

Alfalfa and alfalfa-grass mixture management

by

Iryna McDonald

M.S., Vinnitsia State Agrarian University, 2006

AN ABSTRACT OF A DISSERTATION

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Abstract

Alfalfa is an important forage legume grown in the central Great Plains. However, producers still lack information about the productivity of alfalfa grown with cool-season grasses and the proper time of the last cut of alfalfa in the fall. Two studies are presented in this dissertation. The first study was to determine during a three-year period (2015-2017) the dry matter yield (DMY) and forage nutritive value of alfalfa-grass mixtures compared to alfalfa and grasses grown in monoculture and to assess the effect of nitrogen fertilizer on the dry matter yield and nutritive value of alfalfa-grass mixtures. During the three-years, the DMY was significantly higher in monoculture alfalfa and alfalfa-grass mixtures than in grass monocultures. No significant differences in DMY between alfalfa monoculture and alfalfa-grass mixtures were found. For all treatments, nitrogen application significantly increased DMY compared to the control. In 2016 and 2017, acid detergent fiber (ADF) and neutral detergent fiber (NDF) in smooth brome grass and tall fescue were higher than in other treatments. Nitrogen fertilizer application did not affect nutritive values such as crude protein (CP), ADF, NDF, and relative feed value (RFV) in different treatments of the forage species. The second study determined the effect of timing of a fall cut on dry matter yield, nutritive value, and stand persistence of alfalfa in Northeastern Kansas in the United States. The DMY of first cut in 2016 was significantly higher in the Roundup Ready variety of alfalfa than in the low-lignin variety of alfalfa. There were no significant differences in DMY between alfalfa varieties in the remaining seasonal cuttings in 2016 and 2017 and in the annual total yield in both years. The DMY of the last cut in the fall was the highest in 2015, 2016 and 2017 in plots that were harvested on September 30. In 2017 the highest DMY in first cut was found in plots that were cut on October 15 in the previous year. The last harvests of the 2016 season, which were on October 15 and October 30, had the

highest nutritive value. Opposite results on October 15 and October 30 were observed in 2017.

Alfalfa cut on September 15 and September 30 had a higher stand persistence compared to alfalfa cut on October 15 and October 30. In conclusion, last fall cutting of alfalfa, which could be up to October 15, appeared to be acceptable because it did not affect forage dry matter yield.

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Approved by:

Major Professor
Dr. Doohong Min

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Dedication

This dissertation is dedicated to my wonderful son Maxim, and my husband Larry who always been in my heart through this journey.

Chapter 1 - Literature Review

Alfalfa

Alfalfa (*Medicago sativa* L) is a perennial crop that is recognized in the United States as the most important forage and known commonly as the “Queen of the Forages.” It is highly desirable for hay and feed production for domestic animals (especially ruminants) (Barnhart, 1997). This cool season perennial legume has trifoliate leaves, and the stems originate at the surface of the soil from a single large crown. The seeds are kidney-shaped, with color that varies from olive or yellow to brown. The very small size of the seeds (1-2 millimeters) requires that they be planted close to the soil surface (Gerrish, 1997). Alfalfa roots can grow deeper than 15 feet (4.6 m). Around the world, the various several common names given to alfalfa include Burgundy clover, lucerne, purple medic, median herb, and Chilean clover (Monteros and Bouton, 2009).

In the United States, the value of alfalfa is third after corn (*Zea mays* L.) and soybeans (*Glycine max* L. Merr.) and its national value is more than \$8 billion per year, excluding the value of dairy or other products of animals that are alfalfa’s final products (Veronesi et al., 2010). In California, for example, more than 1 million acres (400,000 ha) of land are used for alfalfa production with an annual value of nearly 1 billion US dollars (McKenzie et al., 1988). Alfalfa is important for many reasons (Howarth, 1988). It is a significant rotation crop, because it can fix nitrogen in the soil resulting in the improvement of soil fertility (Van Keuren and Matches, 1988). Nodules on the alfalfa root contain bacteria that convert atmospheric nitrogen gas into a form that can be utilized by plants (nitrogen fixation) (Lacefield et al., 1987). The crop is seen as valuable also because wildlife prefers fields of alfalfa for a habitat, where food and

shelter can be obtained (Smith and Bouton, 1993). Many varieties of alfalfa are able to tolerate freezing, which is a benefit under cold conditions (Bouton and Gates, 2003).

In most regions, the highest alfalfa yields occur during the spring (Sheaffer et al., 1988). Yield decreases as the number of days of the year increase and as temperatures increase during summer time (Kiesselbach et al., 1929). High temperatures cause the plant to mature faster (Barnes 1988). With no irrigation, there is usually a decline in available moisture during summer months (Popp et al., 2000), which contributes to low yields.

Alfalfa Nutritive Value

In terms of nutritional value, alfalfa is rich in fibers, proteins, vitamins, and minerals, which, together, make a good diet for livestock (Smith et al., 2000). Protein concentration in the dry matter of alfalfa varies from 18 to 25%. The concentration depends on the growth stage, the method of storage, and cultivars (Rumbaugh et al., 1988). The nutritive value of alfalfa is based on the concentration of protein (Fick et al., 1988). However, the cellulose lignin content is taken into account along with that of crude protein when the nutritive value of alfalfa is determined (Milić et al., 2011). The dry matter intake rate of alfalfa depends upon the content of neutral detergent fiber (NDF). Alfalfa with high NDF has a lower quality, that is, reduced nutrient content, compared to alfalfa with low NDF. The content of acid detergent fiber (ADF) indicates the energy production potential. An increase in ADF shows a reduction in energy (reduced quality) (Teuber and Brick, 1988). Various alfalfa cultivars vary in cellulose, ADF, NDF, hemicellulose, protein, vitamins, and mineral content depending on the plant genotype (Baligar et al., 2001).

