Assessment of stockpiling methods to increase late summer and early fall forage biomass

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ABSTRACT

As one of the major forage crops of the United States management programs to optimize stockpiled tall fescue (*Festuca arundinacea* Schreb.) can potentially increase livestock profitability. This study consists of two experiments designed to assess different aspects of summer stockpiling. Experiment 1 evaluated the effects of summer stockpiling endophyte infected Kentucky 31 tall fescue on biomass and nutritive value of tall fescue forage. Treatments included four whole plot treatments (two nitrogen (N) application timing, legume inclusion, and control) each divided into sub-plot cut and no cut treatments. The cut treatment consisted of a single cutting taken in May. Nitrogen in the form of urea was applied at a rate of 56 kg/ha for the March N treatment and for the June N treatment. Yield and quality of summer stockpiled fescue was adequate to support dry beef cows. Experiment 2 evaluated the effects of summer stockpiling on the biomass yield and nutritive value of three types of tall fescue with N fertilization (endophyte infected (E+), endophyte-free (E-), and novel endophyte (MaxQ)) and four species of native warm-season grasses without N fertilization (switchgrass (*Panicum virgatum* L.), big bluestem (*Andropogon gerardii* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Schizachyrium scoparium* (Michx.) Nash)). Native warm-season grasses produced much higher yields than all tall fescue types but the nutritive value was not adequate to support the nutrient requirements of livestock. Summer stockpiled tall fescue is a viable resource to provide low requirement animals with quality forage during late summer and early fall.

DEDICATION

To my parents, Greg and Teresa Hickman, and my brother Samuel Hickman for their support, love, help, and tolerance throughout all my education.

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1. INTRODUCTION

Tall fescue (*Festuca arundinacea* Schreb.) is a cool-season perennial grass that occupies over 35 million acres in the U.S. (Ball et al., 2003). Predominant throughout the transition zone of the United States, tall fescue is the most widely used grass in improved pastures (Hancock and Andrae, 2009). It is the only cool-season grass that persists for more than four years in the middle south (Burns et al., 2002) and is tolerant of many adverse growing conditions (Ball et al., 2007). Tall fescue has two peaks in production, one in the spring and another in the fall, of which the spring production is slightly greater than the fall production. However, once temperatures rise above 30°C (86°F), tall fescue growth declines sharply (Jennings et al., 2008). This period, commonly known as the "summer slump", presents challenges to producers with grazing animals utilizing tall fescue forage. Options to try to solve this decrease in forage availability include: feed stored forage, decrease herd size, plant new and alternative forages, increase acreage in forage production, or simply leaving the animals on existing pasture and absorb possible damage to the plants. Each of these options presents its own challenges, but another possible option could be to stockpile the spring growth of tall fescue in some pastures for utilization during the summer slump.

Stockpiling is the practice of saving forage growth accumulated during one period for later use. This practice has already been implemented by saving fall tall fescue forage accumulation to be grazed later during the winter. Tall fescue lends itself well to such a practice due to its ability to accumulate greater forage yields (Archer and Decker, 1977a; Dierking et al., 2008; Peterson et al., 2001; Riesterer et al., 2000; Robinson et al., 2007) and to maintain nutritive value for longer than many other grasses (Archer and Decker, 1977a; 1977b; Burns and

Chamblee, 2000b; Collins and Balasko, 1981b; Fribourg and Bell, 1984; Hedtcke et al., 2002; Ocumpaugh and Matches, 1977; Peterson et al., 2001; Rayburn et al., 1979; Riesterer et al., 2000; Robinson et al., 2007; Sheehan et al., 1985; Taylor and Templeton, 1976; Volesky et al., 2008). Since this practice works well with tall fescue during the fall, application of this same method during the spring could buffer the lack of forage during the late summer. Two experiments were conducted to test how tall fescue might be summer stockpiled and how stockpiled fescue compares in yield and quality to native warm-season grasses that could be incorporated into a system to provide summer grazing.

The overall objective of Experiment 1 was to assess the effectiveness of different methods of stockpiling at producing adequate biomass yield and nutritive value to support grazing animals. More specifically, the objective was to investigate the ability of different stockpiling methods to fill the gap between the spring and fall growth of tall fescue by assessing their effectiveness at producing adequate biomass and nutritive value to support grazing animals.

The overall objective of Experiment 2 was to compare the biomass yield and nutritive value of three different types of tall fescue to four different native warm-season grass species. More specifically, the objectives were:

1. To evaluate the effect of native warm-season grass species and tall fescue types on the biomass yield and nutritive value of the stockpiled forage
2. To assess the ability of both native warm-season grasses and tall fescue types to provide adequate biomass yield and nutritive value to support grazing animals.

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2. LITERATURE REVIEW

Tall Fescue

Tall fescue (*Festuca arundinacea* Schreb.) is widespread in the United States, occupying over 35 million acres (Ball et al., 2003). It was originally known by many names including Reed fescue (*Festuca elatior* L.), English bluegrass, evergreengrass, tall meadow fescue, and Randoll grass (Burns et al., 2002). Tall fescue forms denser sods, is taller, more tolerant of drought and cold, and more competitive than meadow fescue (Burns et al., 2002). A strain of tall fescue is known to have existed in the United States before 1890 (Jennings et al., 2008) but tall fescue was officially introduced to the United States from Great Britain in the late 1800s (Burns et al., 2002; Jennings et al., 2008). However, it wasn't until 1931 that the strain that existed in the United States was discovered and collected in Menifee County, Kentucky (Burns et al., 2002; Jennings et al., 2008). This strain was released as the cultivar 'Kentucky 31' in the 1940s (Jennings et al., 2008).

Tall fescue is a cool-season perennial grass with an erect bunch-type growth habit with short rhizomes (Ball et al., 2007; Jennings et al., 2008). It is deep rooted, sod forming, and can grow from 2-4 feet tall (Ball et al., 2007; Jennings et al., 2008). The leaves are dark green with prominent veins, somewhat shinny, and possess rough edges (Abaye, 2010; Ball et al., 2007). The leaf is rolled in the bud-shoot and the leaf sheath is round and smooth (Abaye, 2010). Most tillers also possess a short auricle with hairs on the margin (Abaye, 2010). The seed head is a compressed panicle (Ball et al., 2007) with floral induction occurring in early spring and floral initiation occurring in late spring to early summer (Abaye, 2010). Tall fescue reproduces by seed and can spread vegetatively through short rhizomes (Abaye, 2010). It is the only cool-season perennial grass that persists for more than four years in the middle south (Burns et al., 2002). Tall fescue in the middle south, also known as the Piedmont region (Burns et al., 2002), is best adapted to clay or loam soils (Ball et al., 2007). Nevertheless, it is tolerant of poor drainage, low soil fertility, soil acidity, relatively tolerant of drought, and responds well to fertilization (Ball et al., 2007).

Tall fescue is the predominant forage crop in the United States (Hancock and Andrae, 2009), and can be high quality forage but the presence of a fungal endophyte that produces a toxin can affect animal performance (Ball et al., 2007). The fungal endophyte (*Neotyphodium coenophialum)* responsible for the production of the toxins was not discovered until the 1970s (Ball et al., 2003). The endophyte is transmitted from generation to generation through the production of seed and cannot be spread from plant to plant (Ball et al., 2003; Hancock and Andrae, 2009). The fungal endophyte not only produces toxins but imparts positive characteristics to the plant such as drought resistance, longevity, and plant vigor (Hancock and Andrae, 2009). During the 1980s and 1990s, naturally occurring endophyte strains were discovered that did not produce the toxic ergot alkaloids (Hancock and Andrae, 2009). Endophyte-free strains of tall fescue (E-) have been developed but the agronomic performance of the forage is below the level of endophyte infected fescue (E+) (Drewnoski et al., 2007; Jennings et al., 2008). Some studies have found that reinfection of tall fescue cultivars with a fungal endophyte that does not produce the toxins that negatively impact animal performance can produce a plant that does not produce toxins but still has the positive characteristics of infection (Bouton et al., 2002). The fescue cultivars that are infected with an endophyte that has non-ergot producing alkaloids, also known as novel endophyte (EN), have comparable agronomic performance to that of regular endophyte infected tall fescue (E+) (Ball et al., 2003; Hancock and Andrae, 2009). The first novel endophyte fescue cultivars were released in 2000 (Hancock and Andrae, 2009). In a 2007 study conducted by Drewnoski et al., researchers found that novel endophtye fescue had comparable growth, sward composition, forage mass, forage yield, invasion status of non-fescue species, and crude protein levels (CP) to endophyte infected fescue. The novel endophyte fescue was also determined to be suitable for stockpiling (Drewnoski et al., 2007).

Although the endophyte infected tall fescue is known to have negative impacts on animal performance (Ball et al., 2003; Bouton et al., 2002; Burns et al., 2006; Curtis and Kallenbach, 2007; Drewnoski et al., 2007; Hancock and Andrae, 2009; Jennings et al., 2008; Kallenbach et al., 2003; Parish et al., 2003), it appears to have little effect on nutritive value of the forage (Burns et al., 2006; Flores et al., 2007) or how the forage is utilized in the rumen (Flores et al., 2007). In a study conducted in southern Missouri, it was found that herbage mass was 20% greater for Kentucky 31 tall fescue infected with the native endophyte than for either the non-toxic endophyte (HiMag NTE) or the non infected tall fescue (HiMag E-) (Kallenbach et al., 2003). Nutritive value such as acid detergent fiber (ADF), neutral detergent fiber (NDF), and CP were found to be equal for all three types of fescue tested (Kallenbach et al., 2003). Other studies have found no effect of endophyte infection status on dry matter yields of tall fescue (Fritz and Collins, 1991). Similarly, no effect on extent or rate of digestion of NDF, the nitrogen (N) concentration, or the fiber composition of the forage was observed due to infection status (Fritz and Collins, 1991). There is some research that shows that the percentage level of endophyte infection does not influence the dry matter intake or the pasture utilization by cow-calf pairs, and there is no effect on the body weight of the calves (Curtis and Kallenbach, 2007). Under non-grazing conditions, competitiveness of tall fescue is not influenced by the levels of ergopeptine alkaloid produced by the endophyte *Acremonium coenophialum* (now known as *Neotyphodium coenophialum)* (Hill et al., 1991).

Tall fescue is used for many purposes including soil erosion control (Ball et al., 2007; Ball et al., 2003), pasture forage, hay, and stockpiled winter grazing (Ball et al., 2007). Establishment of tall fescue in Virginia can be done in early spring or from August to October (Ball et al., 2007). A broadcast seeding rate of 22-28 kg/ha (20-25 lbs/acre) should be used or seed can be drilled using a rate of 17-22 kg/ha (15-20 lbs/acre) (Ball et al., 2007). Tall fescue will tolerate overgrazing better than most grasses especially if endophyte infected (Ball et al., 2007; Jennings et al., 2008). However, endophyte-free tall fescue is not as tolerant to grazing abuse and should be closely watched, especially during the summer months, so that it is not grazed below three inches (Ball et al., 2007). Tall fescue can be interseeded with various legumes including alfalfa, white clover, and red clover (Ball et al., 2007).

Stockpiling

Stockpiling is a practice that can be used to extend the grazing season by saving certain pastures for grazing in the fall and winter (Johnston and Wand, 2010). Tall fescue is a well suited forage grass for this practice and exhibits several characteristics that make it a good candidate for use in stockpiling. First, tall fescue responds well to nitrogen fertilization (Archer and Decker, 1977a; Ball et al., 2007; Cherney and Cherney, 2006; Collins and Balasko, 1981a; Fribourg and Loveland, 1978b; Jennings et al., 2008; Poore et al., 2000; Rayburn et al., 1979; Riesterer et al., 2000; Singer et al., 2003; Singer et al., 2007; Taylor and Templeton, 1976; Teutsch et al., 2005). Second, driven by cooler temperatures, there is a significant autumn period of growth and tillering (Jennings et al., 2008; Templeton et al., 1961; Yeh et al., 1976) thereby giving tall fescue greater yields than many other grasses (Archer and Decker, 1977a; Dierking et al., 2008; Peterson et al., 2001; Riesterer et al., 2000; Robinson et al., 2007). Third, fescue can recover even after experiencing trampling by animals during wet conditions (Peterson et al., 2001). Finally, tall fescue maintains the quality and the nutritive value of the accumulated forage for several months (Archer and Decker, 1977a; 1977b; Burns and Chamblee, 2000b; Collins and Balasko, 1981b; Fribourg and Bell, 1984; Hedtcke et al., 2002; Ocumpaugh and Matches, 1977; Peterson et al., 2001; Rayburn et al., 1979; Riesterer et al., 2000; Robinson et al., 2007; Sheehan et al., 1985; Taylor and Templeton, 1976; Volesky et al., 2008).

The practice of winter stockpiling

Animals are removed from the pasture to be used for stockpiling in the late summer or early autumn, June to August sometimes as late as September or October, and the forage is allowed to accumulate until utilization (Ball et al., 2003; Natural Resource Consevation Service, 2005). Usually 45-67 kg N/ha (40-60 lbs N/acre) is applied at or before the initiation of stockpiling. However, legumes can be effectively used to provide the nitrogen needed. Depending on the date of initiation of stockpiling, grazing can commence sometime after November (Ball et al., 2003; Natural Resource Consevation Service, 2005). Grazing can be accomplished by allowing animals to graze the entire pasture or by strip grazing (Jennings et al., 2008). The longer the period of time the animals will be allowed to graze one section before being moved, the larger the section will need to be in order to provide adequate feed. The economic return from stockpiled fescue was investigated by Poore et al. (2000). They concluded that stockpiled fescue was equal or superior to traditional methods of hay feeding.

The initiation of stockpiling and utilization of the stockpiled forage has been the subject of much research. Forage generally continues to accumulate until about November but substantial losses start about January (Fribourg and Bell, 1984). Several studies documented a decrease in dry matter yield with a delay in the initiation of stockpiling (Burns and Chamblee, 2000a; Collins and Balasko, 1981a; Fribourg and Loveland, 1978a; Fribourg and Bell, 1984;

Peterson et al., 2001; Rayburn et al., 1979; Volesky et al., 2008). However, the delay in the initiation of stockpiling was found to increase in vitro dry matter disappearance (IVDMD) (Burns and Chamblee, 2000a; 2000b; Collins and Balasko, 1981b; Fribourg and Bell, 1984; Peterson et al., 2001; Rayburn et al., 1979; Volesky et al., 2008), the percentage of green tissue (Burns and Chamblee, 2000a), total non-structural carbohydrates (TNC) (Burns and Chamblee, 2000b; Rayburn et al., 1979), and CP (Rayburn et al., 1979; Volesky et al., 2008). A decrease in NDF (Burns and Chamblee, 2000a; 2000b; Volesky et al., 2008) and low values for ADF, cellulose, and lignin concentrations (Burns and Chamblee, 2000a) were observed in some studies. Other studies have found that NDF, ADF (Fribourg and Bell, 1984), CP (Burns and Chamblee, 2000a; 2000b), and starch levels (Burns and Chamblee, 2000b) were not influenced by initiation date.

Delaying the utilization of the stockpiled forage results in decreased ergovaline concentrations of endophyte infected tall fescue (Burns et al., 2006), decreased TNC concentrations (Collins and Balasko, 1981b; Rayburn et al., 1979), and dry matter yield loss (Ocumpaugh and Matches, 1977; Peterson et al., 2001; Rayburn et al., 1979; Singer et al., 2003). In order to minimize sizeable losses of dry matter (Ocumpaugh and Matches, 1977; Volesky et al., 2008), CP, potassium, and IVDMD, it is recommended that stockpiled forage be utilized before December (Ocumpaugh and Matches, 1977).

Tall fescue can be accumulated during the summer and can provide high nutritive value until about January or until dead tissue dominates the forage (Burns and Chamblee, 2000b). There is a strong relationship between the proportion of dead tissue and the nutritive value of a forage (Burns and Chamblee, 2000b). Declines in nutritive value during the fall and winter are generally associated with normal leaf aging and senescence in the canopy, which if associated with freezing and frost intensity, contribute to declining nutritive value due to release of soluble nutrients (Burns and Chamblee, 2000b). These soluble nutrients are either translocated or leached (Burns and Chamblee, 2000b). As forage is utilized throughout the winter, leaf death tends to increase resulting in a general decrease in IVDMD (Archer and Decker, 1977b; Burns and Chamblee, 2000b; Ocumpaugh and Matches, 1977; Sheehan et al., 1985; Volesky et al., 2008). In vitro dry matter disappearance tends to be inversely related to trends in fiber components (Archer and Decker, 1977b; Sheehan et al., 1985). A numeric increase in IVDMD may be observed in February and March due to the start of spring green up if the temperatures begin to rise (Burns and Chamblee, 2000b). Decreases were observed in standing forage organic matter (SFOM) (Riesterer et al., 2000), in vitro organic matter digestibility (IVOMD) (Hedtcke et al., 2002), CP levels (Archer and Decker, 1977a; Hedtcke et al., 2002; Ocumpaugh and Matches, 1977; Rayburn et al., 1979; Volesky et al., 2008), total sugar concentration (Taylor and Templeton, 1976), phosphorus (Collins and Balasko, 1981b; Taylor and Templeton, 1976) , calcium, magnesium, (Collins and Balasko, 1981b), and potassium concentrations (Collins and Balasko, 1981b; Ocumpaugh and Matches, 1977) as the winter progresses. However, from November to March, CP levels showed little variation in one study (Burns and Chamblee, 2000b), but another study showed increased CP concentrations in late winter (Hedtcke et al., 2002). Neutral detergent fiber (Burns and Chamblee, 2000b; Hedtcke et al., 2002), ADF (Hedtcke et al., 2002; Sheehan et al., 1985), and cellulose (Sheehan et al., 1985) increase as the winter progresses. One experiment showed low total nitrogen content in forage that was stockpiled in spring, summer, and early fall and was harvested in summer and fall (Fribourg and Loveland, 1978a).

Nitrogen Fertilization

Nitrogen fertilization can impact both quality and quantity of stockpiled fescue. The addition of nitrogen at the beginning of the accumulation period has resulted in an increase in dry matter yields (Burns and Chamblee, 2000a; Fribourg and Loveland, 1978b). Rayburn et al. reported peak production the month after nitrogen was applied (1979). The greatest yield increases in one study were found to be with a split application of nitrogen in the spring and after the first cutting of the forage for hay (Cherney and Cherney, 2006). The same study also found that there was no advantage to using a three-way split nitrogen application (Cherney and Cherney, 2006). However, another study found that summer production was greater when a May and July application of nitrogen was made after a March application than when nitrogen was applied in March alone (Fribourg and Loveland, 1978b). Summer applications of fertilizer has variable increases in dry matter yield if adequate soil moisture is not present (Fribourg and Loveland, 1978b). Summer application of nitrogen increased digestibility of the forage during the summer months to levels slightly above those that were measured for forage where no nitrogen was applied (Fribourg and Loveland, 1978b). Nevertheless, these applications may have detrimental effects on forage quality through the possible increase of perloline content, increased nitrate nitrogen levels beyond those levels desirable for quality forage, and some possible stand losses later in the year (Fribourg and Loveland, 1978b). The timing of the application did not have an influence on nitrogen recovery (Cherney and Cherney, 2006). Apparent nitrogen recovery was greater for four harvests per year systems than three harvests per year systems, and recovery rates were the greatest at lower levels than the economically optimum nitrogen rate of fertilization for tall fescue (Hall et al., 2003).

