.

Animals

In year one, 63 calves were divided into equal groups. Seven calves were placed in each of the nine pastures. The beginning average weights of calves were 208 kg for year 1. Calves were weighed every 2 weeks. In year two, 44 calves were used in the study. Five calves were placed in each of the nine pastures except for one group containing four. The beginning average weights of calves were 281 kg for year two. Weights were taken on two consecutive days at the start and end of grazing and averaged to determine starting and ending weight. Average daily gain (ADG) was calculated for each animal.

Grazing Methodologies

Three grazing methods were used in this study. Method 1) cattle were allocated fresh pasture once per week based on DM availability in said pasture. Method 2) cattle were allocated fresh pasture twice per week based on DM availability in said pasture. Method 3) cattle were
given access to the entire pasture area. In pastures where cattle were allocated once per week, the target utilization rate was 60% of the available forage. In pastures where cattle were allocated twice per week, the target utilization rate was 70% of the available forage. Methods 2 and 3 would be considered strip grazing.

**Sward Height**

Sward height was used to estimate forage availability in each pasture. To determine sward height a falling plate meter (Filips Folding Pasture Meter, Jenquip, New Zealand) was used. In order to get an accurate correlation between sward heights and forage availability random falling plate meter readings were taken throughout the pastures. The forage underneath each plate reading was cut as close to ground level as possible with battery-powered lawn edgers (Cordless Grass Shears, Power Glide, Coppell, TX), dried for three days and weighed to determine dry matter as described by Rayburn and Lozier (2003). Regression equations were calculated from the measured sward height and dry matter yield using SigmaPlot 11.0 (Systat, San Jose, Ca). These regression equations were then used to determine forage availability and forage utilization. Random falling plate meter readings were taken from each pasture before and after grazing.

**Forage Collection**

Forage samples were taken every two weeks during the trial. Samples were collected for each pasture from pre and post grazing by grab sampling forage from 30 random locations in the paddock. The samples were dried in a forced air oven (Grieve Corporation, Round Lake, IL) at 60°C for 48 hours. Samples were sequentially ground to pass through a 2 and 1 mm screen using
a using Wiley (Thomas Scientific, Swedesboro, NJ) and Udy sample mills (Udy Corporation, Fort Collins, CO), respectively. Samples were analyzed for dry matter (DM), acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP) via near-infrared spectroscopy (Roberts et al., 2004) (Model 5000, Foss NIRS Systems, Silver Spring, MD).

Near Infrared Spectroscopy (NIRS)

The NIRS was continually calibrated to ensure accurate up to date readings. This was accomplished by running routine diagnostics in order to determine that diagnostic test results were still applicable. After all tests were completed and passed, samples were packed in 5.08 x 6.35 cm glass slides. Samples were then scanned and WinISI II Version 1.5 Software (Infrasoft International LLC, Port Matilda, PA) was used to select samples for the development of a calibration equation. Once developed this equation was used to predict the remaining samples.

Dry Matter

Dry matter for calibration of the NIRS was determined by weighing samples on a Mettler Toledo AB204-S analytical balance (Mettler-Toledo, Inc., Columbus, OH). Weights were recorded and then samples were placed in a forced air oven (Grieve Corporation, Round Lake, IL) at 100°C for 48 hours. Once dried samples were weighed again and recorded. Dry matter was determined by the formula: \( DM\% = \frac{\text{dry sample weight (g)}}{\text{wet sample weight (g)}} \times 100 \)

Crude Protein

Nitrogen content of samples were determined on a Vario Max CNS Macro elemental analyzer (Elementar, Mt Laurel, NJ). Samples were weighed to 0.25 g on a Mettler-Toledo
AB204-S analytical balance (Mettler-Toledo, Inc., Columbus, OH). Samples were then combusted at 900°C in an environment of 99.995% oxygen. Nitrogen was released and measured upon combustion. Percent crude protein was estimated with the following formula: \( CP = \% N \times 6.25 \)