Another component, important in determining the nutritive value of alfalfa, is its lignin content. Just like the human skeleton, lignin is critical in providing plant support, and, hence, in ensuring an upright stand. But it is indigestible. In alfalfa, lignin forms a small portion of the plant (7 to 8%); however, it has a great impact on digestibility (McCasli, 2018). Lignin digestibility drops with increased plant maturity, causing a decline in forage quality. Dairy cows cannot digest lignin and other components that bind with lignin. This further decreases the digestibility of the fibers. Therefore, the lignin content of alfalfa is a limiting factor in the digestibility of fiber in alfalfa. This has resulted in the development of genetically modified, reduced-lignin alfalfa.

This literature review first discusses the historical background of alfalfa. It then considers tall fescue and smooth brome grass, grasses that are used in alfalfa-grass mixtures. Finally, the review outlines the benefits of alfalfa-grass mixtures.

Historical Background and Distribution

Alfalfa has contributed to agriculture for a long time (Daigger et al., 1970). Many ancient civilizations have a long association with alfalfa. Remains of alfalfa more than 6,000 years old have been found in Iran. The oldest written reference to alfalfa is from Turkey and dates from 1,300 B.C. Historical pieces of evidence reveal that alfalfa was likely domesticated in present-day Turkey, Iran, Turkmenistan, the regions with the Caucasus Mountains, and other Asia Minor countries. To the early Babylonians, Persians, Greeks, and Romans, the alfalfa plant was of great significance. Aristotle and Aristophanes referred to the crop in their writings. About 500 B.C., alfalfa was reported to have been brought into Greece by Median armies for the purpose of feeding their chariot warhorses. The crop then spread to other parts of the world by

Arab emperors of the Middle Ages. Alfalfa was associated with the horse in many of these cultures, and the name “alfalfa” is thought to have been derived from its connection with horses. The name “alfalfa” is derived from Persian, Arabic, and Kashmiri words that mean “best horse fodder” and “horsepower.” Alfalfa was spread to the New World by the Portuguese and Spanish during conquests of Peru, Chile, and Mexico. Ample evidence shows that the eastern US colonists, including Thomas Jefferson and George Washington, grew alfalfa on a few acres. However, at this time, the crop was not widely grown in the US, and it was not generally adopted until the early 1850s when it was introduced into the western states. It was during the 1849-1850 Gold Rush that the “Chilean clover” (alfalfa brought from China) was introduced into California, where it quickly adapted to the warm sun and rich soils of the region (Smith and Bouton 1993). Here the beef, horses, and cow’s milk were highly valued. Almost everything was animally powered.

Alfalfa spread east from California into Utah, Nebraska, Nevada, and other states where it took hold very fast (Caddel, 1997). In the 19th century, the plant was a key crop in the expanding west. The testament of the importance of alfalfa is evidenced by the names like Lucerne, California, and Alfalfa County, Oklahoma. By 1900, 98% of the US grown alfalfa was from west of the Mississippi River. Alfalfa became adapted to the cold and wet conditions of the East through the introduction of a cold-tolerant alfalfa from Germany (‘Grimm’ alfalfa). In addition, plant breeding allowed its spread (Smith et al., 2000). By 1950 US alfalfa acreage had expanded to 12 million hectares with most of the expansion in the upper Midwest and Eastern states. Today, this deep-rooted, perennial legume of humble origin, originally growing wild on the steppes of Asia, has now spread throughout Europe, Asia, Northern Africa, Australia, and

North and South America. The productivity of alfalfa, its desirable nutritional traits, and its wide adaptation are highly valued by many farmers and cultures (Ouellet, 1976).

Tall Fescue

Tall fescue (*Festuca arundinacea* Schreb.) is a perennial grass that produces large, usually loose, but sometimes dense, tussocks. The grass has short rhizomes with no stolons (Ball et al., 2003). It is a cool season, long-lived, C₃ species of bunchgrass that is native to Europe, North Africa, and Asia. Tall fescue was first described by the German naturalist, von Schreber in 1771 (Buckner et al., 1979). In 1824, Dumortier gave it the genus description plant name of *Schedonorus*. In 1993, Darbyshire assigned the genus name to *Lolium* under the name *Lolium arundinaceum*. In 1998, the genus *Schedonorus* was resurrected, and the name *Schedonorus arundinaceus* was conserved. *Festuca arundinacea* is now classified in the subgenus *Schedonorus*, a subgenus that is very closely related to *Lolium* (Burns and Chamblee, 1979). This has led to the proposal that the species falling within this subgroup should be classified as *Lolium*. This would mean that tall fescue would become *Lolium arundinacea*, which is a synonym that is accepted (Ocumpaugh and Matches, 1977). To further change and establish another name other than the name *Festuca arundinacea* would be hard, due to its wide usage and the fact that the name is well recognized within the communities of agriculture, veterinary science, and the landscape and lawn care businesses (Shireman, 2015). The leaf blades of tall fescue are dark green with noticeable venation and rough edges (Stricker et al., 1979). The leaf blade surfaces and sheath are smooth. The grass is able to grow up to 0.6 to 1.2 m tall.

Tall fescue was introduced into the US from Europe in the 19th century, and the early tests on its performance were done at the Utah and Kentucky Agricultural Experiment Stations

and in Washington, DC. Tall fescue grass did not become common in the US until the 1940s when ‘Kentucky 31’ was released with the subsequent drop in the usage of meadow fescue (*Festuca elatior* L.) (Jackobs, 1952). Studies showed that tall fescue was taller and tolerated drought better than meadow fescue (Steen et al., 1979). This encouraged further planting of tall fescue. Its widespread planting is due to its persistence, long growing season, adaptability, productivity, and erosion control.

At present, the grass is prominent in all the states and in southern Canada. *Festuca arundinacea* was first documented in Australia (in Victoria) in 1901 as a pasture grass, and it is now widely grown in the southern Australia temperate regions. The grass is also occasionally found in the southern parts of the Northern Territory and south-eastern Queensland. In Japan, tall fescue was first introduced in 1905, being imported as a pasture grass (Yarber, 2008). Currently, the grass is now found on the main islands of Hokkaido, Kyushu, Honshu, and Shikoku, where it is considered an invasive species that occurs in urban areas, grasslands, vacant lots, farm fields, and along streams and waterfronts (Danielson et al., 1976). Today, the widespread cultivation of tall fescue is evidenced by its being grown in the whole of Europe (northern Europe, Russia, and Iceland), central Asia as far east as Xinjiang in China, and northern Asia (to northwestern Siberia) (Buckner et al., 1979). The grass has spread into North Africa, growing from Libya to Morocco, and into South Africa, Kenya, and Ethiopia.