One study compared different nitrogen sources and investigated the utilization of these sources by tall fescue and orchardgrass (Cherney et al., 2002). Nitrogen recovery was higher for commercial fertilizer than for manure, but nitrogen removal was similar for both grass species (Cherney et al., 2002). After two years of manure applications, for at least the next three years, the residual nitrogen from the manure resulted in greater dry matter yields and greater seasonal nitrogen removal than plots that were fertilized using commercial nitrogen sources (Cherney et al., 2002). Nitrogen concentrations in forage are more variable for the manure applications than for the commercial fertilizer applications (Cherney et al., 2002). Nitrogen concentrations were higher in fall re-growth as compared to spring growth, and stand persistence was unaffected by nutrient treatments (Cherney et al., 2002). Tall fescue might be better able to utilize the nutrients in the manure due to more evenly distributed yield as compared to orchardgrass (Cherney et al., 2002). Another study that investigated nitrogen sources found that high lysine fertilizer and ammonium nitrate were similar in yield and quality of forage produced although ammonium nitrate did produce slightly higher dry matter yields in the fall (Singer et al., 2007). One study tested broiler litter, complete fertilizer, ammonium nitrate, ammonium sulfate, urea, and urea-ammonium nitrate and found that ammonium nitrate was the best fertilizer source based on less volatilization losses under pasture conditions, highest yields, and non-inclusion of other potentially unnecessary elements that add additional expense (Teutsch et al., 2005).

The best rate of nitrogen application has been the subject of research and debate. A delay in the initiation of the stockpiling generally seems to increase the optimum nitrogen fertilization application rate (Collins and Balasko, 1981a; 1981b). The economically optimum rate of nitrogen (EONR) fertilization for tall fescue was determined to be 368 kg N/ha or 32 kg/Mg of forage harvested in one study (Hall et al., 2003). Other studies showed that nitrogen fertilization appears to be beneficial and economical if applied at moderate rates (50-100 kg/ha) (Poore et al., 2000; Taylor and Templeton, 1976) in late summer, but it was noted that results will vary by area and producer (Poore et al., 2000).

The next logical step in the investigation of the impact of nitrogen fertilizer is the impact of nitrogen fertilization on the nutritive value or quality of the forage. Some studies found that the application of nitrogen at the initiation of accumulation resulted in decreased IVDMD (Burns and Chamblee, 2000a; Collins and Balasko, 1981b) but that other fiber components (Burns and Chamblee, 2000a), and CP (Burns and Chamblee, 2000b) remained similar to stockpiled forage that did not experience a nitrogen application at the beginning of accumulation. However, other studies found that with nitrogen fertilization, IVDMD (Singer et al., 2007), CP (Archer and Decker, 1977a; Hedtcke et al., 2002; Singer et al., 2007; Taylor and Templeton, 1976; Teutsch et al., 2005), and standing forage organic matter (Riesterer et al., 2000) increased, NDF (Cherney and Cherney, 2006; Hedtcke et al., 2002; Singer et al., 2007) and ADF (Hedtcke et al., 2002) decreased, while TNC remained unchanged (Burns and Chamblee, 2000b). Increased nitrogen levels decreased fiber components (Archer and Decker, 1977b) but increased CP (Archer and Decker, 1977a; Cherney and Cherney, 2006; Singer et al., 2003). IVDMD (Singer et al., 2003), TNC (Collins and Balasko, 1981b), phosphorus (Collins and Balasko, 1981b), potassium (Collins and Balasko, 1981b; Singer et al., 2007), total nitrogen in the forage (Singer et al., 2007), and water soluble carbohydrate concentration (Collins and Balasko, 1981b) increased while NDF (Singer et al., 2003) decreased with increased nitrogen application rate. Concentrations of CP were found to increase up to the highest nitrogen rate applied (Collins and Balasko, 1981b). Another study found that nitrogen rate had no effect on ADF, NDF, or total digestible nutrients (TDN) (Teutsch et al., 2005). One study that investigated the influence of nitrogen application on yield and quality of dry matter found that the amount of dry matter produced that was approximately 55% NDF was not influenced by the nitrogen treatment (Cherney and Cherney, 2006). Some studies have investigated the impact of the source of nitrogen on quality of the resulting forage. Potassium levels (Singer et al., 2007), TDN, ADF, and NDF are not affected by nitrogen source and CP is only slightly influenced (Teutsch et al., 2005).

Frequent nitrogen applications increased the total nitrogen and in vitro digestible dry matter (IVDDM) percentages especially in the summer and fall (Fribourg and Loveland, 1978b). Nitrate nitrogen, perloline, and total nitrogen content increases were observed in the individual harvests following application but perloline content had no apparent effect on IVDDM percent (Fribourg and Loveland, 1978b). Nitrate nitrogen levels were not increased to potentially toxic levels by the frequent nitrogen applications (Fribourg and Loveland, 1978b) but if large amounts of nitrogen are applied or three or more cuttings are taken per year, the nitrate nitrogen levels could become dangerous (Hall et al., 2003). The nitrate nitrogen levels should be monitored but the effects of these levels can be eliminated or minimized through animal ration formulation (Hall et al., 2003). Soil nitrate nitrogen levels were not affected beneath tall fescue (Hall et al., 2003).

Legume Inclusion

Due to the rising costs of nitrogen fertilizers, the cost of stockpiling could increase (Robinson et al., 2007; Teutsch et al., 2005). In order to keep the costs lower, legumes are being considered to provide the needed nitrogen to the stockpiled forage (Robinson et al., 2007). Inclusion of legumes in stockpiled tall fescue can replace the need for nitrogen fertilization (Allen et al., 1992b). However, the tall fescue grown with the legumes does not accumulate as much forage biomass as the tall fescue that is fertilized with nitrogen (Allen et al., 1992b; Vines et al., 2006). Reduced biomass decreased the number of grazing days provided by the stockpiled forage (Allen et al., 1992b; Vines et al., 2006) and increased the number of days of hay feeding (Allen et al., 1992b). However, in the experiment conducted by Allen et al. (1992), the quality, as measured by the average weight gain of the calves, was increased by the inclusion of alfalfa in the stockpiled tall fescue. When red clover was included, the calves performed similarly to the calves that were grazing nitrogen fertilized tall fescue (Allen et al., 1992b). Tall fescue and red clover were used successfully for stockpiling although red clover did not persist (Allen et al., 1992a). Adequate nutrition and biomass were provided by stockpiled tall fescue- red clover to maintain a cow-calf production system (Allen et al., 1992a). It can be concluded from the research that inclusion of legumes in stockpiled tall fescue forage impacts forage quality. Legume inclusion can help increase the overall nutritive value of the stockpiled forage due to legumes possessing higher nutritive value as compared to grasses (Allen et al., 1992b; Robinson et al., 2007; Sheehan et al., 1985). Legume inclusion increases the nitrogen content in the above-ground biomass and does not impact the soil ammonium levels any more than nitrogen fertilization (Vines et al., 2006).

One study has results that could have implications in the use of legumes in summer stockpiling. A study conducted by Vines et al. (2006) found that the inclusion of alfalfa or red clover with tall fescue increased the mid and late summer production of tall fescue to a greater degree than a comparable amount of nitrogen fertilizer. This could be useful in a summer stockpiling situation due to the increased yield from inclusion of legumes and increased quality of forage. Nevertheless, several studies have found that stockpiled legumes decrease in quality more rapidly than do grasses (Peterson et al., 2001; Robinson et al., 2007; Sheehan et al., 1985) and persistence of legumes can be a problem (Allen et al., 1992a; Robinson et al., 2007).

Animal Performance

The ultimate test of whether a production system works is whether it meets the nutritional requirements of the animals and how well the animals perform on the forage. In a study conducted in Missouri, the leaf concentrations of all macronutrients, except calcium, declined (McClain and Blevins, 2007). Supplementation of phosphorus (Collins and Balasko, 1981b; Fribourg and Bell, 1984), magnesium (Collins and Balasko, 1981b), energy (Collins and Balasko, 1981b; Dierking et al., 2008; Hedtcke et al., 2002), and potassium (Fribourg and Bell, 1984; Ocumpaugh and Matches, 1977) may be required to meet nutritional needs especially toward the end of winter. However, the CP of the forage in several studies was adequate to supply the nutritional needs of a mature pregnant non-lactating beef cow (Fribourg and Bell, 1984; Taylor and Templeton, 1976; Volesky et al., 2008) but may need to be supplemented if the animal has higher nutritional requirements (Hedtcke et al., 2002). Stockpiled forage met or exceeded nutrient requirements of dry and lactating beef cows (Kallenbach et al., 2003), and pregnant market cows (Looper et al., 2005). Tall fescue was found to supply enough CP and TDN to meet the requirements of a dry dairy cow but could not meet the requirements for a lactating dairy cow (Dierking et al., 2008). In one experiment, at certain harvest dates within a season, the nitrogen content fell below the National Research Council requirements for a lactating beef cow and in one case it was below the requirements for a dry beef cow (Fribourg and Loveland, 1978a).

Animal performance is important, but when grazing tall fescue, there are several effects on animal performance associated with the endophyte infection. Fescue foot is a condition caused by the toxins produced by the endophyte and is generally associated with cold weather (Ball et al., 2003) especially during the autumn and winter. Fescue foot generally results in lameness, loss of the tips of the tail and/or ears, reduced animal gains, and may result in sloughing of the hooves or feet (Ball et al., 2003). Another negative performance issue is bovine fat necrosis. This condition typically arises where endophyte infected pastures are for the most part pure stands that have experienced heavy fertilization with nitrogen fertilizer or poultry litter (Ball et al., 2003). This condition materializes when hard masses of fat are present in the abdominal cavity and can result in digestive or calving problems (Ball et al., 2003). Probably the largest and best known problem is fescue toxicity. Fescue toxicity results in reduced feed intake (Ball et al., 2003; Jennings et al., 2008) which in turn causes decreased weight gain (Ball et al., 2003). It also causes elevated body temperature (Ball et al., 2003; Jennings et al., 2008) resulting in more time spent in water and/or shade resulting in less time spent grazing (Ball et al., 2003). Fescue toxicity causes higher respiration rate (Ball et al., 2003; Jennings et al., 2008), excessive salivation (Ball et al., 2003), rough hair coat (Ball et al., 2003; Jennings et al., 2008), low blood serum prolactin concentration (Ball et al., 2003), and lower milk production (Ball et al., 2003; Jennings et al., 2008). In addition, it can lower reproductive performance due to decreased conception rates (Ball et al., 2003; Jennings et al., 2008).

Several solutions have been suggested to solve the negative performance problems associated with endophyte infected tall fescue. These solutions include management strategies that favor the production of other grasses, interseeding with legumes to produce a dilution effect, and feeding hay produced from other grasses (Ball et al., 2003). A drug called Domperidone is available but it is expensive and the effects are not long-lasting (Ball et al., 2003). Another possible solution could be stockpiling. Stockpiling of tall fescue can be used to decrease effects from the toxins (Ball et al., 2003) and the total amount of ergot alkaloids present in the stockpiled forage declines as the winter progresses (Burns et al., 2006; Curtis and Kallenbach, 2007; Drewnoski et al., 2007; Flores et al., 2007; Kallenbach et al., 2003) but may begin to increase again from February to April (Looper et al., 2005). The other option would be to replant pastures in novel endophyte fescue or endophyte-free tall fescue (Ball et al., 2003). Experiments have shown that animals grazing endophyte-free or novel endophyte tall fescue have not exhibited symptoms of fescue toxicity (Bouton et al., 2002), and resulted in the same or higher growth performance as compared to endophyte infected tall fescue (Parish et al., 2003). However, replanting pastures is expensive and should be carefully considered before instituted (Ball et al., 2003).

Native Warm-season Grasses

Switchgrass

Switchgrass (*Panicum virgatum* L.) is a perennial warm-season grass species native to the Great Plains and most of the eastern United States. Although native to the eastern United States, it is not as widespread as it once was due to grazing mismanagement. When settlers populated an area, their livestock were allowed to roam and graze freely (Wolf and Fiske, 2009). This led to animals grazing the switchgrass when it first appeared in spring, but the plant was not able to withstand defoliation that early in the season so stands were weakened and eventually disappeared (Wolf and Fiske, 2009) . Switchgrass was replaced by cool-season grasses that were introduced to this country, which initiated growth earlier in the spring and could withstand defoliation sooner (Wolf and Fiske, 2009).

Switchgrass has upland and lowland morphological ecotypes and broadly defined northern and southern physiological ecotypes (Cassida et al., 2005; Parrish et al., 2008). Lowland morphological ecotypes are characterized by adaptation to poor drainage (Ball et al., 2007; Cassida et al., 2005; Wolf and Fiske, 2009), stems that are coarse (Cassida et al., 2005; Parrish et al., 2008), a bunch type growing habit, and growth that can reach heights of over 9 feet (Parrish et al., 2008). Upland morphological ecotypes have good drought tolerance (Ball et al., 2007; Cassida et al., 2005; Wolf and Fiske, 2009), finer stems (Cassida et al., 2005) that are generally less than 8 feet tall, and tend to be more sod-forming in their growth habit due to more vigorous rhizome growth (Parrish et al., 2008). Both morphological ecotypes are deep rooted (Ball et al., 2007; Parrish et al., 2008). Physiological ecotypes are determined by the latitude of origin (Cassida et al., 2005; Parrish et al., 2008). Southern physiological ecotypes produce higher dry matter yields and have a higher moisture content than northern physiological ecotypes (Cassida et al., 2005). Switchgrass is spread by rhizomes (Ball et al., 2007; Parrish et al., 2008) and seed produced from an open panicle seed head (Ball et al., 2007). Switchgrass produces from May to July and matures earlier than many other warm-season grasses (Ball et al., 2007). Therefore, it may become unpalatable early in the summer due to earlier development of stems (Ball et al., 2007) and increased maturity (Guretzky et al., 2011). It possess hairs near the base of the leaf (Ball et al., 2007), and responds to nitrogen fertilization (Ball et al., 2007; Guretzky et al., 2011; Hall, 1982; Waramit, 2010; Wolf and Fiske, 2009).

The combination of morphological and physiological ecotypes produces four categories sometimes called germplasm groups, of which northern upland is most abundant and northern lowland and southern upland are comparatively few (Casler et al., 2004). The combination of both morphological and physiological ecotypes produces yield and nutritive value differences among the germplasm groups (Casler et al., 2004; Cassida et al., 2005; Parrish et al., 2008). The differences among groups can then be used in breeding programs to develop cultivars that possess characteristics that are better suited to a particular use (Casler et al., 2004; Cassida et al., 2005; Parrish et al., 2008) such as biofuel production, co-firing with coal, or being used for grazing and hay.

Switchgrass is especially useful for summer grazing because it is a warm-season grass and hence at its peak production during the hotter temperatures of the summer months. The yield of switchgrass is more than adequate to support grazing animals (Hall, 1982), and can be improved with irrigation (Guretzky et al., 2011; Koshi et al., 1982). However, quality of switchgrass may be problematic. Not only does the quality of switchgrass decline throughout the growing season as the forage increases in maturity (Griffin, 1983; Guretzky et al., 2011; Koshi et al., 1982; Mitchell et al., 2001; Waramit, 2010), but there is also evidence that switchgrass re-growth is lower in quality than the initial growth (Burns, 2011; Sanderson et al., 1999). In spite of low chemical quality analysis values, animals have the ability to select for a higher quality diet than what is offered (Burns, 2011; Burns et al., 2011; Hudson, 2008b; Kirch et al., 2007). This is possibly due to different portions of the plant having different nutritive value compositions (Griffin, 1983; Hu et al., 2010; Jung, 1992).

Indiangrass

Indiangrass (*Sorghastrum nutans* (L.) Nash) is a warm-season perennial bunchgrass that is native to the eastern U.S. and eastern Great Plains tall grass prairie (Ball et al., 2007). It is deep rooted and grows 3 to 6 feet tall (Ball et al., 2007). It spreads by rhizomes and seed produced on a 6 to 12 inch long yellow panicle seed head (Ball et al., 2007). Indiangrass is both heat and drought tolerant but despite these characteristics it is not widely planted in the South at present (Ball et al., 2007). It does best in fertile clay soils that are well-drained (Ball et al., 2007).

Indiangrass produces from late June to September and can be used for either pasture or hay (Ball et al., 2007). As with other grasses, nutritional quality declines with maturity (Hastert et al., 1983; Temu, 2011; Waramit, 2010), but indiangrass has higher nutritional quality than most other warm season grass species (Ball et al., 2007; Hastert et al., 1983; Krueger and Curtis, 1979a). In one experiment, indiangrass produced fewer grazing days than either big bluestem or switchgrass and less gain per hectare, but it produced the greatest steer gain (Krueger and Curtis, 1979a). It responds well to nitrogen (Ball et al., 2007; Hall, 1982; Waramit, 2010), which is the most important fertilizer for indiangrass, and it generally does not respond as well to other nutrient inputs as cool-season grasses (Ball et al., 2007).

Although indiangrass is generally less productive than either switchgrass or big bluestem (Hall, 1982; Krueger and Curtis, 1979a), it still produces adequate yields to support grazing animals (Hall, 1982). Yield can be increased by clipping at the seed-ripening stage or later (Vogel and Bjugstad, 1968) and through nitrogen fertilization (Waramit, 2010).

Big Bluestem

Big bluestem (*Andropogon gerardii* Vitman) is a warm-season perennial grass native to the Great Plains and the eastern United States (Ball et al., 2007). It is a bunch type grass that reproduces by seed on a seed head possessing three to six spikes with twisted awns (Ball et al., 2007). It is deep-rooted, sometimes possessing short rhizomes, and is more drought tolerant than most other warm-season grass species (Ball et al., 2007). It maintains acceptable palatability and nutritive value over a greater length of time than switchgrass and produces from June to August (Ball et al., 2007). When incorporated into a grazing system containing cool-season grasses, big bluestem yielded more animal gain/ha than did the system which incorporated switchgrass with cool-season grasses. Animals grazing big bluestem have similar (Hudson, 2008b) or slightly lower average daily gain than animals grazing switchgrass, but animal gain/ha can be similar (Krueger and Curtis, 1979a) or higher for animals grazing big bluestem than for animals grazing switchgrass (Hudson, 2008b). Due to its ability to produce greater yields for each percent of basal cover, big bluestem can produce yields comparable to switchgrass but with less percent basal cover (Riegel, 1947). In addition, big bluestem responds well to nitrogen fertilization (Ball et al., 2007; Hall, 1982; Waramit, 2010), but it will not tolerate continuous close grazing (Ball et al., 2007).