**Neutral Detergent Fiber**

Samples for NDF determination were weighed, in duplicate, on a Mettler Toledo AB204-S analytical balance (Mettler-Toledo, Inc., Columbus, OH) to 0.5 g (±0.05 g) of air-dried sample. The samples were then placed into Ankom F57 filter bags (Ankom Technology, Macedon, NY) and sealed closed within 0.5cm from the open edge with an Ankom 1915/1920 (Ankom Technology, Macedon, NY) heat sealer. Samples were spread uniformly inside the filter bag in order to eliminate clumps. The samples were then placed in the Ankom 200/220 Fiber Analyzer (Ankom Technology, Macedon, NY) along with 2000 mL NDF solution (Ankom Technology, Macedon, NY) and heated at 100°C for 75 minutes. After heating, samples were rinsed with 2000 ml of hot (90-100°C) water and 4.0 ml of alpha-amylase with agitation for 3-5 minutes. The rinse was repeated two more times. The filter bags were then removed and excess water was pressed out before being placed in beakers and soaked in acetone. Acetone was used in order to help with drying. Bags were soaked for 3 minutes then removed from the beaker. Excess acetone was lightly pressed out. The bags were then spread out to let the acetone evaporate, and were placed in an oven at 105°C for 2 hours. After drying the bags were placed in MoistureStop weigh pouches (Ankom Technology, Macedon, NY) and flattened to remove air. Once bags returned to ambient temperature they were weighed.

**Acid Detergent Fiber**
Similar to NDF, samples for ADF determination were weighed, in duplicate, on a Mettler Toledo AB204-S analytical balance (Mettler-Toledo, Inc., Columbus, OH) to 0.5 g (±0.05 g) of air-dried sample. The samples were then placed into Ankom F57 filter bags (Ankom Technology, Macedon, NY) and sealed closed within 0.5cm from the open edge with an Ankom 1915/1920 (Ankom Technology, Macedon, NY) heat sealer. Samples were spread uniformly inside the filter bag in order to eliminate clumps. Then the samples were placed in Ankom 200/220 Fiber Analyzer vessel (Ankom Technology, Macedon, NY) along with 2000 ml of ambient temperature Acid Detergent solution (Ankom Technology, Macedon, NY). The samples were then heated to 100°C for 60 minutes, followed by rinsing with 2000 ml of 100°C H₂O for 5 minutes with agitation. Samples were rinsed in this manner two more times. The filter bags were then removed and excess water was pressed out before being placed in beakers and soaked in acetone. Samples were then handled as previously described for NDF.

*Experimental Design and Statistical Analysis*

The experiment was conducted twice (2013 and 2014). The experiment design was a randomized complete block design. The first year 63 crossbred calves were randomly assigned to 9 pastures. In the second year 44 crossbred calves were randomly assigned to 9 paddocks. The first year there were 7 calves per pasture. In the following year there were 5 calves per paddock with the exception of one paddock. Data were analyzed using PROC GLM (SAS Institute, Cary, NC).

*Results and Discussion*

*Forage Quantity*
Tall fescue was successfully stockpiled for each year of the study. In both years, the rainfall was greater than 0.25 cm within 5 days of application of N, which is adequate for N source incorporation (Havlin et al., 2005). Killing frosts occurred on November 13th and November 8th of 2013 and 2014 respectively. Rainfall in 2014 was greater than for 2013 (Table 4). We believe this increase in precipitation was the cause for increased stockpiling yields in year two; though both years had greater precipitation during stockpiling than the 63 year average. Forage quantity for years one and two were 4826 kg/ha and 5270 kg/ha respectively (Fig 12). Although year two showed higher yields than year one, there was no significant difference (P > 0.05) in forage quantity between years one and two.

Forage Quality

A year x treatment interaction was observed for nutritive value (P < 0.05). Therefore, results will be presented by year for ADF, NDF, CP, and TDN.

Acid Detergent Fiber

In year one, ADF showed a treatment x harvest date interaction (P < 0.01). ADF increased for all treatments as the study progressed into the spring. Pastures that were allowed to be continuously grazed proved to have the highest ADF values compared to the other treatments (Fig 13). This was as expected since cattle will consume forage with the highest nutritive values first when given the option, while cattle in intensive grazing situations must utilize all available forage at any given time. In year one, ADF formed a quadratic regression line showing how at some point tall fescue began to stop decrease in quality at a lower rate.
In year two, ADF showed a treatment by harvest date interaction ($P < 0.01$) just as in year one. Similar to year one, continuously grazed pastures had the highest ADF values of any of the treatments by the end of the study (Fig 14). Unlike in year one, ADF before day 36 was similar and even lower than that of the other treatments. Year two showed a more linear relationship to ADF than year one. This may be because year two had to be ended sooner than year one.