Due to the outstanding autumn growth of tall fescue and its ability to maintain palatability and quality after a frost, it is used in providing late autumn and winter stockpiled forage that can be used for feeding (Thompson 2013). Stockpiling extends the season of grazing, helping in reducing the costs of winter feeding for many producers. Ocumpaugh and Matches (1977) showed that frequent defoliation in the spring and summer in Missouri resulted in the

reduction of dry matter, but the autumn growth was little affected (Mitchell, 1981). The amount of rainfall before a killing frost had the largest effect on autumn growth. There was a steady decrease in dry matter, crude protein content, K content, and digestibility after a killing frost (Burns et al., 1973). Even though the growth of tall fescue declines after a killing frost, cattle can still utilize the stockpile in most regions throughout winter.

Smooth Brome grass

Smooth brome grass (*Bromus inermis* Leyss.) is a leafy cool-season perennial grass that is mainly cultivated for hay or early spring pasture (Hoveland, 2003). The grass has deep, underground, and widespread rhizomes. It has flat and thin leaves and distinctively closed leaf sheaths. Smooth brome grass is native to Eurasia. The grass was introduced into the southern US for use as a soil binder as well as for forage for livestock production. In North America, the distribution of the grass is mainly in Alaska, all the provinces of Canada, the north-central states of the USA, southern Californian, North Carolina, and northern Oklahoma. The nutritional qualities and good adaptation to different climates of smooth brome grass make it a grass that is widely cultivated and used in North America (Cooper and Taiton, 1968). Smooth brome grass is able to survive drought periods and can be grown on many different soil types. It grows best on well-drained silt-loam or clay-loam soils (Katepa-Mupondwa et al., 2002).

Smooth brome grass is extensively used for rehabilitation purposes. The grass is hardy under cold environmental conditions and fairly resistant to drought and saline soils (Smith et al., 1973). The good soil binding of smooth brome grass is due to its ability to spread rhizomatously. It is for this reason that it is used for soil erosion control and stabilization of streambanks and stream bottoms in many areas of the United States with the exception of the Southeast (Hoveland, 1986). Mined

lands, roadsides, and game ranges have been successfully rehabilitated with the use of smooth brome grass. Brome grass can aggressively colonize many sites. However, it may crowd out the native species. The nutritive value of smooth brome grass varies with the developmental stages. A study conducted by the National Academy of Sciences in the United States found that in fresh, smooth brome grass at the flowering stage the nutritional content on a dry matter basis was as follows: ash, 27.1%, ether extract, 1.9%, crude fiber, 8.3%, N-free extract, 13.2%, crude protein, (%N x 6.25), 2.8%, digestible energy for cattle, 0.79 Mcal/kg, and digestible energy for domestic sheep, 0.78 Mcal/kg.

Benefits of Legume-Grass Mixtures

Grass-legume mixtures have many advantages over the practice of monoculture of either alfalfa or a grass (Casler and Walgenbach, 1990). This has been confirmed through the observation of McCloud and Mott (1953), who showed higher yields in alfalfa-grass mixtures than pure grass stands. In their reasoning, the attribution of the higher mixed stand yield is due to the ability of alfalfa to fix atmospheric nitrogen gas into the soil (Brummer and Bouton, 1991). Pure grass stands always have suboptimal soil nitrogen levels. Therefore, grass-legume mixtures are able to reduce the requirement of nitrogen fertilizer because of the natural fixing of atmospheric nitrogen by the legumes (Islam, 2018). Other benefits include increased forage protein and digestibility, extended periods of grazing, more competition with the weeds, and soil erosion prevention. Other benefits include a wide range of soil conditions that are tolerated, a reduction in bloat when 40% or more grass is contained in the mixture, and a reduction in water-logging (Allen, 1985). There is a reduced potential for nitrate poisoning and grass tetany when the grass-legume mixture contains 40% or more of the legume (Owens et al., 1994). The

realization of these benefits is, however, dependent on a number of factors like location, soil conditions, weather conditions, elevation, species-mixture compatibility, forage-species adaptability, and management practices (Nelson et al., 1986).

At the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle, Wyoming, many long-term studies have been carried out. The elevation of the research center is about 4,200 feet (1,280 m). A tall fescue and alfalfa mixture were used in one study (Chung et al., 1995). The results showed that a grass-legume mixture in a ratio of 50:50 led to increased yield, quality improvement, and reduction in production cost through the elimination of nitrogen fertilizer (Islam, 2018). Different alfalfa cultivars have been shown to be compatible with all grasses including tall fescue (Mooso and Wedin, 1990). In a 50:50 grass-alfalfa mixture study, an increased yield of more than 100% was observed as compared to grass-only plots (Blaser et al., 1956). Stability of high yield over time may be sustained through appropriate selection of adapted grass-legume mixtures (Smith et al., 2000). Therefore, great economic benefits to producers are realized (Wolf et al., 1962).

As noted in the above paragraphs, alfalfa is a leguminous plant that has been commonly grown with perennial grasses in mixtures (Deak et al., 2009). The mixtures considered to be best are those containing an alfalfa cultivar with a productive grass (Harrison et al., 1947). Besides the benefits of alfalfa-grass mixtures, several shortcomings also exist (Jackobs, 1963). For a high yield and quality mixture to be realized in pastures and hay fields, the advantages and limitations of alfalfa-grass mixtures should be carefully managed (Tewari and Schmid, 1960).

According to McCloud and Mott (1953), legumes increase the content of their companion's (grass) protein and carotene when planted in mixed stands (Blaser et al., 1956). The reason for this increase is due to the added soil nitrogen. Livestock increase their intake of the

forage due to an increased legume digestion rate (Raines, 1998). In the study conducted by Jackobs (1963) with legumes mixed with grasses, alfalfa was observed to have the highest production and longest persistence. If alfalfa is included in a pasture, livestock and forage production will be increased.