Big bluestem declines in quality as it increases in maturity over the course of the growing season (Burns, 2011; Forwood and Magai, 1992a; Mitchell et al., 2001; Temu, 2011; Waramit, 2010) which is partially contributed to by the declining amount and quality of leaf tissue and the increase in stem tissue (Forwood and Magai, 1992a; Griffin, 1983). Nevertheless, leaf tissue declines less in quality than stem tissue with maturation (Griffin, 1983; Jung, 1992). In addition, plant tissue that is more mature is more resistant to microbial degradation (Hastert et al., 1983; Jung, 1992) in the rumen resulting in increased time for breakdown and digestion of plant material (Hastert et al., 1983). There is other evidence that suggests that tiller development is at least partially responsible for decreasing leaf digestibility (MacAdam et al., 1996). Despite decreasing quality, if given the opportunity, animals will select for a higher quality than what is offered overall (Burns, 2011; Hudson, 2008b; Kirch et al., 2007). Declining quality could be combated by starting with higher quality forage. Despite earlier evidence suggesting otherwise (Ross et al., 1975), it is possible to breed big bluestem to develop strains that possess higher quality than the base populations and produce greater animal gains than base populations (Mitchell et al., 2005). However, yields are still sufficient to support grazing animals (Forwood and Magai, 1992a; Hall, 1982) and yield and tillering can be increased if the forage is cut or grazed after the seed-ripened stage (Vogel and Bjugstad, 1968).

Little Bluestem

Little bluestem (*Schizachyrium scoparium* (Michx.) Nash) is a native warm-season perennial bunchgrass (Karn, 1990). It does well on sites that are susceptible to drought and is a good forage producer (Karn, 1990).

Maturity of little bluestem has a negative impact on nutritive value (Karn, 1990) and interestingly, increased ozone concentrations can negatively impact nutritional quality as well (Powell et al., 2003). There is evidence to suggest that breeding programs to select for improved forage quality could be possible with little bluestem (Karn, 1990). Yields and spring tillering of little bluestem can be increased by cutting or grazing at the seed-ripening stage or later (Vogel and Bjugstad, 1968). This agrees with other findings that tiller recruitment appears to be influenced by herbivory, which influences mortality, more than by the re-growth potential of initiated tillers (Leite, 1986). A rotational stocking system would allow greater control over the frequency and uniformity of tiller defoliation (Derner et al., 1994). However, careful management would be required because there are potential problems in getting little bluestem to persist if it undergoes multiple close defoliations during the growing season (Mullahey et al., 1990).

Burning is a practice that has been used as a maintenance tool for native warm-season grasses. Annual burning can be used to increase grazers preference for little bluestem (Pfeiffer and Hartnett, 1995). However, since burning favors growth of larger basal area plants and grazers preferentially grazed larger basal area plants, a burning and grazing combination could detrimentally impact the stand over time (Pfeiffer and Hartnett, 1995). Over time, it would be expected that a population shift toward plants with a smaller basal area would occur (Pfeiffer and Hartnett, 1995). This shift toward smaller basal area plants might not have an impact on yield. Little bluestem has the capacity to produce large forage yields with less basal area than some other native-warm-season grasses (Riegel, 1947). The yield produced by little bluestem in one Kansas study was greater than yields produced by switchgrass and big bluestem (Riegel, 1947).

In addition, burning does not appear to negatively impact tiller production, and it can increase live stem and sheath biomass (Svejcar and Christiansen, 1986).

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3. ASSESSMENT OF VARIOUS METHODS OF SUMMER STOCKPILING TALL FESCUE

Abstract

Grown on more than 14.2 million hectares in the United States and over 1.32 million hectares in Virginia alone, tall fescue (*Festuca arundinacea* Schreb.) is a cool-season grass that produces flushes of growth in the spring and fall under Virginia climatic conditions. Management programs that optimize autumn and or summer stockpiled tall fescue may potentially increase livestock profitability in Virginia and throughout the region. The objective of this study was to assess the effect of summer stockpiling endophyte infected Kentucky 31 tall fescue on biomass and nutritive value of tall fescue forage. The experiment consists of four treatments each replicated six times in a split plot design. The four whole plot treatments were two nitrogen (N) application timing, legume inclusion, and control. Each of the four treatments was divided into a sub-plot treatment of either a cut or a no cut treatment. The cut treatment consisted of a single cutting taken in May. Nitrogen in the form of urea was applied in March (before the cutting) to one N application timing treatment and in June (after the cutting) to the June N application timing treatment at the rate of 56 kg/ha. There was no effect of fertilization on overall yield or fiber content. However, a year by cut interaction influenced yield ($p = 0.0224$). In 2011, the cut treatment resulted in over 54% more overall yield than the 2012 cut treatment. However, in 2012 the yield for the no cut treatment was similar to the 2011 cut treatment yield. Overall, regardless of treatment, yield from summer stockpile was affected by the amount of rainfall following the initiation of the stockpiling. Both yield and quality of the summer stockpiled fescue was adequate to support beef cows at a maintenance level.

Introduction

Tall fescue (*Festuca arundinacea* Schreb.) is a cool-season perennial grass that exhibits its greatest growth in the spring with significantly less growth in the fall. However, during the hotter temperatures of summer, tall fescue productivity decreases dramatically. This causes a shortage in available forage for livestock producers. Ideally, producers would like to be able to continue to utilize existing pasture during the summer without having to utilize stored feed or establishing warm-season species. However, if some cool-season pastures are converted to warm-season grass pastures, then total acreage of cool-season grasses would be reduced in the spring and early fall and producers could encounter some economic disadvantages (Hudson, 2008). On the other hand, if animals are simply left on dormant pastures the producer runs the risk of damaging the tall fescue plants through overgrazing.

Stockpiling fescue for use at a later date could present a solution to the problem of late summer forage availability. Fall stockpiling of tall fescue is a practice that is well documented and researched. It is simply the practice of saving the autumn accumulated growth for utilization later during the winter months. Although many types of forages can be used for stockpiling, its significant growth prior to the winter months (Jennings et al., 2008; Templeton et al., 1961; Yeh et al., 1976) and the maintenance of high quality forage during the winter (Archer and Decker, 1977a; 1977b; Burns and Chamblee, 2000b; Collins and Balasko, 1981b; Fribourg and Bell, 1984; Hedtcke et al., 2002; Ocumpaugh and Matches, 1977; Peterson et al., 2001; Rayburn et al., 1979; Riesterer et al., 2000; Robinson et al., 2007; Sheehan et al., 1985; Taylor and Templeton, 1976; Volesky et al., 2008) are all characteristics of tall fescue that make it an excellent candidate for stockpiling. A primary factor affecting yield and quality of stockpiled tall fescue is N fertilization (Archer and Decker, 1977a; Ball et al., 2007; Cherney and Cherney, 2006; Collins and Balasko, 1981a; Fribourg and Loveland, 1978b; Jennings et al., 2008; Poore et al., 2000;

Rayburn et al., 1979; Riesterer et al., 2000; Singer et al., 2003; Singer et al., 2007; Taylor and Templeton, 1976; Teutsch et al., 2005).

Tall fescue possesses a fungal endophyte that can cause detrimental effects to grazing animals (Ball et al., 2003; Jennings et al., 2008). However, there is evidence that the amount of toxins in fall stockpiled forage decreases over time (Burns et al., 2006; Drewnoski et al., 2007; Kallenbach et al., 2003), that the toxins do not impact calf gain (Curtis and Kallenbach, 2007), and have little effect on nutritive value or ruminal disappearance of the forage (Flores et al., 2007). If levels of the toxins decrease throughout the utilization period of fall stockpiled forage (Burns et al., 2006; Drewnoski et al., 2007; Kallenbach et al., 2003), then perhaps toxins in summer stockpiled forage would present less of a problem than might be otherwise predicted. The objective of this experiment was to investigate the ability of different stockpiling methods to fill the gap between the spring and fall growth of tall fescue by assessing their effectiveness at producing adequate biomass and nutritive value to support grazing animals.

Methods and Materials

A small plot experiment was conducted in 2011 and 2012 at the Shenandoah Valley Agricultural Research and Extension Center located in Steele's Tavern, Virginia. The experimental design was a split plot design with six replications of fertilization treatments as the main plot and cutting treatment as the sub-plots. The four fertilization treatments included two nitrogen (N) application timing treatments, a legume inclusion treatment, and a control (Fig 3-1). The whole plot treatment measured 6.096 m X 9.144 m (20' X 30') and each whole plot was divided into a sub-plot treatment consisting of cut and no cut treatments each measuring 3.048 m X 9.144 m (10' X 30'). Alleys between fertilization treatments measured 6.096 m (20') and alleys measuring 3.048 m (10') were left between replications. The small plots, including alleys, utilized a total area of 51.816 m X 54.864 m (170' X 180'). The cutting treatment consisted of a single cut taken in May or a no cut treatment. Nitrogen in the form of urea was broadcasted in March (before the cutting) to the March N application timing treatment and in June (after the cut) to the June N application timing treatment at the rate of 56 kg/ha (50 lbs/acre) (Fig 3-1). Originally, nitrogen was to be applied in May, but due to management constrains, we were not able to apply nitrogen until early June in both years. The experiment utilized existing endophyte infected Kentucky 31 tall fescue pasture that was at least 50 years old. Soil samples were randomly taken prior to treatment from the entire experimental site and were submitted to the Virginia Tech soil lab for a routine analysis.

Control- no cut	**Legumes- no cut**	**N March-no cut**	**N June- no cut**
Control- May cutting	**Legumes- May cutting**	**N March- May cutting**	**N June- May cutting**

Figure 3-1. Plot map showing treatment layouts, Shenandoah Valley AREC

For the legume treatment, Cinnamon Plus red clover (*Trifolium pratense*) and Pinnacle ladino clover (*Trifolium repens*) were frost seeded into the tall fescue stand on February 7, 2011. The red and ladino clover seed used was inoculated and broadcast into the tall fescue. Red clover and ladino clover were seeded at a rate of 7.85 kg/ha (7 lbs/acre) and 2.24 kg/ha (2 lbs/acre), respectively on pure live seed (PLS) basis. Using a quadrat (0.125 m^2), clover seedling density counts were made on April 20, 2011, and two quadrats from each legume treatment were counted (Appendix A-1). All plots that did not receive the legume treatment were sprayed with aminopyralid (2-pyridinecarboxylic acid, 4-amino-3, 6-dichloropyridine), trade name Milestone™, on April 25, 2011 to kill any volunteer legumes in the plots.

Forage Assessment

Biomass yield

In May, initial samples for biomass yield were obtained by harvesting a single quadrat ($0.25\ m^2$) per fertilization and cutting treatment combination (Table 3.1) to a stubble height of 10 cm (4 in). Samples were hand separated into legume and non-legume components. Samples for the final biomass yield assessment were obtained in the same manner in August (Table 3.1). Prior to harvesting the forage within the quadrat, botanical composition was assessed visually using the DAFOR Scale (Abaye et al., 1997; Brodie, 1985). Grab samples were obtained for nutritive value analysis. The entire field of which the plots were a part had been summer stockpiled. At the end of the experiment, the plots were grazed, and plant heights were taken pre- and post-grazing (Table 3.2). The plots were included in the first section as the field was strip grazed by 61 cows and calves in 2011and 45 cows and calves in 2012. After six days of grazing in 2011, the cattle were fenced out of the plots, and the plots were mowed to an even height on September 12, 2011. All forage samples were dried in a forced air-oven at 60^{0}C for at least 48 hours and biomass yield was calculated on a dry matter basis. After drying, samples for nutritive analysis were ground to pass through a 1-mm screen using a Wiley sample mill (Thomas Scientific, Swedesboro, NJ).

Table 3.1 Nitrogen application, cutting, and sampling dates

Nitrogen treatment		**Cutting treatment applied**	**Initial sampling date**	**Final sampling date**
March	**June**			
14	6	June 1	May 25-26	August 15
22	1	May 30	May 29	August 15

Table 3.2 Dates of grazing initiation, cattle removal, and pre- and post-grazing heights sampling

Year	Pre-grazing heights taken	Grazing initiated	Cattle removed	Post-grazing heights taken
2011	August 24	August 26	September 1	September 2
2012	August 15	August 16	----------------	August 21

Nutritive value analysis

Using wet chemistry, 16 out of 48 quality samples were analyzed for dry matter, ash content (AOAC, 2000), neutral detergent fiber (NDF) (Van Soest and Wine, 1967), acid detergent fiber (ADF) (Goering et al., 1970; Van Soest, 1963), and crude protein (CP). Levels of NDF and ADF for calibration sets were determined using the ANKOM filter bag system (ANKOM Technologies, 2003). Total N was determined by a nitrogen analyzer (varioEL CN cube, Elementar Americas, Mt. Laurel, NJ) using a modified Dumas method (AOAC, 2000). Crude protein was calculated as total N x 6.25. Neutral detergent fiber, ADF, and CP were predicted for all samples using near infrared spectroscopy (NIRS). WINISI II software was used to select a calibration dataset for wet chemistry determination (Infrasoft International, Port Matilda, PA). The coefficients of determination, standard errors of calibration, and cross validations for the calibration equations were, 0.97, 0.93, and 1.21; 0.98, 0.65, and 0.95, and 0.87, 0.71, and 0.92 for NDF, ADF and CP, respectively.

Environmental conditions during the two experimental years

Rainfall and temperature data were collected at the Shenandoah Valley Agricultural Research and Extension Center to help explain the influence on forage growth and nutritive value throughout the season and among years. The 2011 and 2012 rainfall and temperature data were compared against a nine year historical average to determine the typical weather patterns expected as compared to historical averages.

Data analysis

All yield and nutritive value data were analyzed using SAS statistical analysis software (SAS, 2008). All data was checked for normality using PROC UNIVARIATE (SAS, 2008). All nutritive value data was normally distributed. Yield data was not normally distributed and data was not transformed. Data was analyzed for the effect of fertilization treatment, cutting treatment, year, and all interactions between the three using PROC GLIMMIX (SAS, 2008). Significant two-way interactions were sliced by year. Significance was determined at a level of $\alpha = 0.05$ and responses for significant effects were separated using the Tukey-Kramer grouping of least squares means.

A "use" variable was calculated and used to analyze the yield data. This was necessary in order to accurately and fairly compare results from cut treatments where forage was removed as hay and no cut treatments where biomass was left to accumulate through August. The use variable represented the amount of forage available for use at the end of the experiment. For all the no cut treatments, use represented the yield from the final sampling. For the cut treatments, use represented the yield from the final sampling plus the amount of forage removed for hay. The amount of forage removed for hay was equal to the yield from the initial sampling. The amount of forage available at the end of the experiment to be grazed (final sampling) was analyzed separately.

All nutritive value data is the result of the final sampling. This is the nutritive value of the forage available in the field in August to be grazed. No nutritive value data was collected on the hay that was harvested.

Results and Discussion

Environmental conditions during the two experimental years

During 2011 there was greater than average precipitation during most of the year and growing season (Fig 3-2). In 2012, half the year exhibited greater precipitation than average and most of that was during the growing season (Fig 3-2). From January to August in 2011as compared to 2012, precipitation was greater by one, two, four, and three centimeters for February, March, April, and June, respectively (Fig 3-2). In 2012 as compared to 2011, precipitation was greater by five, four, and 0.5 cm for January, May, and July, respectively (Fig 3-2). Total precipitation was the same for the month of August in both years, but in the days prior to final harvest, greater precipitation was recorded in 2012 than in 2011.

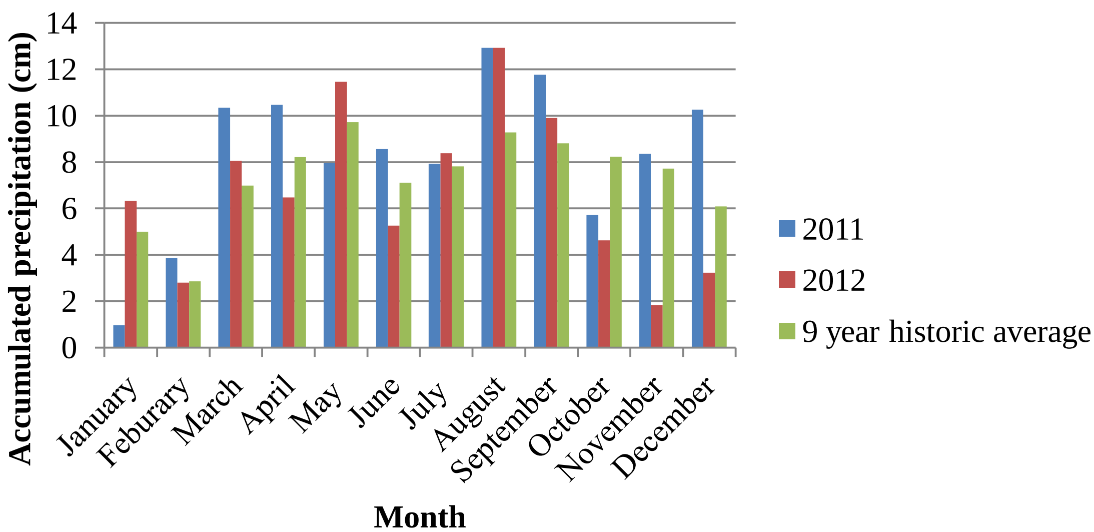

Figure 3-2. Accumulated precipitation by month for 2011, 2012, and a 9 year historic average for Shenandoah Valley AREC

The average temperature was greater for most of the year in both 2011 and 2012 than the historic average (Fig 3-3). Temperatures in 2011 were higher later in the growing season than in 2012 (Fig 3-3).