*Neutral Detergent Fiber*

A treatment by harvest date interaction ($P < 0.01$) was observed in year one for NDF. Neutral detergent fiber for the continuously grazed pastures compared to strip grazed areas continually increased as the study proceeded (Fig 15). As with ADF this was expected. Neutral detergent fiber followed the same trend as ADF, increasing as the study progressed into spring.

In year two, there was no harvest date x treatment interactions ($P > 0.05$). Therefore the main effects of harvest date and forage nutrient content are presented. As predicted, NDF values increased as the harvest date progressed (Fig 16). The NDF value increased by more than 18% by the end of the study, this increase in fiber that is not easily digested was anticipated and likely limited intake. Pastures where cattle were allocated twice per week had lower NDF values than pastures where cattle had full access ($P < 0.05$) (Fig 17). Though this followed the same pattern as the previous year the differences in magnitude were less.

*Crude Protein*

For year one, no harvest date x treatment interaction ($P > 0.05$) was observed. Both treatment and harvest date influenced CP in year one. Therefore main effects will be presented for treatment and harvest date. As the study progressed CP decreased significantly ($P < 0.01$)
The initial samples on day two showed CP at 9.8% this value decreased to 8.5% by day 72. Crude protein varied across all treatments. In year one, pastures where cattle were moved once per week had the highest CP followed by pastures where cattle were moved twice per week which were 9.1 and 8.8, respectfully. Continuously grazed pastures had the lowest CP of 8.5 (Fig 19). In year one, CP values never exceeded 10.2%. These CP level would be sufficient to maintain dry beef cows on, but they were not adequate for lactating beef cows or growing steers gaining 0.68 kg/day.

There was no harvest date x treatment interaction (P > 0.05) in year two. Crude protein values in year two displayed a harvest date interaction (P < 0.01). Main effects for harvest date are presented. As it was in year one, CP decreased as the study progressed (Fig 20). Initial samples on day 8 showed CP values at 11%, samples at the end of the study had decreased to 9.2%. With CP values above 11%, lactating beef cows could meet necessary CP requirements for the first 10 days of the study. After the first 10 days, additional supplementation would be need to lactating beef cows. Treatment had no effect on CP in year two.

Total Digestible Nutrients

Year one TDN values had a treatment by harvest date interaction (P < 0.01). Therefore interaction means are presented. Later harvest dates were found to have lower TDN (Fig 21). Also treatment one had the lowest TDN of all the treatments by the conclusion of the study. TDN is inversely correlated to ADF, therefore these results were expected. The trend in year one where forage quality was lower in continuous treatments compared to treatments were cattle were more closely managed maybe the reason for the higher ADG observed in the study among the treatments 2 and 3. Total digestible nutrient content of tall fescue was found to be above
50%, for all treatments, indicating that dry beef cows could be maintained. In year one, TDN levels were adequate for lactating beef cows until day 20 for continuously grazed pastures and day 30 for pastures where cattle were moved.

Similar to year one, TDN in year two showed a treatment by harvest date interaction (P < 0.01). Total digestible nutrients decreased in a linear manner as the study progressed (Fig 22). In treatments 2 and 3 TDN decrease more gradually. As previously stated, NDF and ADF followed a similar trend. In year two, lactating beef cows would have been able to graze without supplementation till day 30 in continuous grazing access pastures and for pastures moved once per week, while pastures moved twice per week did not see TDN decline to below 60% till day 50 (Fig 22). Total digestible nutrients in pastures were high enough (50%) to maintain dry beef cows for the entire study. The steep decline in TDN for continuously grazed pastures in year two compared to ADG in those same pastures were not was as expected. Pastures where cattle were moved which displayed higher TDN were thought to produce higher ADG, as seen in year one.

Overall, forage quality results in this study were in agreement with Fribourg and Bell (1984), who found that forage quality decreases in fall stockpiled tall fescue as the grazing season progresses. Cattle stocking rates may also play a role in some stockpiling situations (Fribourg and Bell, 1984). Additional supplementation, to meet TDN and CP requirements, would be needed to produce higher ADG.