Grasses are important in improving soil cover, which helps in lowering soil erosion and the invasion of weeds (Ball et al., 2002). The advantage that comes with adding alfalfa to grass is the ability to reduce frothy bloat (Sheaffer et al., 1998). Alfalfa and grass both add benefits, when planted together in mixtures.

Despite the advantages of growing alfalfa with grass, a limitation occurs because of the competitive interactions between the grass and alfalfa. In the seeding year, there is little competition due to the still immaturity of both the alfalfa and grass (Yarber, 2008). This goes up at the end of the first season. Germination and emergence of alfalfa are quicker than the grass. But upon emergence, there is a slower growth of alfalfa seedlings compared to grass (Chamblee and Lovvorn, 1953). The production of the alfalfa shoot is, hence, reduced as the plants mature, because the grass crown out competes the alfalfa (Popp et al., 1997). The yield and persistence of alfalfa is reduced. Most species of grass also start to grow earlier in the spring than alfalfa (Bouton and Smith, 2018). Alfalfa is out-competed by the grasses after overwintering.

Several tests have shown the interaction of different species of grass with alfalfa (McCloud and Mott, 1953). In one study carried out by McCloud and Mott (1953), they mixed alfalfa with smooth brome grass. They found that alfalfa yield in the mixture was reduced by the sod-forming brome grass (Bittman et al., 1991). They concluded that brome grass shaded the alfalfa, because of its tall, leafy structure. Several studies have shown that, over time, alfalfa

decreases as part of the composition of grass-alfalfa mixtures. Hence there is a decline in the nutritional value of alfalfa (Comstock and Law, 1948).

Alfalfa is known for being a high-quality, nutritious legume. Tall fescue is known for its persistence (Bond et al., 1984). In alfalfa-tall fescue mixtures, there are unique considerations (Smith et al., 1992). Just like the benefits seen in other legume-grass mixtures, alfalfa-tall fescue mixtures help in the reduction of soil erosion, increase in conservation of soil water, reduce stand thinning due to legume mortality, and increase weed control (Raines, 1998).

Mixtures of alfalfa with tall fescue have an advantage compared to mixtures of alfalfa with other grasses like smooth brome grass and orchardgrass (Quiros and Bauman, 1988). Tall fescue is long-lived, and, in the autumn and early winter, a dry matter is produced (Burton et al., 1994). Under winter stockpiling, there is a longer retaining of quality, nonstructural carbohydrates, and biomass by tall fescue compared to other grass species (Hill et al., 1988). Hoveland et al., (1986) compared a number of grass-legume mixtures and showed that legume-orchardgrass mixtures yielded less than legume-tall fescue mixtures. Smith et al. (1992) reported that, in the late winter and spring, tall fescue had good growth. This resulted in an increase in the yield of alfalfa-tall fescue mixtures. Comstock and Law (1948) in Washington showed that alfalfa-tall fescue mixtures had higher yields compared to pure alfalfa.

Many benefits come with growing alfalfa with tall fescue (Casler et al., 1998). Longer growing seasons and higher yields have been shown in alfalfa-tall fescue mixtures when compared to monocultures (Kust, and Smith, 1961). Nevertheless, a greater regrowth of alfalfa when in pure stands has been shown in a study done by Berdahl et al. (1986). But this regrowth has also been seen in mixtures in a study done by Rhykerd et al. (1967). Therefore, great benefits are realized when alfalfa is grown in mixtures with other grasses.

Farmers need to determine the type of hay to be produced and pasture to be used in feeding livestock, which will result in high-quality milk, meat, or other dairy products. Alfalfa, a perennial legume crop, has been the best choice worldwide due to its high-quality composition and its adaptability under challenging climatic conditions. When in mixed growth with grasses like tall fescue and smooth brome grass, it has additional advantages. For these reasons, alfalfa is recognized as an important forage for livestock production. Alfalfa cultivars have been bred for high nutritional value, and, with further studies, alfalfa cultivars will be developed with improved quality, which will result in increased production.

The literature review showed that studies on alfalfa-grass mixtures are lacking in the semi-arid regions of the USA, including Kansas. Therefore, as reported in this thesis, alfalfa-grass mixtures were studied in Manhattan, Kansas, under rainfed conditions for three years. Mixtures of alfalfa, tall fescue, and smooth brome grass were investigated, and the nutritional value of these mixtures was determined.

Study Objectives

Chapter 2: Effects of alfalfa and alfalfa-grass mixtures with nitrogen fertilization on dry matter yield and forage nutritive value.

The objective of this study was to determine during a three-year study (2015-2017) the dry matter yield and forage nutritive value of alfalfa-grass mixtures compared to those of alfalfa and grasses grown in monoculture and to assess nitrogen fertilizer effects on alfalfa-grass mixtures' dry matter yield and forage nutritive value.

Chapter 3: Effect of a last fall cutting date on dry matter yield, nutritive value, and stand persistence of alfalfa.

The objective of this study was to evaluate the effect of the timing of the last fall harvest on dry matter yield, nutritive value, and stand persistence of three different alfalfa varieties.