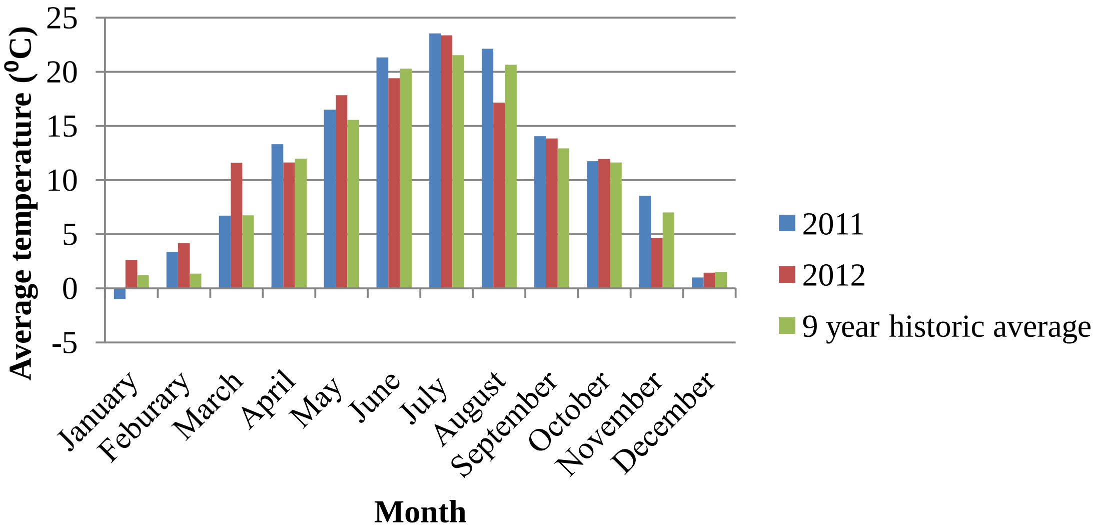

Figure 3-3. Average temperature (^{0}C) by month for 2011, 2012, and a 9 year historic average for Shenandoah Valley AREC

Total biomass yield

There was variation in total forage biomass yield available for use between treatments and years. Differences in average biomass yield are expected as weather conditions fluctuate between years. Yield was influenced by a year by cut interaction ($p = 0.0224$). Since there was no effect of fertilization and no interaction between fertilization and cut, results presented are averaged over fertilization treatment. The effect of cut and no cut treatments on yield was dramatically different between the two experimental years (Fig 3-4). While the cut treatment resulted in a similar yield to the no cut treatment in 2011, the no cut treatment resulted in a higher yield than the cut treatment in 2012 (Fig 3-4). In 2012, the yield for the no cut treatment was higher by 49% than the cut treatment (Fig 3-4). The yield for the cut treatment in 2011 was 54% greater than the 2012 cut treatment (Fig 3-4). This can be explained by the different environmental conditions during the 2011 and 2012 growing seasons. There was a greater amount of growth earlier in the season in 2011 compared with 2012 as evidenced by differences in hay yields ($p = 0.0014$) (Fig 3-5). Therefore, the greatest contribution to the higher use yield of the 2011 cut treatment (hay + final harvest) was from the hay yield which was removed earlier in the season, not from the final sampling of the cut treatment. At the time of the final sampling in August, in 2011, the tall fescue stand in the no cut treatment had less of an increase in biomass from the initial to the final sampling than occurred in 2012 (Appendix A-4). This could be due to losses of the earlier biomass growth through senescence (low leaf: stem) and the suppression of growth from new tillers due to lack of stimulation from harvest or grazing management. In 2012, the higher yield from the no cut versus cut treatment (Fig 3-4) can be attributed to two factors. First, early spring initial growth of tall fescue was significantly lower (Fig 3-5) and most of the growth remained vegetative (high leaf: stem) so the losses from senescence at the time of harvest was minimal. Second, although the amount of moisture received during the months of July and August of 2011 and 2012 was similar (Appendix A-3), temperature was much cooler in 2012 (Fig 3-3). Cooler temperatures are known to promote growth of cool-season grasses in summer months (Templeton et al., 1961; Yeh et al., 1976).

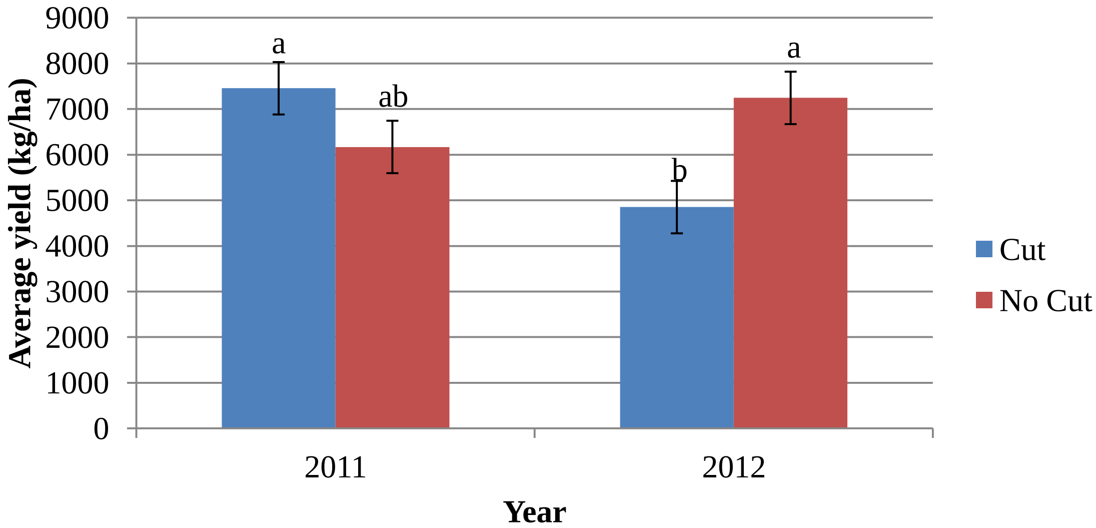

Figure 3-4. Average biomass yield for use (kg/ha) by cutting treatment and year. Results are averaged over fertilization treatments. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

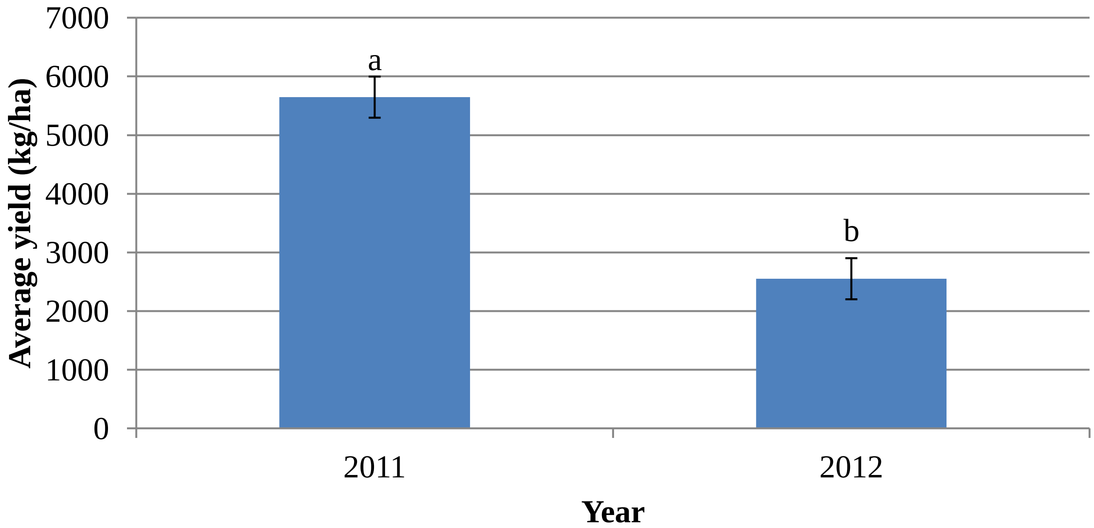

Figure 3-5. Average biomass hay yield (kg/ha) of cut only treatments by year. Results are averaged over fertilization treatments. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Forage available for grazing

Figure 3-6 shows the amount of forage that was available for grazing in August. This amount does not include the initial biomass yield (hay yield). The difference in the amount of forage available for grazing at the end of the experiment varied among the cut and no cut treatments ($p = 0.0004$) (Fig 3-6). Despite year having no effect on final grazing yields from cut treatments, the hay yield in 2011 (5646.8 kg/ha) was higher and more than double the hay yield in 2012 (2551.7 kg/ha) (Fig 3-5). This increased hay yield in 2011 boosted the overall yield available for use to greater than the 2012 cut treatment overall yield (Fig 3-4). Fertilizer treatment had no effect on final biomass yield (grazing yield) for the no cut treatment but did influence the grazing yield for the cut treatment ($p = 0.0352$) (Fig 3-7). The June N application produced the highest yield among the cut treatments due to the N being applied after the hay harvest (Fig 3-7). Growth was thereby stimulated by cutting and by the application of nitrogen. Treatments that had N applied in March had already taken advantage of the N to increase growth and had most of this forage removed as hay. On a dry matter basis, the legume components were negligible, and therefore, less than desirable to contribute to growth through N fixation (Fig 3-7).

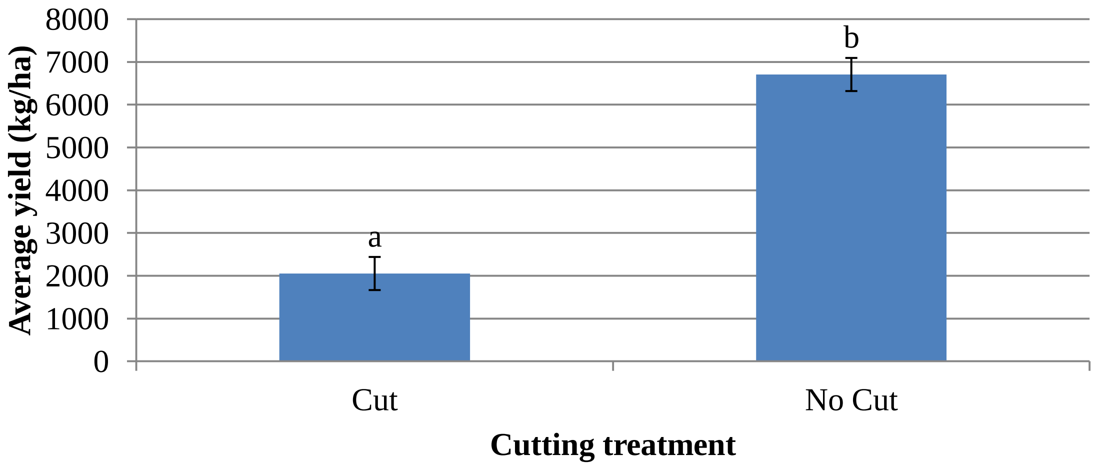

Figure 3-6. Average biomass yield for grazing (kg/ha) by cutting treatment. Results are averaged over fertilization treatments and years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

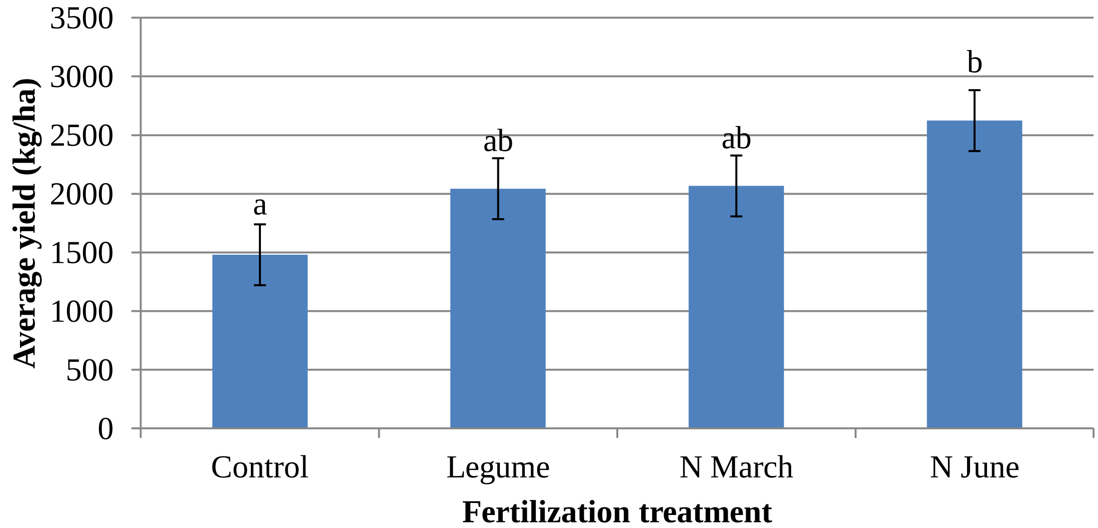

Figure 3-7. Average biomass yield for grazing (kg/ha) by fertilization treatment for only the cut treatments. Results are averaged over years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Nutritive value

Variations in NDF, ADF, and CP were found across treatments. For both NDF and ADF, the effects of cut ($p < 0.0001$) and the year by cut interaction ($p < 0.0001$) were observed. Due to the year by cut interaction, data will be presented by cut and year. The no cut treatment exhibited higher NDF levels, in both years, than the cut treatment (Fig 3-8). Overall, the 2011 cut and no cut treatments had the lowest and highest NDF levels, respectively (Fig 3-8). The difference between the two cutting treatments for NDF in 2011 was 12 percentage points but only 2.3 percentage points in 2012 (Fig 3-8). Neutral detergent fiber is closely related to stage of maturity. Forage at vegetative stages will have lower NDF compared to forage with advanced growth stages (Ball et al., 2007; Burns and Chamblee, 2000b; Hedtcke et al., 2002; Sheehan et al., 1985). Hence the cut treatment resulting in lower NDF compared to the no cut treatment (Fig 3-8). Similar results for cut versus no cut was reported (Ball et al., 2007).

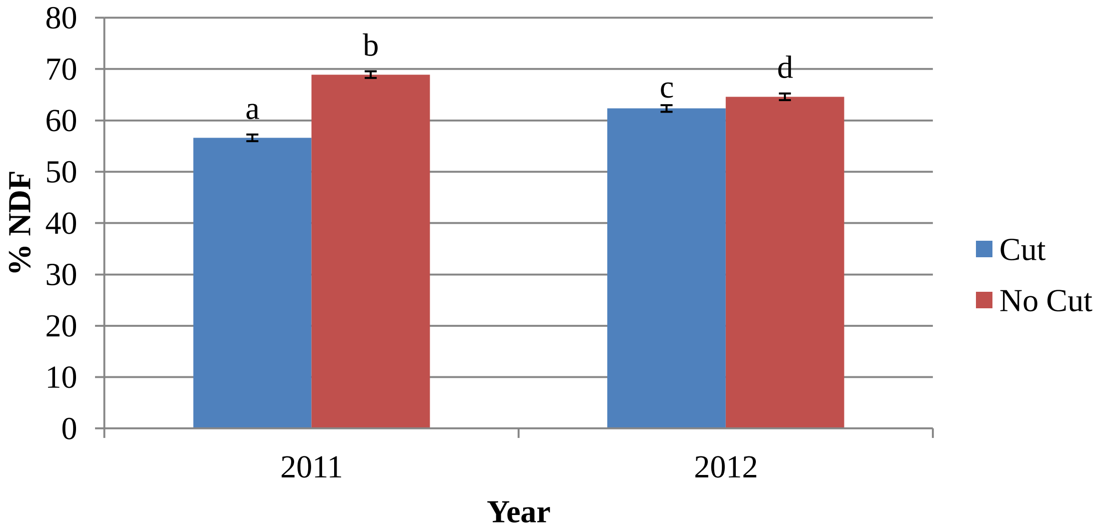

Figure 3-8. Percent neutral detergent fiber by cutting treatment and year. Results are averaged over fertilization treatments. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Acid detergent fiber results were also influenced by year ($p = 0.0186$). Due to the year by cut interaction, data will be presented by cut and year. Similar to NDF, ADF levels were higher in no cut as compared to the cut treatments and in 2011as compared to 2012. The 2011 cut and no cut treatments possessed the lowest and highest ADF levels, respectively (Fig 3-9). The difference between the cut treatments was more evident in 2011 (8.9 percentage points) than in 2012 (2.2 percentage points) (Fig 3-9). Results reflecting the relationships between growth stages and fiber have been reported (Ball et al., 2007; Burns and Chamblee, 2000b; Hedtcke et al., 2002; Sheehan et al., 1985). Those ADF values reported in our experiment were considered prime hay quality for the 2011 cut treatment (Ball et al., 2007). The percent ADF range was comparable to alfalfa ranging from bud to full bloom in maturity (Ball et al., 2007).

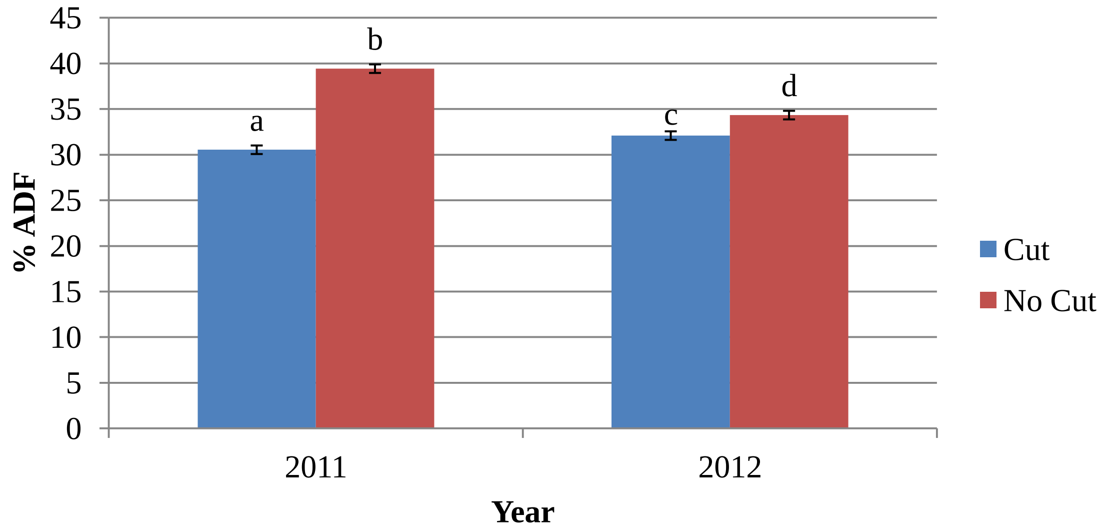

Figure 3-9. Percent acid detergent fiber by cutting treatment and year. Results are averaged over fertilization treatments. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Crude protein was affected by fertilization ($p = 0.0178$), year ($p = 0.0002$), and the year by cut interaction ($p < 0.0001$). The June N application resulted in higher CP levels than any other fertilization treatment due to the timing of the nitrogen application (Fig 3-10). When nitrogen was applied in March, the plant was able to use the nitrogen to increase growth and quality, but the cut plots then had this higher quality forage removed as hay. Therefore, the effect of nitrogen fertilization on crude protein levels is not as great because half the plots have had this higher quality forage removed. With the June N application, the full effect of N fertilization on CP levels is realized because N was applied after hay was removed from the cut treatments. Thereby, both the forage in the cut and no cut treatments experienced an increase in CP levels and none of this higher quality forage was removed before the final sampling. The effect of N fertilization on CP has been documented (Archer and Decker, 1977a; Ball et al., 2007; Hedtcke et al., 2002; Singer et al., 2003; Singer et al., 2007; Taylor and Templeton, 1976;

Teutsch et al., 2005). The lack of response to legume inclusion (Fig 3-10) can be contributed to the less than desired legume content in the stand. In our experiment, the amount of clover in the stand was minimal and did not contribute to nutritive value through N fertilization via N fixation. The lack of the legume persistence in the plots could be attributed to the lack of frequent cutting management and shading by the tall fescue. Previous research has shown greater levels of CP in legumes versus grasses (Allen et al., 1992b; Robinson et al., 2007; Sheehan et al., 1985).