*Average Daily Gain*

The grazing period for year one was from December 3rd to February 15th. Year two began on December 4th and concluded on February 5th. Average daily gain was calculated for the
entirety of the grazing period. Year one calves had an ADG of 0.36 kg/d. Average daily gain of calves in year two were 0.42 kg/d. A year x treatment interaction (P < 0.0001) was also observed. Therefore all data will be presented by year.

Average daily gain for cattle allowed to continuously graze, cattle moved once per week, and cattle moved twice per week were 0.30 kg/d, 0.41 kg/d, and 0.36 kg/d, respectively (Table 5). In year one, cattle moved once and twice per week had significantly similar (P > 0.05) ADG. A significant difference (P < 0.05) in ADG was observed between cattle moved once and twice per week (P > 0.01) and between cattle allowed to continuously graze (P > 0.05).

Average daily gain for cattle in year two was 0.59 kg/d for cattle allowed to continuously graze, 0.30 kg/d for cattle moved once per week, and 0.36 kg/d for cattle moved twice per week (Table 8). In year two, cattle moved once and twice per week had lower ADG (P < 0.01) than cattle in the continuous treatment. Cattle moved once and twice per week had an ADG that did not differ between treatments (P < 0.05).

Cattle in year one that were moved once per week showed higher ADG than cattle moved twice per week and cattle allowed to continually graze. This contradicts results in year two where cattle allowed to continually graze had higher ADG than cattle in either controlled grazing treatment. These results for year two were unexpected but may be due to the trial only lasting 64 days compared to 76 days in year one.

In year two, the trial was ended early because the cattle were needed for another study. By ending the study early, cattle in the continuous treatments were not able to graze to the same extent as year one. The greater access to high quality forage along with fewer days to deplete
pastures in continues grazing treatments may have influenced the results in year two of this study.

*Gain per Hectare*

A year x treatment interaction was observed (P < 0.01) for gain/ha. Therefore all data will be presented by year. In year one, all treatments had similar gain per hectare. Treatment gain per hectare for cattle allowed to continuously graze, cattle moved once per week, and cattle moved twice per week were 1.04, 1.59, and 1.42 kg/ha/day, respectively (Table 6). Gain per hectare did not differ between treatments (P < 0.05).

Year two cattle gains were more than twice that of year one. Gains for cattle allowed to continuously graze, cattle moved once per week, and cattle moved twice per week were 2.77, 3.43, and 3.90 kg/ha/day, respectively (Table 6). Gain per hectare did not differ between treatments (P < 0.05).

*Utilization*

A year x treatment interaction was observed (P < 0.01) for utilization. Utilization data will be presented by year.

In year one, cattle in treatments moved once and twice per week showed similar rates of forage utilization (P > 0.05) (Fig 23). These rates were 41% and 43% of available forage, respectively. Cattle allowed to continuously graze had a utilization rate of 16% of available forage. The utilization rate in cattle allowed to continuously graze was significantly different (P < 0.01) than utilization rates for cattle moved once and twice per week.
In year two, utilization rates were significantly different (P < 0.05) among all treatments. Cattle allowed to continuously graze utilized 14% of available forage, cattle moved once per week consumed 60% of available forage, and cattle moved twice per week consumed 55% of the available forage.

The lower rate of forage utilization shown by cattle allowed to continuously graze for both years was expected. The large pasture areas allowed cattle to selectively graze and avoid less palatable forage. This forage management style did not utilize the forage stand which may explain why grazing days for the full access continuously grazing treatment were lower in year two. Furthermore, this also may explain why ADG per hectare was lowest in continuous groups for both years.

_Grazing Days_

Year one began with cattle entering pastures on December 3rd. Cattle grazed for as many as 84 days in some pastures until forage was no longer available. Year two commenced when cattle began grazing on December 4th and ended on February 5th for a total of 64 grazing days.

No difference (P > 0.05) was found between any of the treatments for grazing days in year one. Overall grazing days for cattle allowed to continuously graze, cattle moved once per week, and cattle moved twice per week were 288 days, 287 days, and 326 days respectively (Table 7). In year two, cattle moved once per week and cattle moved twice per week showed similar grazing days, 721 days and 608 days respectively. Year two cattle in the continuous treatment had a grazing rate of 301 days. There was a significant difference observed (P < 0.01)
between treatments in year two. Treatments where cattle were moved once and twice a week showed an increase the grazing days compared to the continuous treatment cattle.