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Chapter 2 - Effects of Alfalfa and Alfalfa-Grass Mixtures with Nitrogen Fertilization on Dry Matter Yield and Forage Nutritive Value

Abstract

Alfalfa (*Medicago sativa* L.) is an important forage legume grown in Kansas and its productivity with cool-season grasses, however, is unknown. The objective of this study was to determine during a three-year study (2015-2017) the dry matter yield and forage nutritive value of alfalfa-grass mixtures compared to those of alfalfa and grasses grown in monoculture and to assess nitrogen fertilizer effects on alfalfa-grass mixtures' dry matter yield and forage nutritive value. Three different alfalfa varieties were planted (low-lignin, Roundup Ready, and conventional alfalfa) and two kinds of cool-season grasses (smooth brome, *Bromus inermis* Leyss, and tall fescue, *Festuca arundinacea* Schreb) were planted as monoculture or in alfalfa-grass mixtures. Nitrogen fertilizer (urea) was applied at a rate of 56 kg ha⁻¹ after planting on April 24, 2015, April 30, 2016, and April 27, 2017 at the green up, and after a second cutting on June 23, 2016 and June 27, 2017. Control plants received no nitrogen. Forage samples were collected to determine dry matter yield and forage quality. Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and relative feed value (RFV) were measured. Dry matter yield was significantly higher in monoculture alfalfa and alfalfa-grass mixtures than in grass monocultures. No significant differences in dry matter yield between alfalfa monoculture and alfalfa-grass mixtures were found. No significant differences in dry matter yield occurred between alfalfa-grass mixtures. For all treatments, nitrogen application significantly increased dry matter yield compared to the control. In 2016 and 2017, the low-lignin alfalfa monoculture

had the lowest ADF and the grass monocultures had the highest ADF. In 2016 and 2017, NDF in smooth brome grass and tall fescue was higher than in other treatments. A low-lignin alfalfa monoculture had significantly lower NDF concentration compared to alfalfa-grass mixtures, such as conventional alfalfa with smooth brome grass, conventional alfalfa and tall fescue, Roundup-Ready alfalfa with smooth brome grass, and the mixtures of alfalfa species with two grasses combined. When averaged over 2016 and 2017, RFV was highest in low-lignin alfalfa and lowest in the grass monocultures. In both years, nitrogen fertilizer application did not affect nutritive values such as CP, ADF, NDF, and RFV in the forage species treatments.

Keywords: forage, nutritive value, dry matter yield, *Medicago sativa* L., *Bromus inermis* Leyss., *Festuca arundinacea* Schreb.

Introduction

Alfalfa (*Medicago sativa* L.) is a perennial legume that is important in forage production worldwide due to its high forage quality and dry matter yield (Barnes et al., 2003, Lacefield et al., 2009). Legumes benefit grass pastures not only by transferring fixed nitrogen to the grasses (Ta and Faris, 1987; Heichel and Henjum, 1991; Malhi et al., 2002) but also by providing biomass to the total yield of a pasture. This is important during the middle of the summer, when alfalfa grows better than grasses. The grasses then can provide forage to animals (Seugh et al., 2000; Kopp et al., 2003), and planting alfalfa with grasses is a new way of improving forage yield and quality that has been studied in the USA. However, little research on legume-grass mixtures has been done in in Kansas.

Farmers often plant grasses in pastures, because they can control weeds and improve grazing conditions (Sturludottir et al., 2013; Waldron et al., 2017). Also, planting legumes with grasses helps improve forage quality and increases dry matter yield of pastures compared to pastures with pure grasses (Albayrak and Ekiz, 2005). Because legume crops can provide nitrogen to the grasses, Woodfield and Clark (2009) recommended that farmers use a new strategy in farming and plant legumes with grasses. Legume-grass mixtures are not as easy to manage as monoculture grasslands, because the legumes and grasses compete for water, nutrients, and light (Charles and Lehmann, 1989; Berdahl et al., 2001; Albayrak and Ekiz, 2005; Cinar and Hatipoglu, 2014). However, much research has shown that the advantages of legume-grass mixtures outweigh the disadvantages.

Tracy et al. (2016) showed that yields of pastures with grasses mixed with alfalfa were almost identical to yields of pastures with only grasses that were fertilized. Sengul (2003) found that dry matter yield of legume-grass mixtures, both with and without fertilizer, was higher than

dry matter yield of grass monocultures. Planting legumes with grasses can supply the grasses with >80% of the nitrogen that they need through nitrogen fixation (Heichel and Henjum, 1991; Rasmussen et al., 2012). Grasses in the spring react positively to available nitrogen in the soil, and usually nitrogen in fertilizer or manure is applied to grasses in the spring. Legumes fix little nitrogen in early spring, because of low temperatures (Liu et al., 2011). Therefore, it is recommended that nitrogen fertilizer be applied to legume-grass mixtures in the early spring, which increases biomass of grasses at that time (Schils et al., 2000 a, b; Humphreys et al., 2009).

The importance of forage quality cannot be over-emphasized as far as the sustainability and profitability of any farm are concerned. It is essential for sufficient animal nutrition, so the animals can have high gain rates, ample production of milk, and efficient production. Immense variations in the quality of forage within and among forage crops occur, just as is the case for variations in nutritional needs within and among animal classes and species (Ball et al., 2001). Forage quality is directly related to the content and availability of essential nutrients for the consuming animals and defined by three processes, which are the capacity of the animal to consume, assimilate (availability), and digest (digestibility) the essential nutrients in the feed (Van Saun, 2018). Various factors affect the quality of forage. In the same or different years, similar plants can have varying quality, even when each has been planted in the same field. Grass-legume mixtures are acknowledged to have higher crude protein concentrations, as well as lower fiber concentrations, compared to pure grass stands (Ball et al., 2001). Brown et al. (2018) observed that in grass-mixtures crude protein increases, as well as dry matter yield. Forage quality is affected by fertilization, where the fertilization of grasses using nitrogen usually results in a substantial increase in yield, while also generally increasing crude protein levels.

Therefore, the objectives of this study were to evaluate the productivity of alfalfa-grass mixtures compared to alfalfa in monoculture and grasses in monoculture and to assess the effect of nitrogen fertilizer on forage dry matter yield and nutritive value of the monocultures of alfalfa and grasses and alfalfa-grass mixtures.

Materials and Methods

Study Site

The experiment was conducted at the Ashland Bottoms Research Farm of Kansas State University (39°14' N, 96°64'W) between April 2015 and December 2017. The soil type at the study site was a Belvue silt loam (coarse-silty, mixed, superactive, nonacid, mesic Typic, Udifluvents) (Soil Survey Staff, 2017). A soil test, done at the Soil Testing Laboratory at Kansas State University, showed that the study field had a pH of 6.96 and an organic matter content of 2.0%.