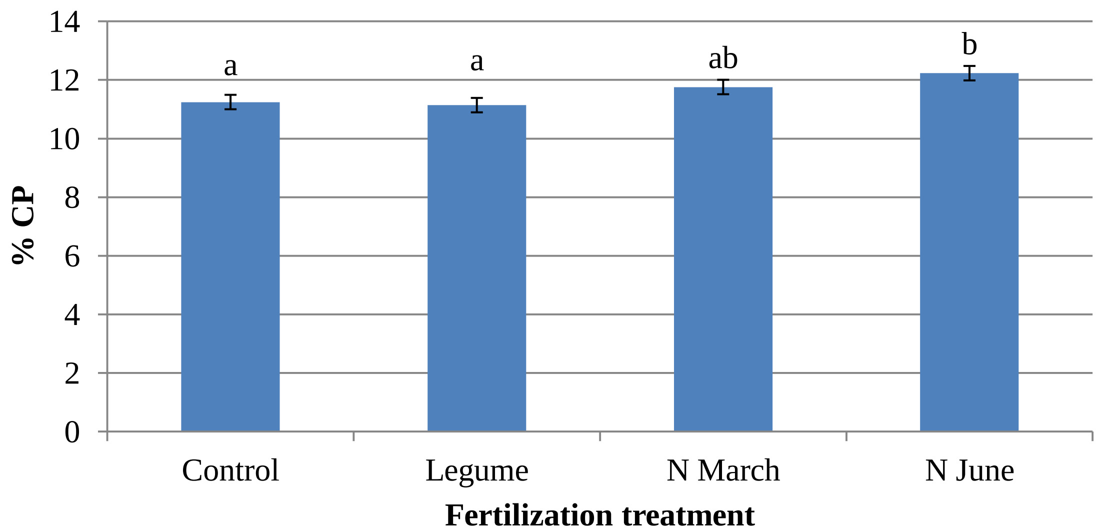

Figure 3-10. Percent crude protein by fertilization treatment. Results are averaged over cutting treatments and years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Due to the year by cut interaction, data is presented by cut and year. The highest and lowest CP levels were in the 2012 no cut and 2011 no cut treatments, respectively (Fig 3-11). Cut treatments had similar CP levels between years (Fig 3-11). The difference in CP levels between cut and no cut treatments is less evident in 2012 (1.6 percentage points) as compared to 2011 (2.6 percentage points) (Fig 3-11). Similar results in CP values for fall stockpiled tall fescue accumulated for shorter versus longer accumulation periods was reported by several researchers (Ocumpaugh and Matches, 1977; Rayburn et al., 1979; Volesky et al., 2008). As for NDF and ADF, the difference in CP levels between the cut and no cut treatments can be attributed to maturity associated with advanced growth stages (Ball et al., 2007). However, the result for CP was not consistent over the two experimental years. While CP was higher in the cut treatment in 2011, the result was reversed in 2012 (Fig 3-11). We attribute this to the previously discussed continued growth and tillering that occurred in summer and the higher leaf: stem in 2012 as compared to 2011.

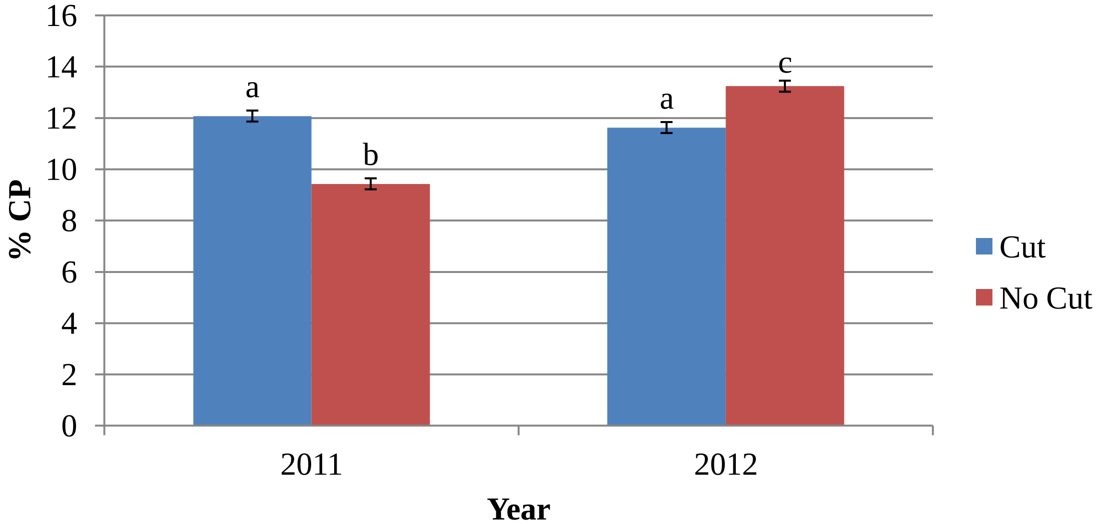

Figure 3-11. Percent crude protein by cutting treatment and year. Results are averaged over fertilization treatments. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Summary and Conclusions

The various treatments, cut versus no cut and legume versus N applications, all resulted in variable yield over the two experimental years. The effect of cut versus no cut on overall biomass yield was directly related to the initial forage growth prior to stockpiling and moisture and temperature during the stockpiling period. The overall yield and nutritive value was not influenced by the presence of legumes due to the less than desired amount of clover present in the stand. The failure to establish and maintain a high level of legumes in the stand was attributed to the high density of tall fescue residue during establishment and problems with persistence during stockpiling. Schlueter and Tracy (2012) have shown the negative coorelation between crop residue and legume establishment. Although, nitrogen fertilization improved forage quality, overall, the effect was more due to forage maturity than treatment .

In our experiment, at the end of the summer stockpiling period in both 2011 and 2012, there was reasonably high biomass yield available for use. However, the source of the total biomass yield for use differed between the two experimental years. That is, in 2011, the total available forage for use by the end of the summer was more attributed to the hay yield versus the standing biomass (grazing yield) in 2012. Therefore, regardless of the feed source (hay versus grazeable forage), summer stockpiling can be a viable alternative to those producers having cattle that do not require high forage quality, such as animals on maintenance level of feed requirements.

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4. COMPARING SUMMER STOCKPILED TALL FESCUE TYPES TO NATIVE WARM-SEASON GRASSES

Abstract

Tall fescue (*Festuca arundinacea* Schreb.) is a cool-season perennial grass that is only productive during cool-moist months. On the other hand, native warm-season grasses are capable of producing forage during the hot summer months through early fall and could be used to fill the gap in production that exists for cool-season grasses. The objective of this study was to assess the yield and nutritive value of four native warm-season grasses versus three tall fescue types. Three replications of three types of tall fescue (endophyte infected (E+), endophyte-free (E-), and novel endophyte (MaxQ)), and four replications of four native warm-season grass species (switchgrass (*Panicum virgatum* L.), big bluestem (*Andropogon gerardii* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Schizachyrium scoparium* (Michx.) Nash)) were used. The experiments were conducted at Kentland Farm near Blacksburg, VA during the 2011 and 2012 growing seasons. The three year old tall fescue plots were fertilized in March of both years with nitrogen in the form of urea at a rate of 56 kg/ha (52 lbs/acre). The native warm-season grasses were not fertilized. No difference in biomass yield was observed between the fescue types and ranged from 2454 to 3123 kg/ha. The biomass yield of the native grasses was much higher than the fescue types ranging from 5971 to 26,372 kg/ha. While both the cool-season and native grasses produced relatively high yield, the nutritive value was within and below the acceptable level for the fescue types and native grasses, respectively. Based on the data we collected, both the cool-season and native grasses can provide adequate feed to fill the production gap (mid-summer to mid-fall), if the grasses are managed to maximize their nutritive value and yield potential.

Introduction

Warm-season grasses can be used during the summer months to fill in gaps created by the low productivity of cool-season grasses. Native warm-season grasses can produce adequate yields to support the needs of grazing animals with lower nutritional requirements especially when utilized during late spring and early summer. However, late summer and early fall present challenges to producers with cool-season pastures. During this time period, tall fescue is just starting the fall growth period but the biomass yield is not yet sufficient to support grazing animals. Native warm-season grasses are reaching the end of their production period. Therefore, the need exists for a forage source that provides both adequate yield and nutritive value to support grazing animals during the period of late summer and early fall. In 2011 and 2012, we compared the yield and nutritive value of three types of tall fescue (*Festuca arundinacea* Schreb.) (endophyte infected (E+), endophyte-free (E-), and novel endophyte (MaxQ)) with four native warm-season grass species (switchgrass (*Panicum virgatum* L.), big bluestem (*Andropogon gerardii* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Schizachyrium scoparium* (Michx.) Nash)). The overall objective of the experiment was to compare the yield and nutritive value of summer stockpiled tall fescue types with harvested native warm-season grasses during the late summer and early fall.

Methods and Materials

In 2008, several cool-season and warm-season annual and perennial forages were established and evaluated for biomass yield and nutritive values. The experiments were used to support several graduate students projects. Both the warm-season grass plots and the tall fescue type plots were part of two separate larger experiments which originally had a randomized complete block design in their separate experiments. From one experiment, we utilized three tall fescue types: endophyte infected tall fescue (KY31 E+), endophyte-free (KY31 E-), and novel endophyte (Jesup MaxQ). Tall fescue plots measured 3 m X 9 m (9.84' X 29.53') and were replicated three times. Plots were seeded at a rate of 35 (31.3 lbs/acre PLS), 33 (29.5 lbs/acre PLS), and 34 kg/ha (30.4 lbs/acre PLS)pure-live seed (PLS) for endophyte infected, endophyte-free and novel endophyte, respectively (Newman et al., 2012). Nitrogen was applied in the form of urea at the rate of 56 kg/ha (52 lbs/acre) on March 10, 2011 and March 22, 2012.

The warm-season grass species utilized from the other experiment were: 'Cave-in-Rock' switchgrass (*Panicum virgatum* L.), 'Niagara' New York ecotype big bluestem (*Andropogon gerardii* Vitman), Pennsylvania ecotype indiangrass (*Sorghastrum nutans* (L.) Nash), and Fort Indiantown Gap Pennsylvania ecotype little bluestem (*Schizachyrium scoparium* (Michx.) Nash). Warm-season grass plots measured 2 m X 3 m (6.56' X 9.84'). Plots were broadcast seeded at a rate of 14.01 kg/ha PLS (12.5 lbs/acre PLS), were replicated four times, and were never fertilized with nitrogen (Bonin, 2011). Samples for biomass yield were obtained by taking a single quadrat (0.25 m^2) at both sampling dates in both years. Plots were sampled July 1 and August 17 in 2011 and June 25 and August 7 in 2012. The tall fescue plots were harvested to a stubble height of 10 cm (4 in), while warm-season grass plots were harvested to a stubble height of 15 cm (6 in). All data presented is based on the final sampling in August.

Samples were dried and biomass yield was calculated on dry matter basis. Sub samples were obtained from the biomass yield for the nutritive value analysis. Neutral detergent fiber (NDF) (Van Soest and Wine, 1967), acid detergent fiber (ADF) (Goering et al., 1970; Van Soest, 1963), and crude protein (CP) (AOAC, 2000) were analyzed in the lab.

Rainfall and temperature data were collected at Kentland Farm in 2011 and 2012 and compared against a 14 year historical average to determine the typical weather patterns expected as compared to historical averages.

Data analysis

All yield and nutritive value data were analyzed using SAS statistical analysis software (SAS, 2008). All data for both fescue samples and native warm-season grass samples was checked for normality using PROC UNIVARIATE (SAS, 2008). All yield and nutritive value data for fescue and native warm-season grasses were normally distributed. Data was analyzed for the effect of fescue type (treatment) and grass species (treatment) using PROC GLIMMIX for fescue samples and native warm-season grass samples, respectively (SAS, 2008). Data was also analyzed for the effects of year and year by treatment interactions using PROC GLIMMIX (SAS, 2008).

Results and Discussion

Precipitation was higher in 2011 compared to 2012 and higher than the historic average during the growing season of tall fescue (March-August) (Appendix B-2). The average temperature was higher in 2011 compared to 2012 and higher than the historic average during most of the growing season (Appendix B-3).

Biomass yield

There was no difference in biomass yield between the tall fescue types (Fig 4-1). Yield was 2454, 3123, and 2975 kg/ha for Max Q, E+, and E-, respectively (Fig 4-1).

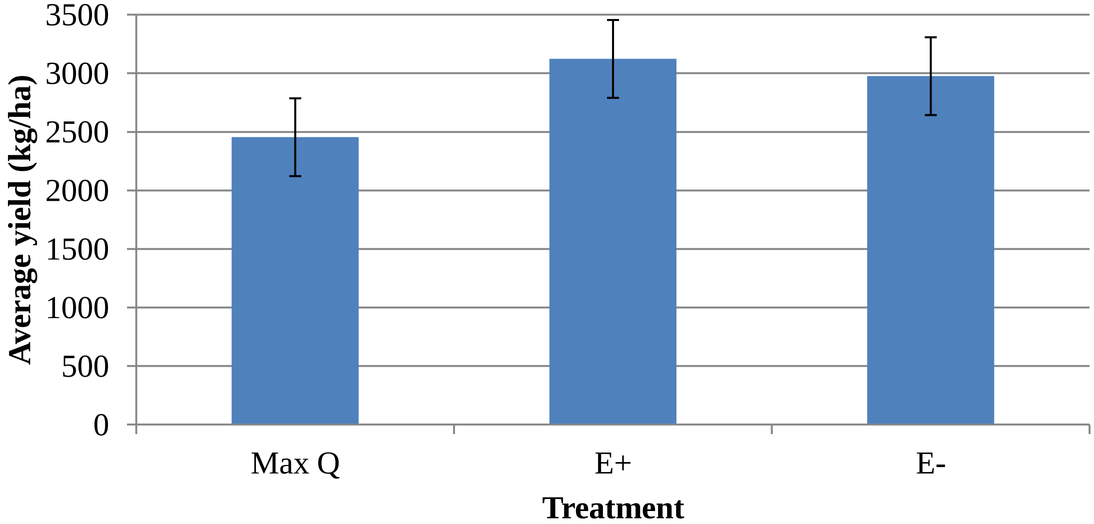

Figure 4-1. Average biomass yield (kg/ha) by treatment for tall fescue types. Results are averaged over both years. Bars indicate standard error.

Among the native warm-season grasses, treatment ($p < 0.0001$) influenced yield. Switchgrass produced far more biomass than indiangrass, big bluestem, or little bluestem (Fig 4-2). The difference in biomass yield was 13,697, 14,207, and 20,401 kg/ha between switchgrass and indiangrass, big bluestem, and little bluestem, respectively (Fig 4-2). The biomass yield for switchgrass we observed was similar to the biomass yield observed for fertilized switchgrass managed as a dual purpose bioenergy and forage crop (Guretzky et al., 2011).

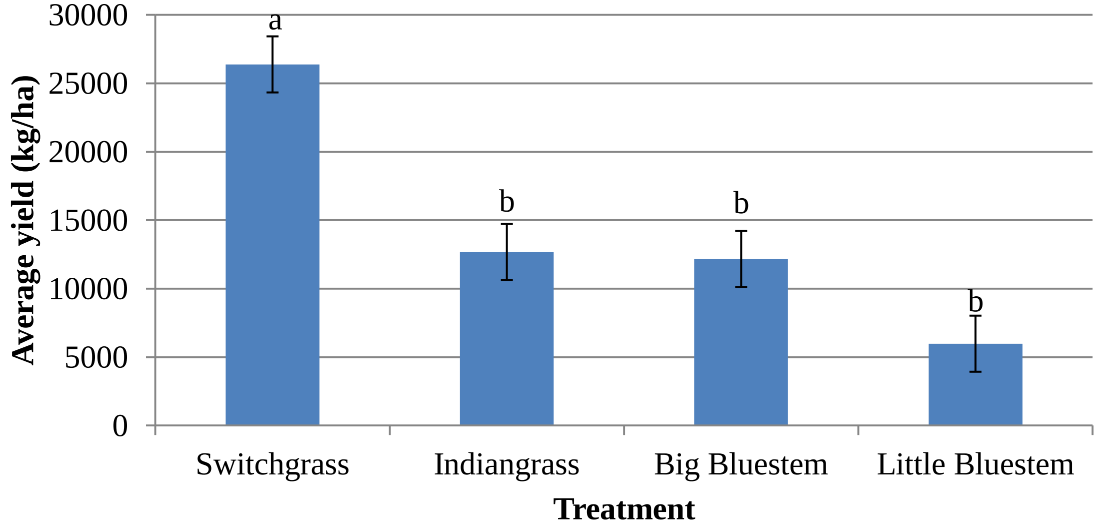

Figure 4-2. Average biomass yield (kg/ha) by treatment for native warm-season grasses. Results are averaged over both years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Nutritive value

Generally, for the tall fescue types, no difference in nutritive value was observed (Appendix B-4, 6, 8). Similar results were obtained (Burns et al., 2006; Flores et al., 2007; Fritz and Collins, 1991; Kallenbach et al., 2003) while other researchers (Drewnoski et al., 2007) found differences in nutritive value among fescue types. Nutritive value was higher in 2012 than in 2011 [NDF ($p = 0.0171$), ADF ($p = 0.0060$), and CP ($p = 0.0040$)] for all tall fescue types with lower NDF (Fig 4-3) and ADF levels (Fig 4-3) and higher CP levels (Fig 4-4). The lower fiber and CP levels in 2012 can be attributed to the stage of maturity at harvest. The negative effect of maturity on forage quality was reported (Burns and Chamblee, 2000b; Hedtcke et al., 2002;

Sheehan et al., 1985).

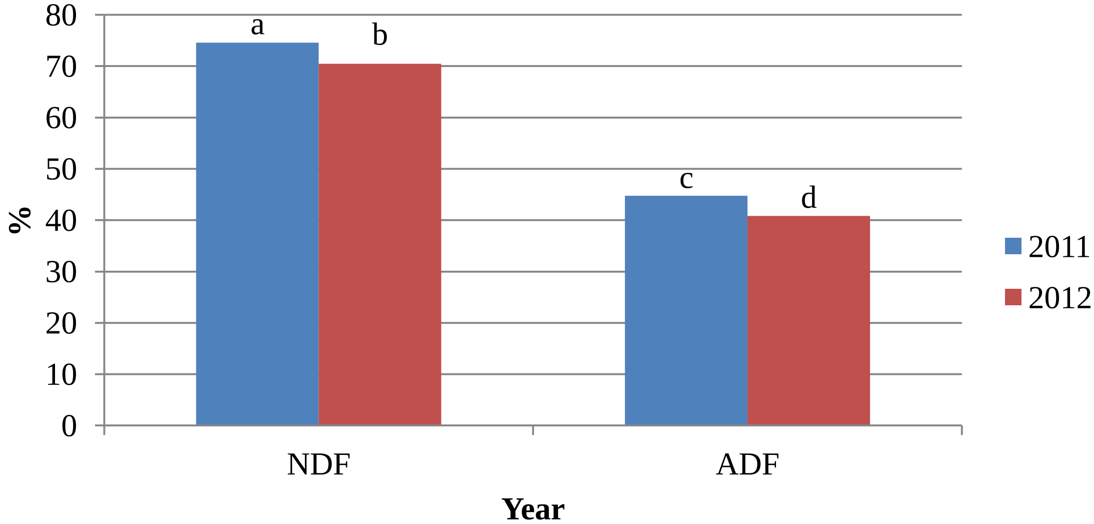

Figure 4-3. Percent neutral detergent fiber and acid detergent fiber by year for tall fescue types. Results are averaged over tall fescue types. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$). Comparisons are not made between neutral and acid detergent fiber.