Conclusion

Stockpiled tall fescue has adequate nutritive value to support stocker calves. When stockpiling tall fescue is coupled with strip grazing systems forage utilization and grazing days can be increased. Furthermore, combining the practice of stockpiling tall fescue in the fall with an intensive grazing management can prove to increase stocker cattle production efficiency. The use of additional high nutritive quality supplementation may prove to be beneficial to stocker calves ADG, especially in the late winter when stockpiled tall fescue approaches its lowest nutrient value. Fewer cattle and the early removal of cattle in year two may have been influential to the outcome of the study. A larger sample group that could be allowed to graze for a longer period should be used. Further work should examine subsequent pasture production and soil quality.
Literature Cited


**Table 4.** Rainfall for 2012, 2013, and 2014 and deviation from 63 year average\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>DEV(^2)</th>
<th>2013</th>
<th>DEV(^2)</th>
<th>2014</th>
<th>DEV(^2)</th>
</tr>
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<tbody>
<tr>
<td>JAN</td>
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<td>25.76</td>
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<td>152.17</td>
<td>40.03</td>
<td>125.2</td>
<td>13.06</td>
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\(^1\)Rainfall was calculated in (cm)

\(^2\)Deviation from 63 year average (cm)
<table>
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<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Access</td>
<td>0.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.59&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moved 1x/wk</td>
<td>0.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moved 2x/wk</td>
<td>0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.36&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup> ADG calculated as (EW-IW)/d; where EW = ending weight for period (average of last two consecutive weights); IW = initial weight for period (average of last two consecutive weights); and d = days in period

<sup>2</sup> Means within a column with letters that differ are significantly different (P < 0.05)

<sup>3</sup> Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week
Table 6. Least square means for average daily gain per area (kg/day/ha) by year\(^1,2\)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Access</td>
<td>1.04(^a)</td>
<td>2.77(^a)</td>
</tr>
<tr>
<td>Moved 1x/wk</td>
<td>1.59(^a)</td>
<td>3.43(^a)</td>
</tr>
<tr>
<td>Moved 2x/wk</td>
<td>1.42(^a)</td>
<td>3.90(^a)</td>
</tr>
</tbody>
</table>

\(^1\) ADG calculated as (EW-IW)/d; where EW = ending weight for period (average of last two consecutive weights); IW = initial weight for period (average of last two consecutive weights); and d = days in period.

\(^2\) Means within a column with letters that differ are significantly different (P < 0.05).

\(^3\) Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week.
Table 7. Least square means for potential grazing days (days/ha) by year$^{1,2}$

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Access</td>
<td>288$^a$</td>
<td>301$^a$</td>
</tr>
<tr>
<td>Moved 1x/wk</td>
<td>287$^a$</td>
<td>721$^b$</td>
</tr>
<tr>
<td>Moved 2x/wk</td>
<td>326$^a$</td>
<td>608$^b$</td>
</tr>
</tbody>
</table>

$^1$Grazing days calculated as $1/\{(A / d)/n\}$; where A = area grazed; d = days grazed; and n = number of calves

$^2$Means within a column with letters that differ are significantly different (P < 0.05)

$^3$Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week
Figure 12. Stockpiled tall fescue quantity for each year\textsuperscript{1,2,3,4}
\begin{itemize}
  \item \textsuperscript{1}Express on a dry matter basis
  \item \textsuperscript{2}Bars where letters differ are significantly different (P < 0.05)
  \item \textsuperscript{3}Year one = 2013; Year two = 2014
  \item \textsuperscript{4}Standard error = 150.67
\end{itemize}
Figure 13. Acid detergent fiber of clipped stockpiled tall fescue samples over time for year one$^{1,2,3}$

$^1$Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

$^2$Expressed on a dry matter basis

$^3$Year one = 2013
Figure 14. Acid detergent fiber of clipped stockpiled tall fescue samples over time for year two$^{1,2,3}$

$^1$Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

$^2$Expressed on a dry matter basis

$^3$Year two = 2014
Figure 15. Neutral detergent fiber of clipped stockpiled tall fescue samples over time for year one.\textsuperscript{1,2,3}

\textsuperscript{1}Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

\textsuperscript{2}Expressed on a dry matter basis

\textsuperscript{3}Year one = 2013
Figure 16. Neutral detergent fiber of clipped stockpiled tall fescue samples over time for year two.\textsuperscript{1,2}

\textsuperscript{1}Expressed on a dry matter basis
\textsuperscript{2}Year two = 2014
Figure 17. Neutral detergent fiber of clipped stockpiled tall fescue samples by treatment for year two. 