Weather data were collected from an automated Kansas Mesonet Station located at the Ashland Bottoms Research Farm. The station is part of the Weather Data Library at Kansas State University and the State Climate Office (Kansas Mesonet, 2017). Average minimum and maximum temperatures and precipitation for the study period are given in Table 2.1.

Three different alfalfa varieties were planted: 'Hi-Gest 360 LL,' a low-lignin variety, 'RR Tonica,' a Roundup Ready variety, and 'Gunner,' a conventional alfalfa variety. Two kinds of grasses, smooth brome grass and tall fescue, were planted as monoculture crops and in the legume-grass mixtures as binary and trio mixtures. When an alfalfa variety was planted with one grass (either smooth brome grass or tall fescue), it was called a binary mixture. When an alfalfa variety was planted with both grasses, it was called a trio mixture. This resulted in 14 different treatments

(Table 2.2). All 14 treatments were treated with nitrogen to provide 28 treatments in total: 14 with nitrogen and 14 without nitrogen. The treatments without nitrogen were called the controls. Nitrogen was applied as urea at a rate of 56 kg ha⁻¹ after planting on April 24, 2015 and at green up and after the second cutting in 2016 and 2017. In monocultures, the seeding rates were as follows: alfalfa variety, 20.18 kg ha⁻¹; tall fescue, 13.45 kg ha⁻¹; and smooth brome grass, 16.81 kg ha⁻¹. In binary mixtures, seeding rates were as follows: alfalfa variety, 11.21 kg ha⁻¹; tall fescue, 8.97 kg ha⁻¹; and smooth brome grass, 11.21 kg ha⁻¹. In trio mixtures, an alfalfa variety, smooth brome grass, and tall fescue all had a seeding rate of 7.85 kg ha⁻¹. During the establishment year favorable growing conditions led to high weed populations, and, due to this, the first cut in 2015 was controlled by mowing the study field completely, and after that the weed population was controlled by hand-weeding.

The experimental design was a split plot (with or without nitrogen) in a randomized complete block design with four replications. There were 28 treatments of two nitrogen application rates as whole plots and 14 forage species as subplots. Plot size was 1 m wide and 6 m long, for a total of 112 plots. In 2016, plots were harvested on May 19, June 22, July 27, and September 3; in 2017, they were harvested on May 24, June 26, July 28, and September 1.

Dry Matter Yield

Forage samples were collected to determine percent moisture (dry matter) and dry matter yield. Each plot was harvested using a flail type Carter forage harvester (Carter Manufacturing Company, Brookston, Indiana). Sub-samples were collected, placed into paper bags, and put in a cooler; bags were taken out of the cooler, weighed, and placed in a dryer at 60 °C for 72 hours and dried to constant weight to determine dry matter yield.

The dry matter (DM) was calculated as follows:

$$\text{DM (\%)} = (\text{dry weight of sample/original fresh weight of sample}) \times 100$$

Forage Nutritive Value

The dry samples were ground in a Wiley mill with a 1 mm screen. Total nitrogen in the samples was determined by the Soil Testing Laboratory at Kansas State University. The laboratory digests the samples using a sulfuric peroxide acid digestion, and then the digest is analyzed for nitrogen by a colorimetric procedure using the Rapid Flow Analyzer (Model RFA-300) and RFA Methodology No. A303-S072 from Alpchem Corporation, Clackamas, OR. Crude protein (CP) in percent was calculated by multiplying the total nitrogen (%) by 6.25.

The wet chemistry methods of Van Soest et al. (1991), described below, were used to determine acid detergent fiber (ADF) and neutral detergent fiber (NDF).

Relative feed value (RFV) is calculated from digestible dry matter digestibility (DMD) and dry matter intake (DMI) using ADF (%) and NDF (%), respectively (Rohweder et al., 1978). Using the equations of Rohweder et al. (1978), the RFV of legume-grass mixtures and monocultures was calculated as follows:

$$\text{Dry matter digestibility (DMD, \%)} = 88.9 - (0.779 \times \text{ADF})$$

$$\text{Dry matter intake (DMI, \%)} = 120 / (\text{NDF})$$

$$\text{Relative feed value (RFV)} = (\text{DMD} \times \text{DMI}) / 1.29$$

Following the protocol of ANKOM Technology (Macedon, New York), the forage samples were prepared for ADF and NDF analysis.

Statistical Analysis

Differences in dry matter yield and forage quality were evaluated by ANOVA using PROC GLIMMIX (SAS 9.3, SAS Institute Inc., Cary, NC, USA.2011). The ANOVA for these variables was conducted for each year, and for each cut, with 14 combinations of species as a fixed effect. Block was a random effect, and all data were checked for normality and homogeneity of variance. Mean separation was performed using the Bonferroni correction. All statistical comparisons were made at the significance level of $\alpha = 0.05$.

Results and Discussion

The study evaluated the suitability of alfalfa-grass mixtures as compared to alfalfa monocultures and grass monocultures for forage production. It also assessed the effect of nitrogen fertilization on dry matter production and forage nutritive value of different forage species.

Dry Matter Yield (DMY)

The means and total of dry matter yield were shown in Table 3. There was no interaction between species treatments and nitrogen fertilizer application in all cuts of both years for DMY.

The forage DMY of the first cut in 2016 was significantly higher in alfalfa monocultures and alfalfa-grass mixtures than in the monocultures of smooth brome grass and tall fescue. No difference in DMY was found in the three different alfalfa varieties, two cool-season grasses monocultures, and alfalfa-grass mixtures. DMY with nitrogen application was significantly ($P < 0.05$) higher than the control (DMY with N application: 5.3 Mg ha^{-1} and control: 4.8 Mg ha^{-1}) indicating that nitrogen fertilization appears to be a desirable practice in increasing dry matter yield in this study. The DMY of the second cut in 2016 was significantly ($P < 0.05$) higher in alfalfa monoculture and legume-grass mixtures than in monocultures of smooth brome grass and

tall fescue. The yield difference between monoculture grasses and other species treatments was greater in the second cutting than the first cutting. This might be due to increasing air temperature and lower precipitation after first cutting until second cutting. The DMY with nitrogen application was significantly higher than without nitrogen application (DMY with N application: 5.2 Mg ha⁻¹ and without 4.7 Mg ha⁻¹). The dry matter yield trend of the second cutting was similar to that of the first cutting, and DMY of different-species treatment in the second cutting was similar to that in the first cutting.