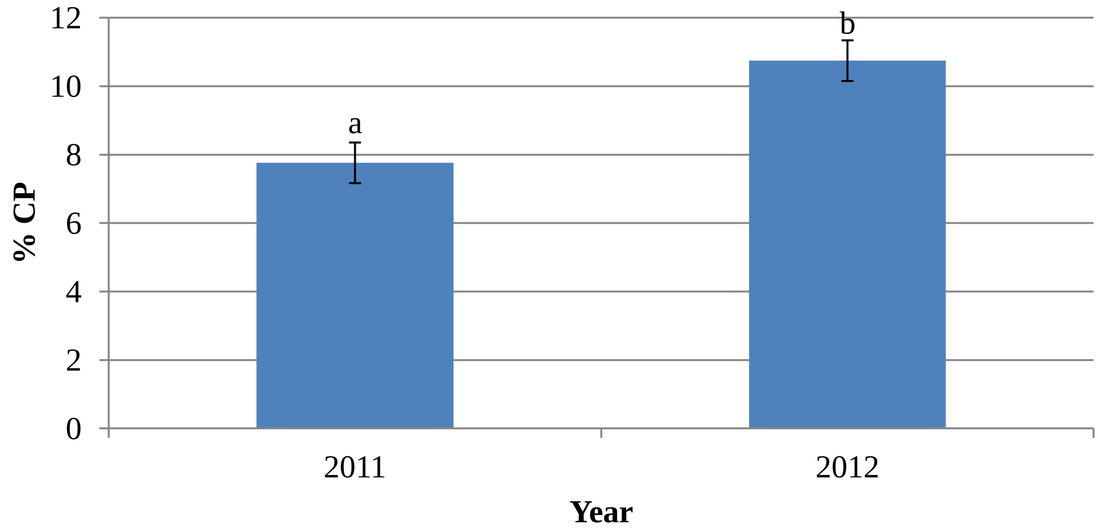

Figure 4-4. Percent crude protein by year for tall fescue types. Results are averaged over tall fescue types. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Both treatment ($p < 0.0001$) and the year by treatment interaction ($p = 0.0102$) influenced NDF for warm-season grasses. Averaged over years, NDF was the lowest for switchgrass compared to the other native grasses (Appendix B-9). Similar results were reported by some researchers (Cuomo and Anderson, 1996; Jefferson et al., 2004; Kirch et al., 2007; Powell et al., 2003; Sanderson, 2008; Sanderson and Burns, 2010; Sanderson et al., 1999; Twidwell et al., 1988), but mixed results were reported by others (Cuomo and Anderson, 1996; Guretzky et al., 2011; Jefferson et al., 2004; Madakadze et al., 1998). Figure 4-5 shows the year by treatment effect. In 2011, NDF value was lower for switchgrass than indiangrass, big bluestem, and little bluestem but was only lower than indiangrass in 2012 (Fig 4-5). The NDF value for big bluestem and little bluestem was higher in 2011 compared to 2012 (Fig 4-5).

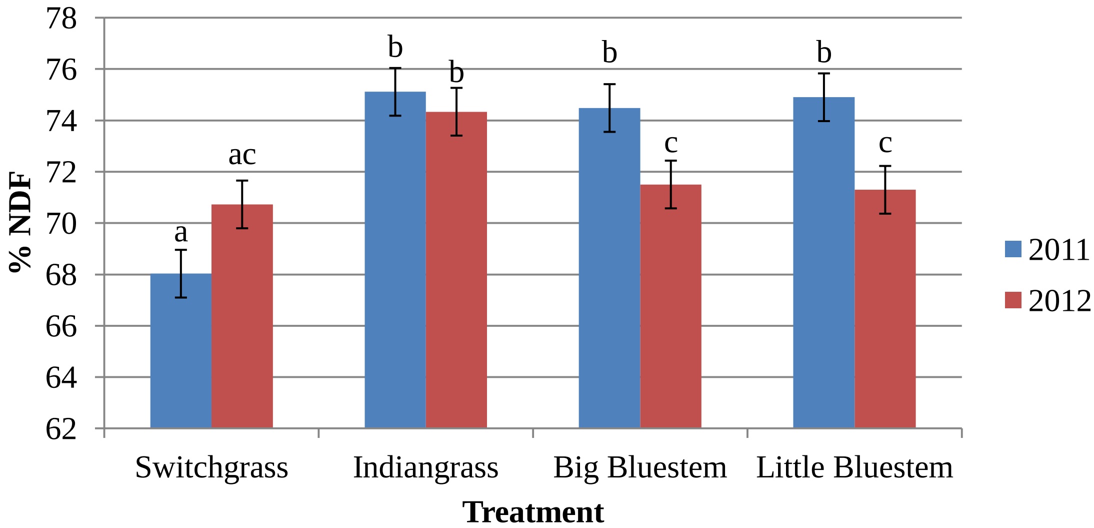

Figure 4-5. Percent neutral detergent fiber by treatment and year for native warm-season grasses. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Averaged over both years, the only difference in ADF between treatments ($p = 0.0108$) was the lower ADF value of switchgrass as compared with big bluestem (Appendix B-11). Similar results were obtained by (Cuomo and Anderson, 1996; Kirch et al., 2007; Powell et al., 2003; Sanderson and Burns, 2010; Twidwell et al., 1988) but results were mixed compared with other researchers (Guretzky et al., 2011; Madakadze et al., 1998). There was a treatment by year interaction ($p = 0.0477$) but only little bluestem had lower ADF levels in 2012 as compared to 2011 (Fig 4-6). The differences in NDF and ADF values among the native species can be attributed to the difference in their morphological and phenological characteristics coupled with environmental conditions during the growing season. The differences we observed in fiber contents among the native grasses could be attributed to the differences in stem: leaf among the native grasses as previous works have shown (Griffin, 1983; Jung, 1992; Twidwell et al., 1988) as well as the impact of different environmental conditions. However, we do not have sufficient data to determine the exact reasons why we observed differences in nutritive values among the native warm-season grass species.

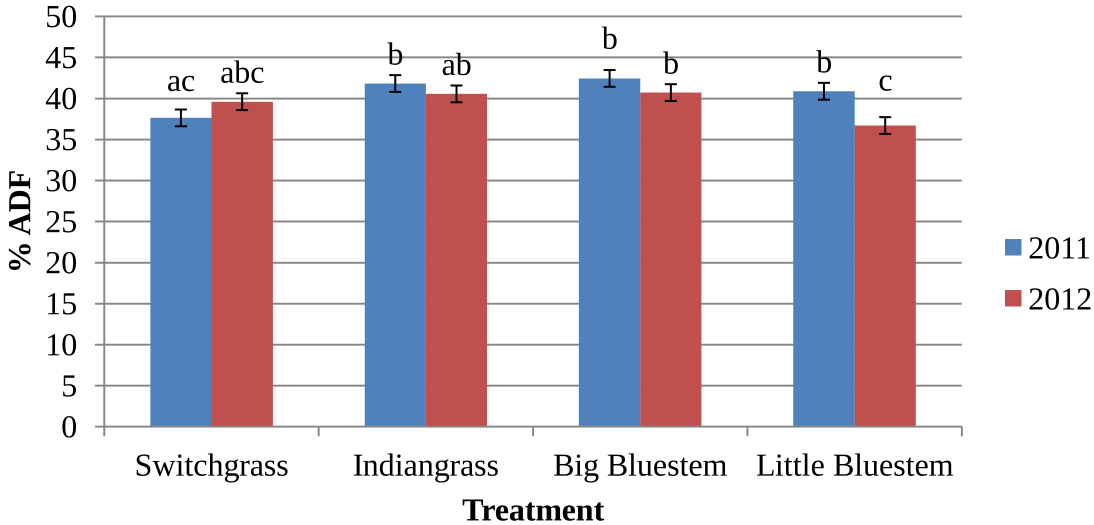

Figure 4-6. Percent acid detergent fiber by treatment and year for native warm-season grasses. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Crude protein was impacted by treatment ($p = 0.0120$), year ($p = 0.0067$), and a year by treatment interaction ($p = 0.0393$). No difference in CP averaged over years among indiangrass, little bluestem, and switchgrass was observed (Appendix B-13). Overall, the CP levels were low for all the native species, and similar to other research where switchgrass, big bluestem, and indiangrass was harvested in August (Krueger and Curtis, 1979). However, other results were mixed (Cuomo and Anderson, 1996; Forwood and Magai, 1992; Koshi et al., 1982). The low values observed can be attributed to maturity at harvest and lack of N fertilization (Fig 4-7).

Crude protein was higher in 2012 (6.0%) as compared to 2011(5.1%) (Appendix B-14) due to more favorable growing conditions in 2012, presumably allowing a greater portion of green tissue to be present at the final harvest as compared to 2011. In addition, the harvest in

2012 was slightly sooner than the 2011 harvest which could have contributed to the higher CP levels due to the forage potentially being in a more vegetative state. However, only indiangrass exhibited a higher CP level in 2012 as compared to 2011 (Fig 4-7).

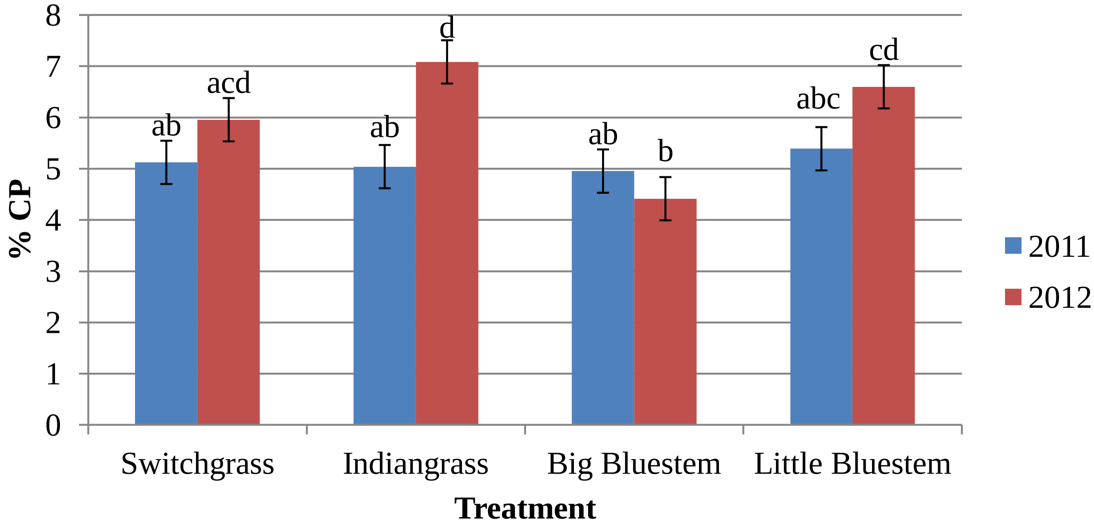

Figure 4-7. Percent crude protein by treatment and year for native warm-season grasses. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

Summary and Implications

There was no yield or nutritive value difference between the tall fescue types over the two experimental years. Total yield ranged from 2454-3123 kg/ha for the season. This suggests that E+, E-, or MaxQ can be successfully stockpiled with no differences in yield and nutritive value. Overall, our results suggest that summer stockpiled tall fescue can be a good source of feed during late summer and early fall when feed resource is often scarce.

Differences in yield and nutritive value were observed among the native warm-season grasses. Yield was very high for the native grasses, ranging from 5971 to 26,372 kg/ha, but overall quality was very low. The CP value of the native grasses ranged from 5-7% which is below the amount required for all classes of livestock. The data we collected indicated that, regardless of types, at a similar stage of maturity, tall fescue will have a higher feed value than the native grasses.

Although maturity is inversely related to the nutritive value of both introduced and native species, the decline in quality with maturity is more pronounced in native grasses. This is due to the fact that native grasses (warm-season grasses) inherently have a higher ratio of less digestible tissue than cool-season grasses. In order to improve the nutritive value of both the cool-season and the native grasses, it will be important to harvest or graze while the grasses species are not fully matured. If managed to maximize their nutritive value and yield potential, native grasses would be utilized during early summer. Based on the data we collected, summer stockpiled tall fescue can provide adequate feed to fill the production gap in late summer and early fall.

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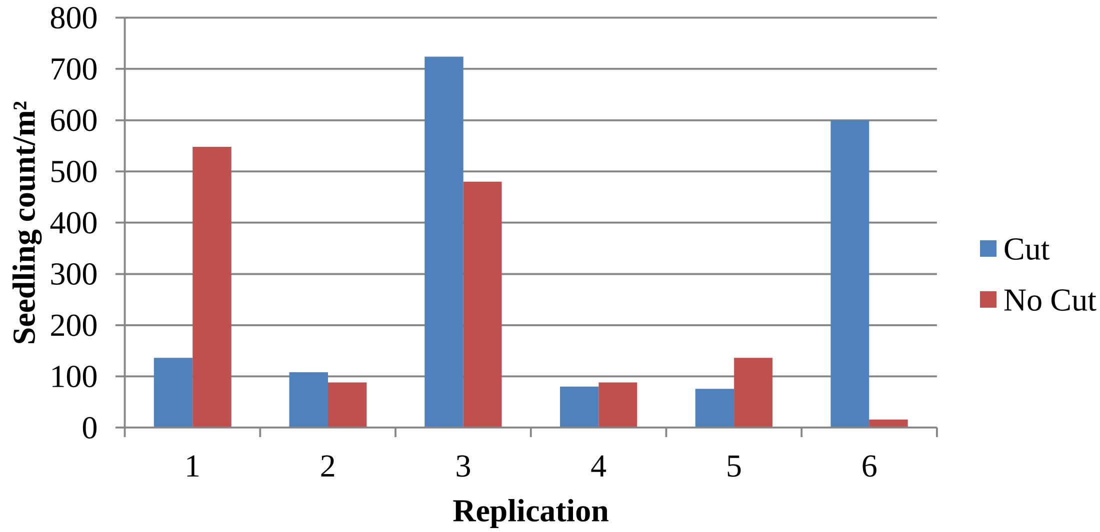
5. Summary and Conclusions

Tall fescue plays a major role as a forage crop in the United States due to its wide adaptation and tolerance to various stressors. Producers with tall fescue pastures face the challenges presented by its seasonal forage distribution curve. The majority of the seasonal forage yield is produced in early spring (April/May) with a relatively small but significant production in early fall, leaving a production gap in mid-summer. This study explored methods to provide forage during the late summer and early fall while comparing these methods with other available options.

Investigation of the best method of stockpiling tall fescue showed that both yield and nutritive value of stockpiled tall fescue varied during the two experimental years due to variations in rainfall and temperature experienced. Fertilization of tall fescue can increase yield and nutritive value if adequate rainfall is received. Harvesting tall fescue as hay before the initiation of stockpiling can increase overall yield available for use if growing conditions favor abundant growth before hay harvest and typical mid-summer dormancy is experienced. However, yield and nutritive value advantages can be experienced if summer temperatures are cooler and fescue receives rainfall needed to continue growth and production. The risk of potentially decreased yield and nutritive value from not harvesting hay would have to be weighed against the costs of harvesting and feeding hay. Producers need to determine if the risk and costs of harvesting hay would be greater than if forage was allowed to continue growth through spring and summer to be grazed in late summer and early fall. Adequate yield and quality was produced by all fertilization and cutting combinations to support animals with low nutritional requirements.

Expansion of the investigation of summer stockpiling included the need to compare tall fescue with native warm-season grass alternatives that could provide forage during late summer and early fall. Despite variations between years, no difference in yield or nutritive value was experienced for tall fescue types. Overall, switchgrass exhibited the highest yield and lowest fiber of any of the warm-season grass species. However, crude protein levels for all warm-season grasses were not adequate to support even the lowest requirement class of beef cattle. Nitrogen fertilization could boost crude protein levels of the warm-season grasses, which did not receive nitrogen fertilization, but if the grass is not harvested at an early stage of maturity, low forage quality associated with maturity could continue to present challenges. Stockpiled tall fescue, while yielding much less, met the nutritional needs of dry beef cows. Native warm-season grasses can have a place in the production system; however, producers can realize increased benefit from utilization earlier in the summer.

Summer stockpiled tall fescue resulted in adequate yield and nutritive value to support the nutrient need of grazing animals despite management strategy and growing conditions. Stockpiled tall fescue produced less yield but higher nutritive value than native warm-season grasses. By still providing adequate yield and nutritive value despite management strategy, tall fescue exhibited flexibility in response to the method of summer stockpiling that can be utilized to meet differing producer requirements and resources. Although individual results will vary depending on specific conditions present, management of summer stockpiled tall fescue can be customized to meet individual producer needs and objectives to provide forage for late summer and early fall.



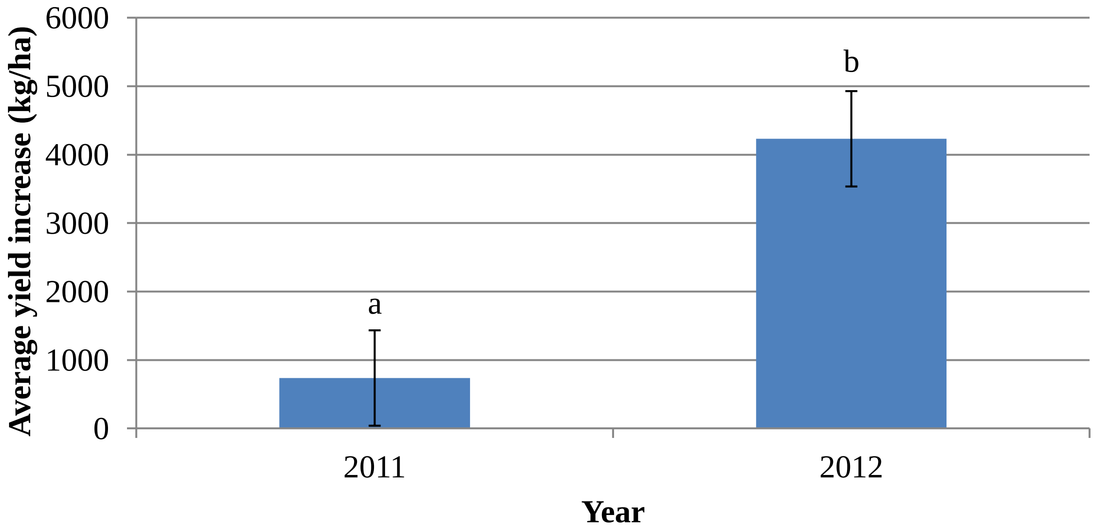
Appendix A - 1. Average seedling count per square meter by replication taken at initiation of experiment before treatments were applied.