1Expressed on a dry matter basis
2Bars where letters differ are significantly different (P < 0.05)
3Year two = 2014
4Standard error = 5.35
Figure 18. Crude protein of clipped stockpiled tall fescue samples over time for year one\textsuperscript{1,2}
\textsuperscript{1}Crude protein determined by \% nitrogen of stockpiled tall fescue times 6.25 expressed on a dry matter basis
\textsuperscript{2}Year one = 2013
**Figure 19.** Crude protein of clipped stockpiled tall fescue samples by treatment for year one

1. Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week
2. Crude protein determined by % nitrogen of stockpiled tall fescue times 6.25 expressed on a dry matter basis
3. Year one = 2013
4. Standard error = 0.28
Figure 20. Crude protein of clipped stockpiled tall fescue samples over time for year two\textsuperscript{1,2}

\textsuperscript{1}Crude protein determined by \% nitrogen of stockpiled tall fescue times 6.25 expressed on a dry matter basis
\textsuperscript{2}Year two = 2014
Figure 21. Total digestible nutrients of clipped stockpiled tall fescue samples over time for year one.\(^1,2,3,4\)

\(^1\)Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

\(^2\)Total digestible nutrients calculated as \(100.32 - 1.118 \times \text{ADF}\); where \(\text{ADF} = \text{acid detergent fiber}\)

\(^3\)Expressed on a dry matter basis

\(^4\)Year one = 2013
Figure 22. Total digestible nutrients of clipped stockpiled tall fescue samples over time for year two.\textsuperscript{1,2,3,4}

\textsuperscript{1}Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week
\textsuperscript{2}Total digestible nutrients calculated as 100.32 – 1.118 x ADF; where ADF = acid detergent fiber
\textsuperscript{3}Expressed on a dry matter basis
\textsuperscript{4}Year two = 2014
Figure 23. Stockpiled tall fescue utilization for each treatment$^{1,2,3,4}$

$^1$Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

$^2$Bars where letters differ are significantly different (P < 0.05)

$^3$Year one = 2013; Year two = 2014

$^4$Year one standard error = 0.03; Year two standard error = 0.02
Appendix A - 1. Average daily gain per hectare for each treatment\textsuperscript{1,2,3,4,5}

\textsuperscript{1}ADG calculated as (EW-IW)/d; where EW = ending weight for period (average of last two consecutive weights); IW = initial weight for period (average of last two consecutive weights); and d = days in period

\textsuperscript{2}Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

\textsuperscript{3}Bars where letters differ are significantly different (P < 0.05)

\textsuperscript{4}Year one = 2013; Year two = 2014

\textsuperscript{5}Year one standard error = 0.22; Year two standard error = 0.33
Appendix A - 2. Potential grazing days for each treatment\textsuperscript{1,2,3,4,5}

\textsuperscript{1}Grazing days calculated as $1/(A / d)/n$; where $A =$ area grazed; $d =$ days grazed; and $n =$ number of calves

\textsuperscript{2}Bars where letters differ are significantly different (P < 0.05)

\textsuperscript{3}Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week

\textsuperscript{4}Year one = 2013; Year two = 2014

\textsuperscript{5}Year one standard error = 13.46; Year two standard error = 14.16
Appendix A - 3. Stockpiled tall fescue quantity at different harvest dates\(^1,2,3\)

\(^1\)Expressed on a dry matter basis
\(^2\)Full access = continuously grazed pasture; Moved 1x/wk = pasture added once per week; Moved 2x/wk = pasture added twice per week
\(^3\)Standard error: Full access = 95.0; Moved 1x/wk = 78.5; and Moved 2x/wk = 68.1