Because smooth brome grass and tall fescue are cool season grasses, they recovered poorly from the second cut in 2016, and this led to slow regrowth and dry matter yield. Therefore, the plots with pure grasses were not harvested in the third cut in 2016. In third cut in 2016, there was no statistical difference in DMY across treatments and fertilizer applications. The DMY of the fourth cut 2016 was significantly ($P < 0.05$) higher in the smooth brome grass plots than in RRA+TF. No difference in DMY was found in different alfalfa varieties and the two cool-season grasses. Also, the DMY with nitrogen application treatment was significantly greater than that of the control. Overall, the annual total DMY in 2016 had the same trend as that in the first and second cuttings, indicating that nitrogen fertilization increased the DMY by 1.2 Mg ha⁻¹ compared to no nitrogen fertilization. The data also showed that monocultures of cool-season grasses such as smooth brome grass and tall fescue had significantly lower DMY than other species treatments. Also, it appears that planting alfalfa with cool-season grasses had similar DMY compared to that in monoculture alfalfa.

The DMY of smooth brome grass in the first cut in 2017 (also known as the second production year) was significantly lower than the following combinations: Roundup Ready alfalfa with smooth brome grass; conventional alfalfa with smooth brome grass and tall fescue; and

Roundup Ready alfalfa with smooth brome grass and tall fescue (Table 3). No difference in DMY was found in alfalfa varieties and alfalfa-grass mixtures. In the second cut, the biomasses of smooth brome grass and tall fescue were not collected because the regrowth of biomasses was small. No significant differences were found in dry matter yield among forage species due to nitrogen application. In general, in the third cut of 2017, the DMY of most combinations was higher than that of the smooth brome grass. No DMY difference was found in alfalfa monocultures and alfalfa-grass mixtures. The DMY was significantly ($P<0.05$) higher with nitrogen fertilizer application than in the control. Similar results were found in the fourth cut in 2017 where DMY was significantly ($P<0.05$) higher in alfalfa monoculture varieties and legume-grass mixtures than in smooth brome grass. Unlike the fourth cutting in 2016, there was no significant difference in DMY with nitrogen application in the fourth cutting in 2017.

The possibility of legume-grass mixtures in improving forage quality and increasing dry matter yield over grass monocultures has been studied by many people (Sleugh et al., 2000; Guldán et al., 2000; Gierus et al., 2012). In general, results show that legume-grass mixtures provide higher dry matter yield compared to grass monoculture stands (Albayrak and Ekiz, 2005). In both years of this study (2016 and 2017), dry matter yields of alfalfa monocultures and alfalfa-grass mixtures were significantly higher than dry matter yield of monoculture grasses. Unexpectedly, the dry matter yield of alfalfa in monocultures was not significantly different from that of alfalfa in mixtures with grasses. The monocultures of smooth brome grass and tall fescue had the lowest biomass of all treatment (in 2016 SB: 8.4 Mg ha^{-1} , TF: 8.5 Mg ha^{-1} ; other treatments ranged from 18.7 Mg ha^{-1} to 20.2 Mg ha^{-1} ; in 2017 SB: 10.2 Mg ha^{-1} , TF: 12.2 Mg ha^{-1} ; other treatments ranged from 18.8 Mg ha^{-1} to 20.3 Mg ha^{-1}). Sleugh et al. (2000), Mortenson et al. (2004), and Rao et al. (2007) observed that planting grasses with legumes increases yield and availability of nitrogen in

the soil. Our results agreed with those of Kopp et al. (2003), who found that applying nitrogen fertilizer at a rate of 68 to 110 kg ha⁻¹ improved forage production by 64%. Nitrogen application increased the forage yield overall in total yield but did not improve yield significantly in each treatment of our study. In both years, the total yield was significantly ($P<0.05$) higher with nitrogen application than without (with nitrogen in 2016 DMY: 19.2 Mg ha⁻¹, in 2017 DMY: 19.8 Mg ha⁻¹; without in 2016 DMY: 18.0 Mg ha⁻¹, in 2017 DMY: 18.9 Mg ha⁻¹) (Table 3, Fig.1 and Fig. 2). Based on two production-year-yield data (2016 and 2017), planting two of the most common grasses in Kansas such as smooth brome grass and tall fescue with legume species such as alfalfa appears to be a more desirable practice than planting monoculture grasses. Also, alfalfa varieties did not affect the dry matter yield, indicating that variety selection of alfalfa does not appear to affect dry matter yield when alfalfa is being planted with cool-season grasses.

Nutritive Values

Crude Protein (CP)

An important forage nutritive value parameter is crude protein. The mean CP concentrations of each cut in 2016 and 2017 are shown in Table 2.4 with CP ranging from 65 to 199 g kg⁻¹ DM. In all cuts of both years, there was no interaction between species treatments and fertilizer application for CP.

The CP concentration in the first cut in 2016 was significantly ($P<0.05$) lower in grass monocultures than in alfalfa monoculture and alfalfa-grass mixtures except the mixture of conventional alfalfa with smooth brome grass. In the second cut and third cut of 2016 no significant differences in CP concentration among treatments were found. In the third cut of 2016 we did not harvest the grasses in the summer, and we did not harvest the second cut 2017

due to poor regrowth. When we harvested the smooth brome grass and tall fescue in the fourth cut in 2016, we found a significantly ($P<0.05$) lower CP concentration in smooth brome grass and tall fescue than other species treatments. The low-lignin alfalfa monoculture had a significantly ($P<0.05$) higher CP concentration than the mixture of low-lignin alfalfa with smooth brome grass. In the first cut of 2017 the tall fescue monoculture had a significantly ($P<0.05$) lower ($107 \text{ g kg}^{-1} \text{ DM}$) CP concentration than alfalfa monocultures and the alfalfa-grass mixture of Roundup Ready alfalfa with tall fescue ($149 \text{ g kg}^{-1} \text{ DM}$). In the second, third, and fourth cuts of 2017, no differences in CP concentration were found, because nitrogen was applied after the second cut. Grass monocultures were not harvested in the second cut of 2017 due to poor regrowth. However, it has been shown that planting alfalfa with grasses in mixtures increases crude protein compared to crude protein in grass monocultures (Brown et al., 2018), and our data support this statement. On average, the CP concentration of alfalfa monocultures and alfalfa-grass mixture treatments was significantly ($P<0.05$) higher than in monoculture cool-season-grasses.