Appendix A - 2. Precipitation accumulation following nitrogen application

Treatment	Date of application	Precipitation accumulation (7days)	Precipitation accumulation (14 days)
N March	3/14/2011	0.79 cm	1.78 cm
	3/22/2012	4.62 cm	4.78 cm
N June	6/6/2011	0.99 cm	5.16 cm
	6/1/2012	2.26 cm	5.00 cm

Appendix A - 3. Precipitation (cm) accumulation by month by year

Month	2011	2012
January	0.38	2.49
February	1.52	1.10
March	4.07	3.17
April	4.12	2.55
May	3.13	4.51
June	3.37	2.07
July	3.12	3.30
August (to the 15th)	2.69	4.41
Total	22.4	23.6



Appendix A - 4. Average biomass yield increase (kg/ha) by year of only the no cut treatment between the initial and final sampling. Results averaged over fertilization treatment. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).

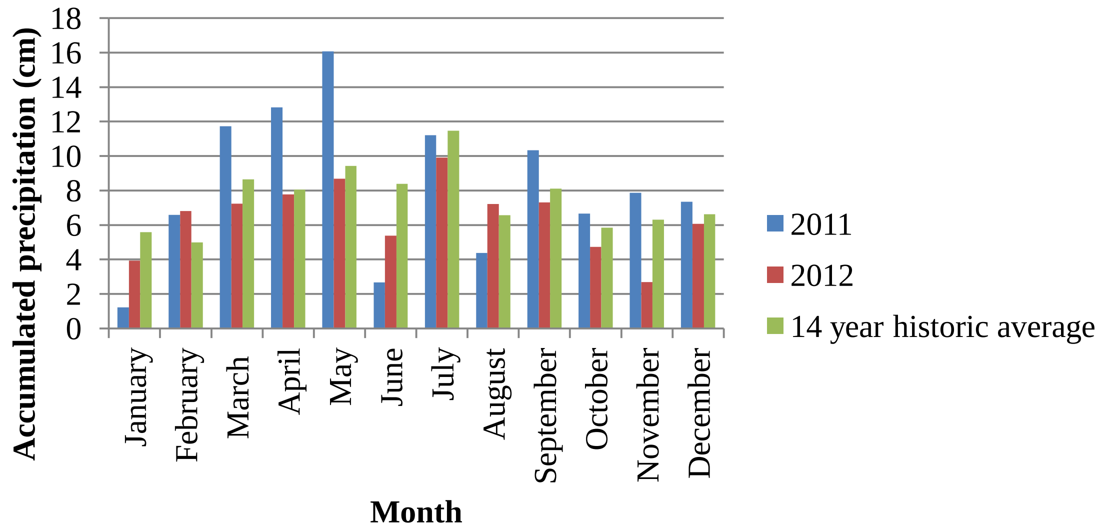
Appendix A - 5. Number of grazing days one hectare of each fertilization and cutting treatment in each year would provide for one average weight beef cow (612.35kg) assuming consumption of 2% body weight per day on a dry matter basis and 70% utilization of forage provided.

$$\frac{(\textbf{Average dry matter yield of treatment} \times \textbf{0.70})}{\textbf{12.25kg of feed per day}}$$

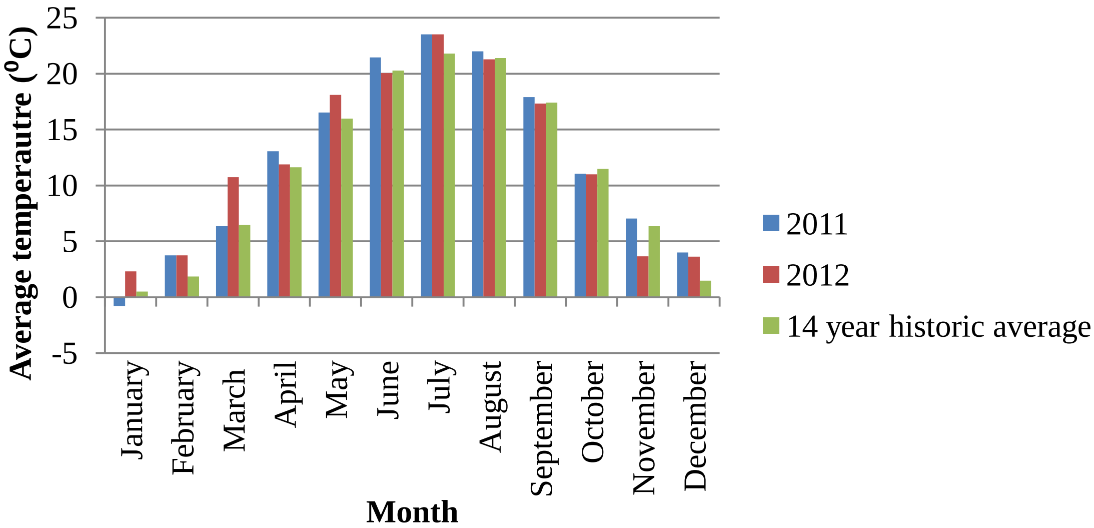
Treatment	DM yield (kg/ha) 2011	2011 Grazing days provided	DM yield (kg/ha) 2012	2012 Grazing days provided
Control	5273.20	301.33	5033.20	287.61
Legume	7336.80	419.25	6080.00	347.43
N March	6386.80	364.96	6650.00	380.00
N June	8250.00	471.43	6423.20	367.04
Cut	7454.80	425.99	4850.00	277.14
No Cut	6168.40	352.48	7243.20	413.90

Appendix B - 1. Growth stages of native warm-season grasses at all samplings using Zadok's scale

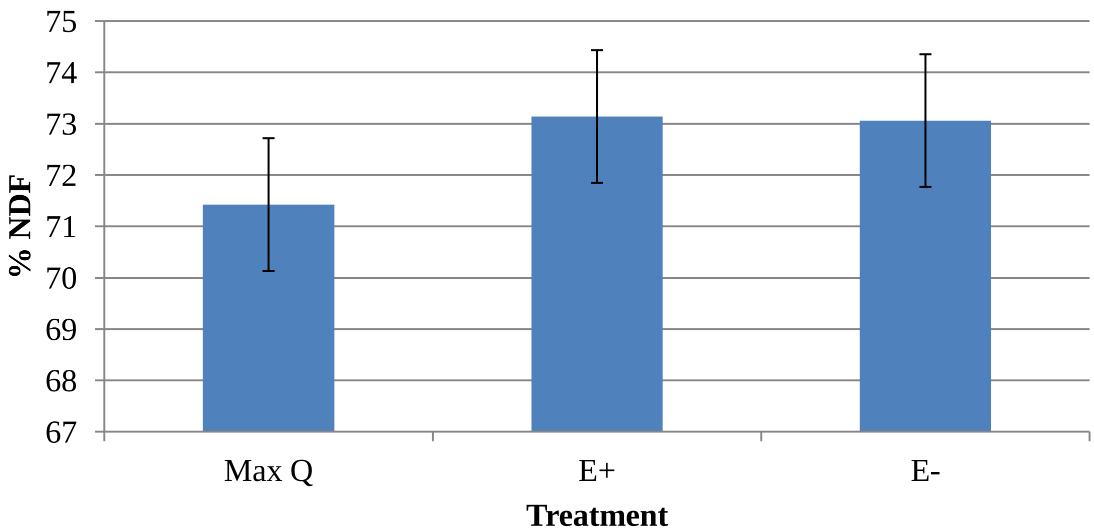
	Sampling Date			
	7/1/2011	**8/17/2011**	**6/25/2012**	**8/7/2012**
Switchgrass	39-55	59	37-59	59
Indiangrass	37-47	59	31-37	59
Big Bluestem	47-59	59	59	90
Little Bluestem	37-55	59	30-45	59



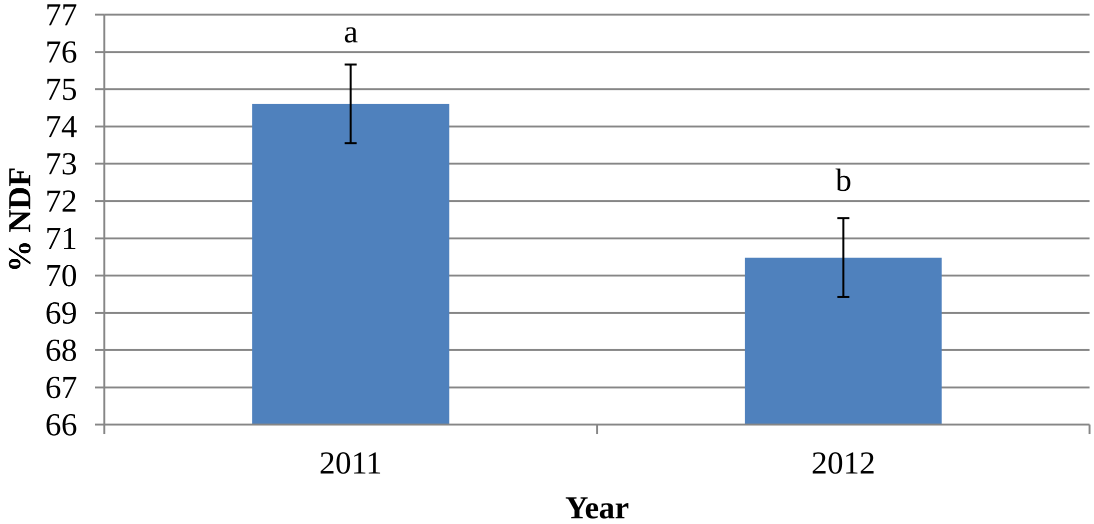
Appendix B - 2. Accumulated precipitation by month for 2011, 2012, and a 14 year historic average for Kentland Farm



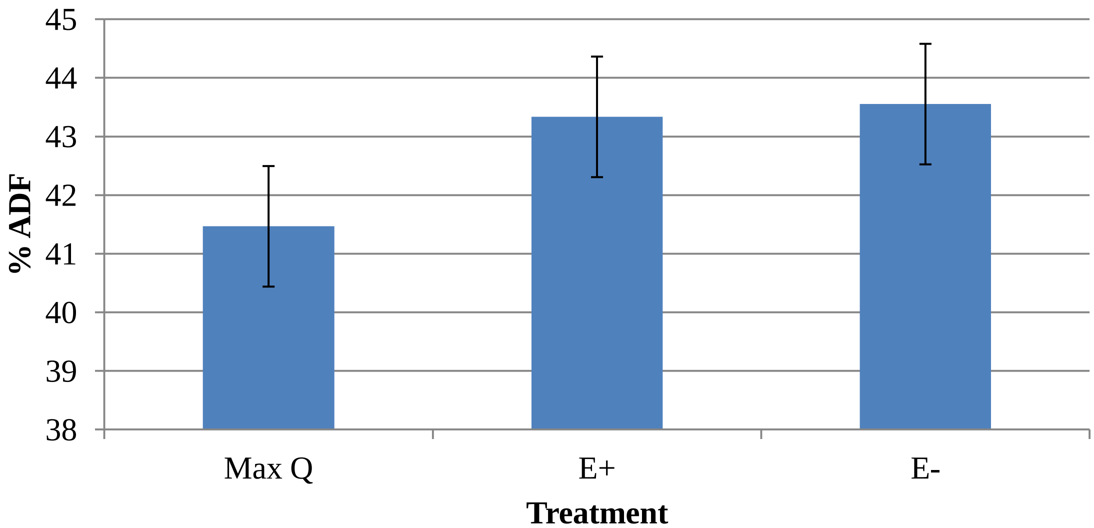
Appendix B - 3. Average temperature (^{0}C) by month for 2011, 2012, and a 14 year historic average for Kentland Farm



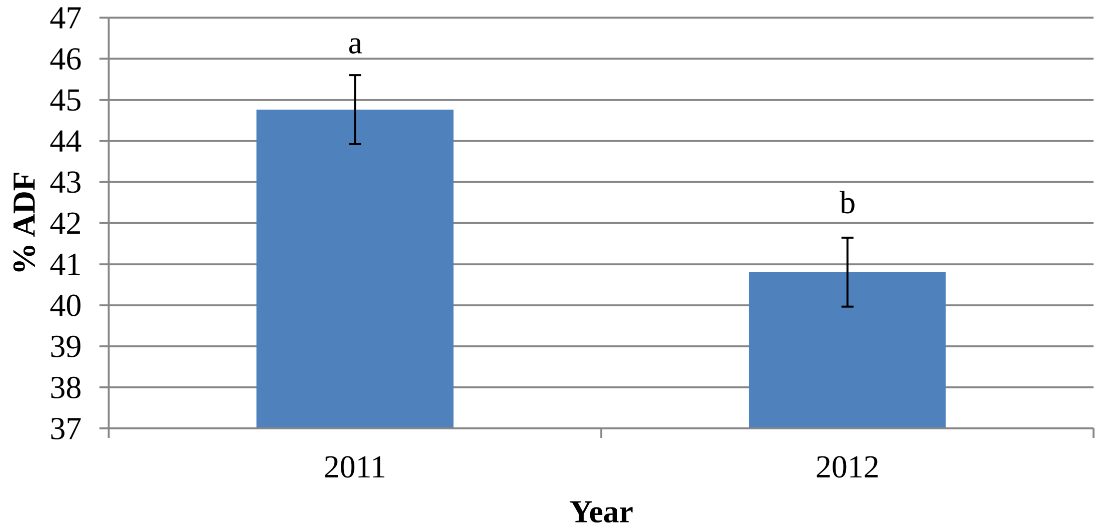
Appendix B - 4. Percent neutral detergent fiber by treatment for tall fescue types. Results are averaged over both years. Bars indicate standard error.



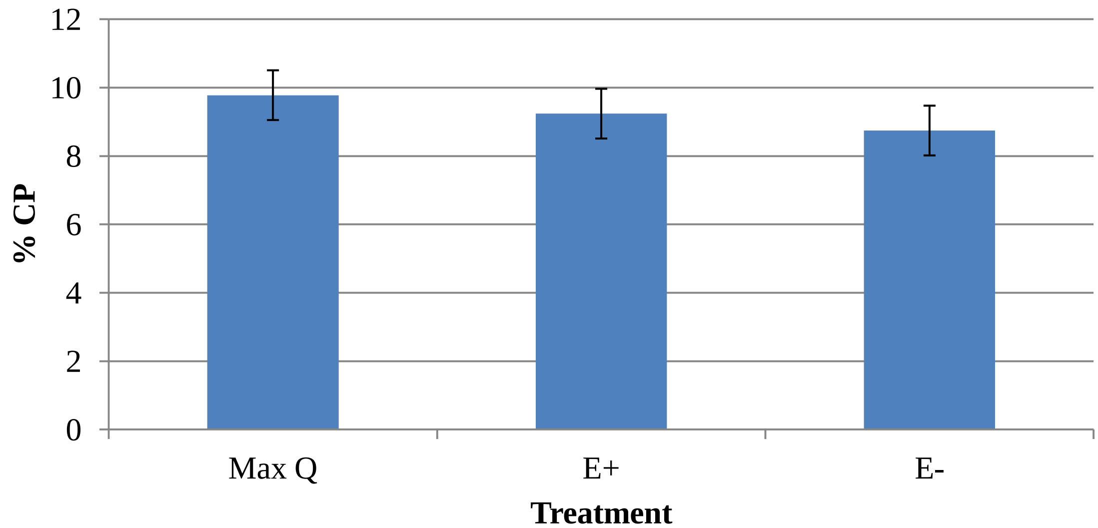
Appendix B - 5. Percent neutral detergent fiber by year for tall fescue types. Results are averaged over tall fescue types. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



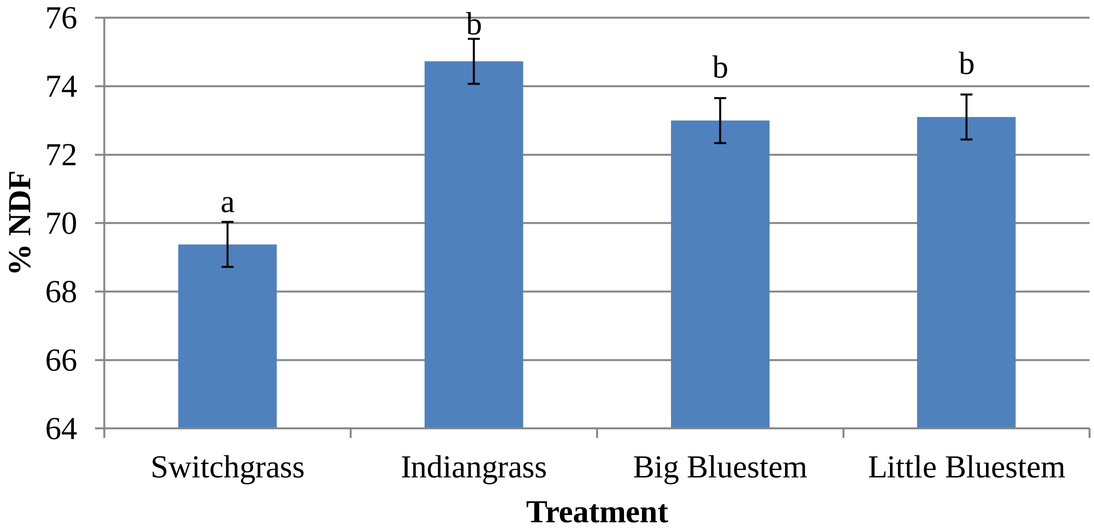
Appendix B - 6. Percent acid detergent fiber by treatment for tall fescue types. Results are averaged over both years. Bars indicate standard error.



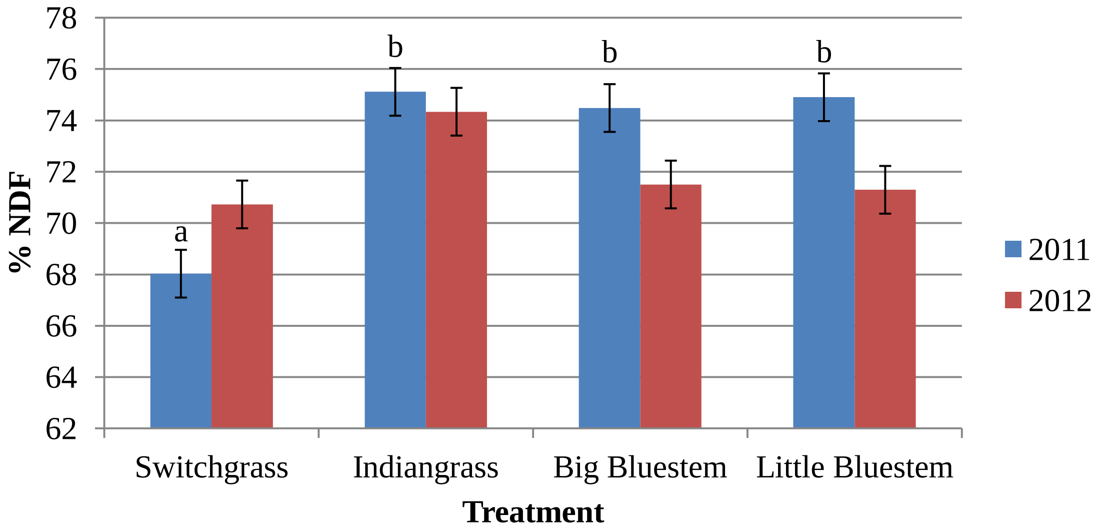
Appendix B - 7. Percent acid detergent fiber by year for tall fescue types. Results are averaged over tall fescue types. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



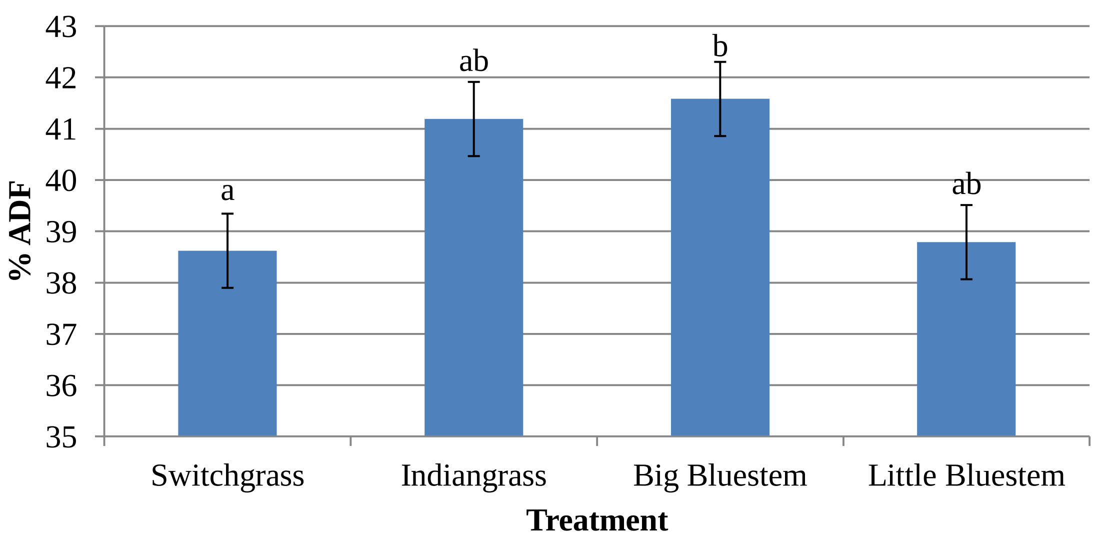
Appendix B - 8. Percent crude protein by treatment for tall fescue types. Results are averaged over both years. Bars indicate standard error.



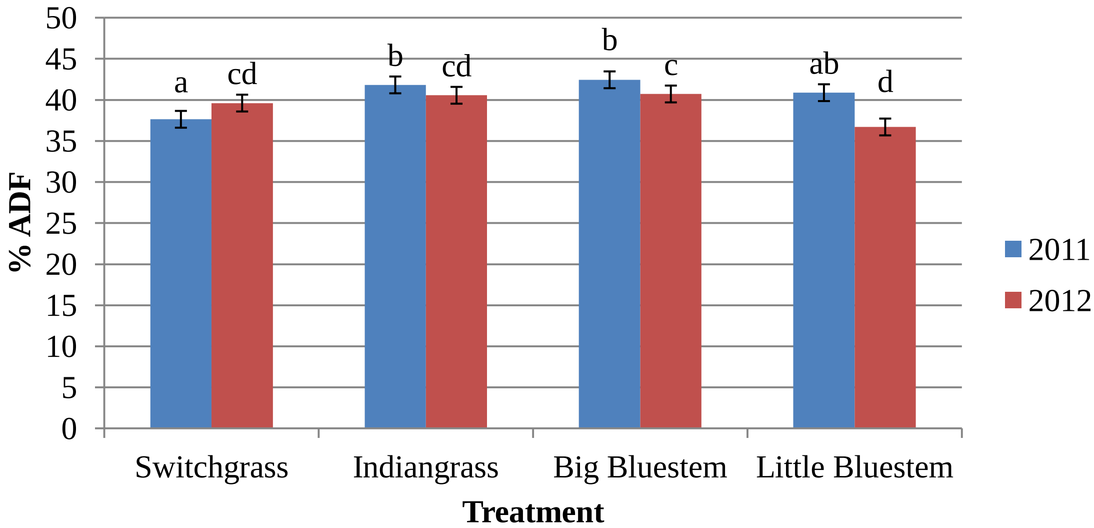
Appendix B - 9. Percent neutral detergent fiber by treatment for native warm-season grasses. Results are averaged over both years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



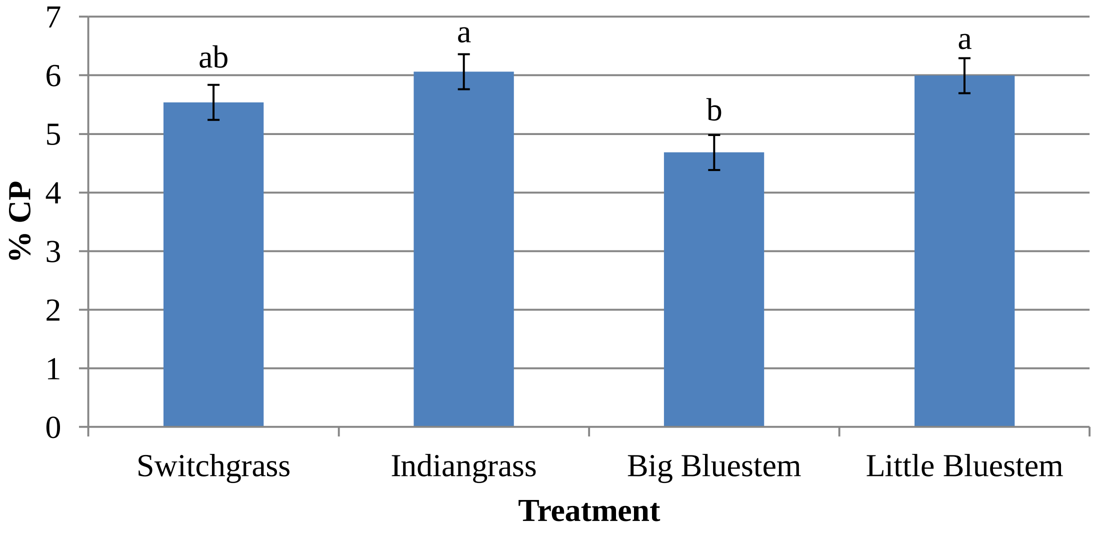
Appendix B - 10. Percent neutral detergent fiber by treatment and year (sliced by year) for native warm-season grasses. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$). No letters indicate no significant differences within that year.



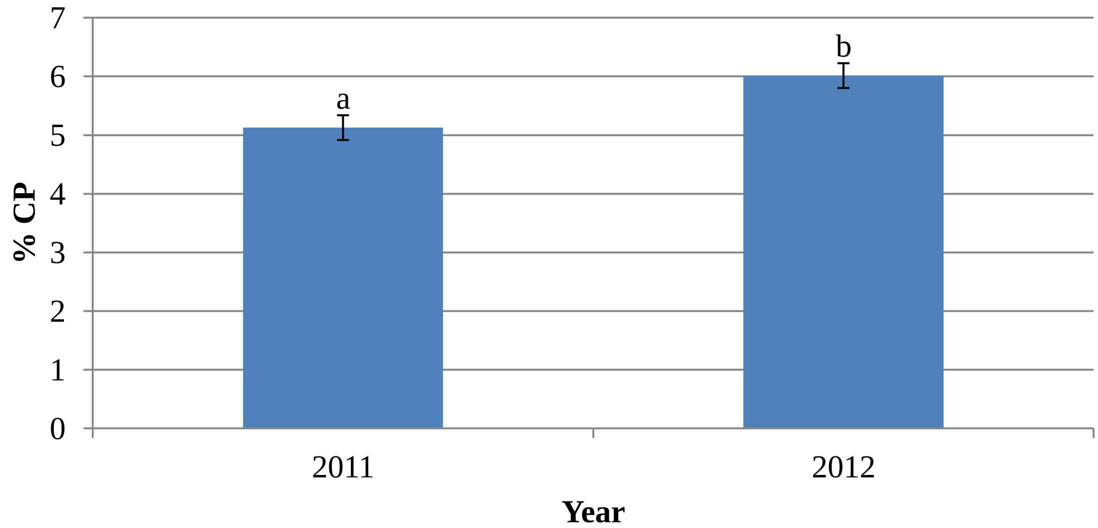
Appendix B - 11. Percent acid detergent fiber by treatment for native warm-season grasses. Results are averaged over both years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



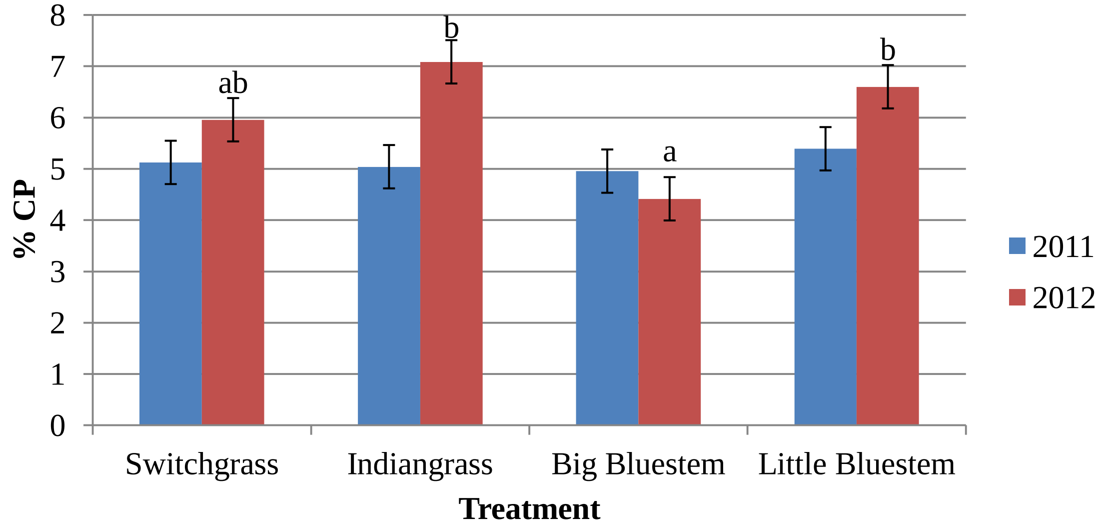
Appendix B - 12. Percent acid detergent fiber by treatment and year (sliced by year) for native warm-season grasses. Bars indicate standard error. Treatments are only compared to each other within each individual year. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



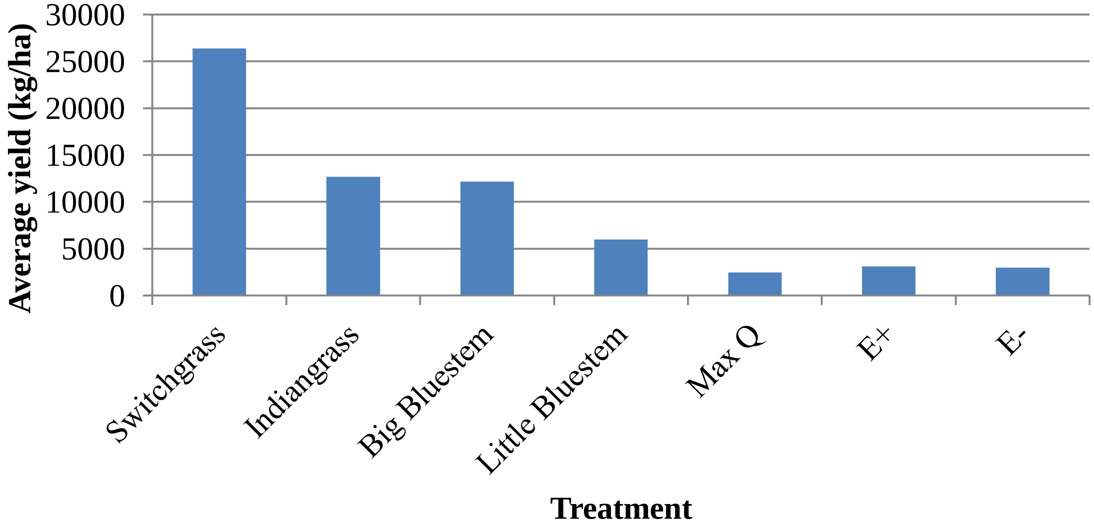
Appendix B - 13. Percent crude protein by treatment for native warm-season grasses. Results are averaged over both years. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



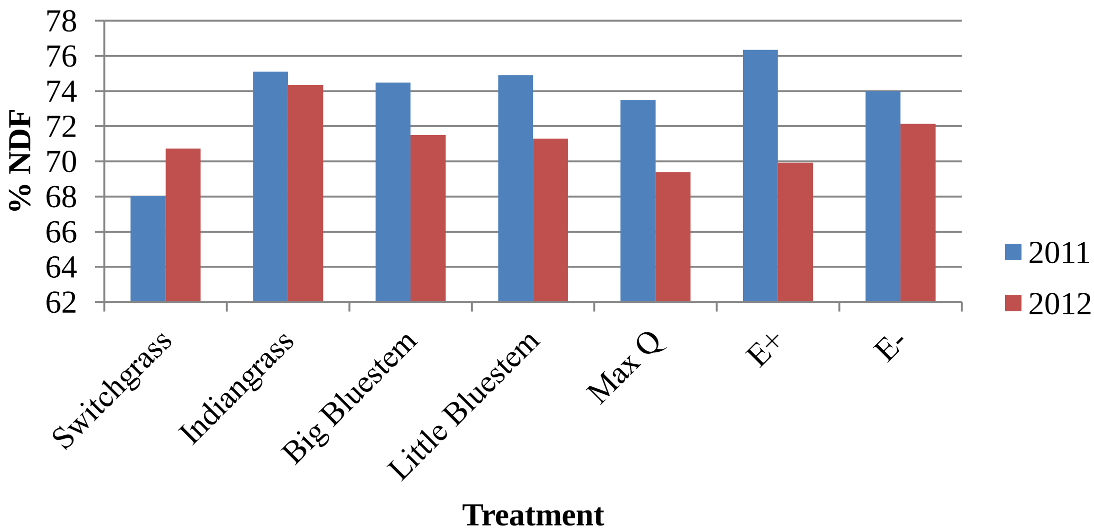
Appendix B - 14. Percent crude protein by year for native warm-season grasses. Results are averaged over all native warm-season grass species. Bars indicate standard error. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



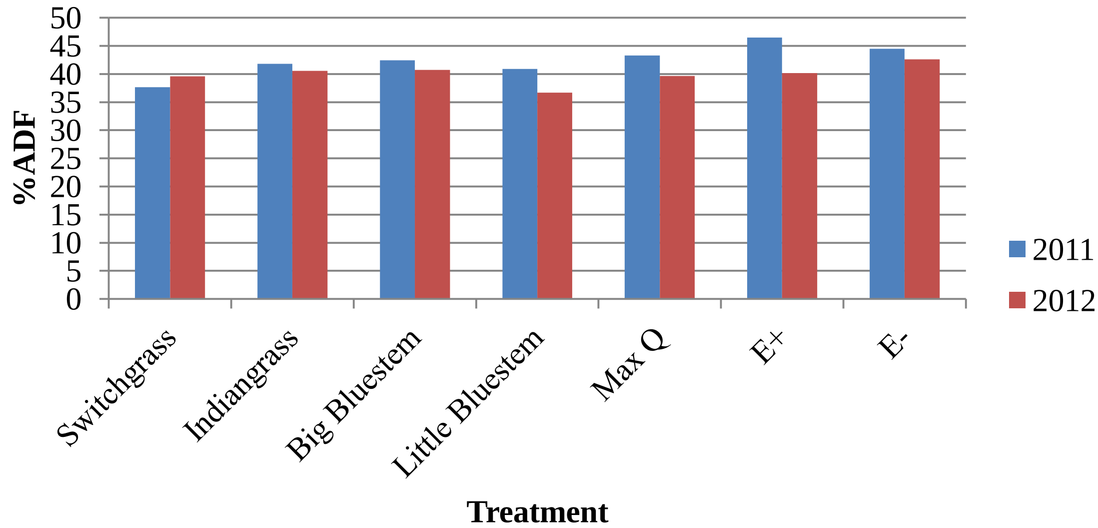
Appendix B - 15. Percent crude protein by treatment and year (sliced by year) for native warm-season grasses. Bars indicate standard error. Treatments are only compared to each other within each individual year. Means for bars followed by the same letter are not significantly different according to Tukey's test ($p < 0.05$).



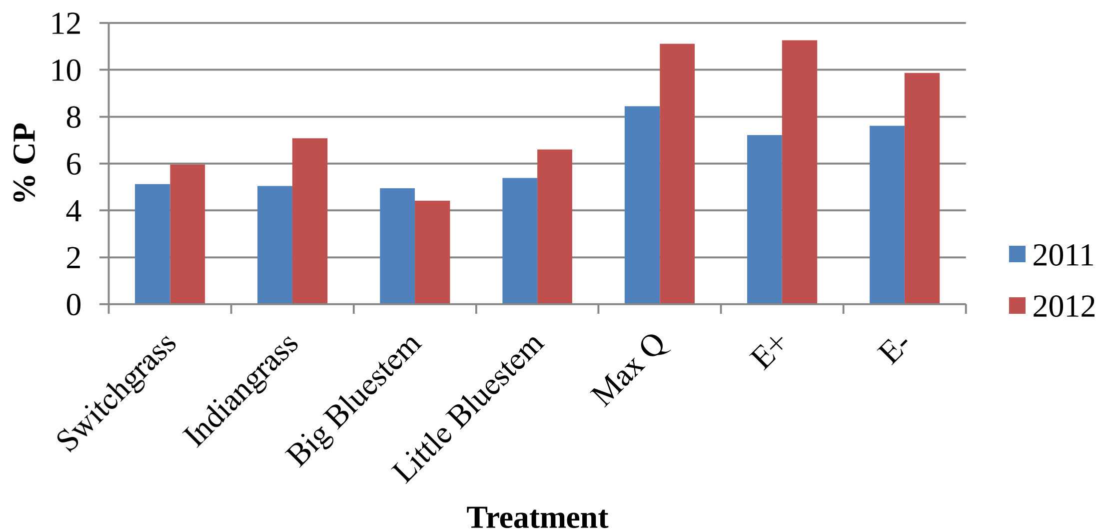
Appendix B - 16. Average biomass yield (kg/ha) for all native warm-season grasses and tall fescue types averaged over both years.



Appendix B - 17. Percent neutral detergent fiber for all native warm-season grasses and tall fescue types by year.



Appendix B - 18. Percent acid detergent fiber for all native warm-season grasses and tall fescue types by year.



Appendix B - 19. Percent crude protein for all native warm-season grasses and tall fescue types by year.