Overall, in 2016 and 2017 there were no significant differences in CP with nitrogen fertilizer treatment. On average, the CP was similar in both years (CP $106 - 162 \text{ g kg}^{-1} \text{ DM}$ in 2016; CP $125 - 152 \text{ g kg}^{-1} \text{ DM}$ in 2017). No significant differences in CP were observed between the mixtures and the alfalfa monocultures. The grass monocultures had a significantly ($P<0.05$) lower CP than other species treatments. In 2016 the CP in grass monocultures was slightly lower than CP in 2017 in grasses. Schmidt (1993) saw that change in forage quality could be due to temperature and precipitation variance. In our study, 2017 was much drier than 2016, and the dryness might have led to an increase in the crude protein in the smooth brome grass and tall fescue.

Acid Detergent Fiber (ADF)

The mean ADF concentrations are shown in Table 2.5 and the ADF ranged from 323 to 367 g kg⁻¹ DM. There was no interaction between forage species treatments and nitrogen fertilizer application in all cuts of both years for ADF. The concentration of ADF was significantly ($P<0.05$) higher in smooth brome grass than in alfalfa monocultures in the first cut in 2016, but there were no differences in ADF among the legume-grass mixtures and alfalfa monocultures. In the second cut in 2016, the low-lignin alfalfa variety had a significantly ($P<0.05$) lower ADF content than mixtures A+SB and A+ TF (364, 418, and 431 g kg⁻¹ DM, respectively). Nitrogen fertilizer application did not have a significant effect on ADF content in the second cut. No differences in ADF concentration were observed for treatments in the third cut. In the fourth cut of 2016, ADF content of low lignin alfalfa was significantly ($P<0.05$) lower than grass monocultures and conventional alfalfa with grass mixtures. Nitrogen fertilizer application had no significant effect on ADF concentration.

In the first cut in 2017, no significant differences in ADF concentration among the alfalfa monocultures, grasses, and legume-grass mixtures were observed. Nitrogen application did not affect ADF. In the second cut of 2017, there were no significant differences among treatments, except the Roundup Ready alfalfa had a significantly ($P<0.05$) lower ADF than the mixture of Roundup Ready alfalfa with smooth brome grass (RRA: 309 g kg⁻¹ DM, RRA+SB: 365 g kg⁻¹ DM). No significant difference was found in ADF concentration due to nitrogen application. In the third cut in 2017, the low-lignin alfalfa variety had significantly ($P<0.05$) lower ADF than the Roundup Ready alfalfa (LLA: 335 g kg⁻¹ DM, RRA: 377 g kg⁻¹ DM). Nitrogen application had no significant effect on ADF concentration. In the fourth cut of 2017, the low-lignin alfalfa had the lowest ADF (312 g kg⁻¹ DM), and smooth brome grass had

significantly ($P<0.05$) the highest ADF ($371 \text{ g kg}^{-1} \text{ DM}$). Nitrogen fertilizer application did not affect ADF concentration.

Based on two years of data, ADF was significantly ($P<0.05$) lower in low-lignin alfalfa (LLA: $357 \text{ g kg}^{-1} \text{ DM}$) than in smooth brome grass (SB: $386 \text{ g kg}^{-1} \text{ DM}$) and these combinations: A+TF ($390 \text{ g kg}^{-1} \text{ DM}$), RRA+SB ($383 \text{ g kg}^{-1} \text{ DM}$), A+SB+TF ($400 \text{ g kg}^{-1} \text{ DM}$), RRA+SB+TF ($393 \text{ g kg}^{-1} \text{ DM}$). In 2017, ADF was significantly ($P<0.05$) lower in the low-lignin alfalfa monoculture ($333 \text{ g kg}^{-1} \text{ DM}$) than in the grass plots; in mixtures with conventional alfalfa with two or one grass combinations; and in Roundup Ready alfalfa plots with one or two grasses. In both years, nitrogen fertilizer application did not affect ADF content. Several factors affect forage quality including species, stage of maturity when the forages are harvested, growing conditions, and the botanical composition of the pastures (Buxton, 1996; Yarrow and Penning, 2001; Deprez et al., 2004). In this study at each cutting in both years, alfalfa was harvested based on 1/10 bloom stage of alfalfa maturity. Results of our study showed that, on average, ADF was significantly lower in the low-lignin alfalfa in both years than ADF in pure grasses and alfalfa-grass mixtures.

Neutral Detergent Fiber (NDF)

The NDF is also an important parameter of forage quality (Cabellero et al., 1995; Assefa and Ledin, 2001), which is determined by species, stage of maturity when the forages are harvested, growing conditions, and the botanical composition of the pastures (Buxton, 1996; Yarrow and Penning, 2001; Deprez et al., 2004). The mean NDF concentrations are shown in Table 2.6. There was no interaction between treatments and nitrogen fertilizer application in all cuts of both years for NDF.

The NDF concentration in the first cut of 2016 was significantly ($P<0.05$) lower in alfalfa monocultures compared to grasses in monoculture. The low-lignin alfalfa variety had the lowest NDF (LLA: 460 g kg⁻¹ DM, SB: 614 g kg⁻¹ DM, TF: 574 g kg⁻¹ DM). No difference in NDF was found in alfalfa-grass mixtures. Nitrogen fertilizer application significantly increased the NDF. With nitrogen application, the NDF was 534 g kg⁻¹ DM, and without nitrogen NDF it was 513 g kg⁻¹ DM. In the second cut of 2016, tall fescue had a significantly ($P<0.05$) higher NDF than alfalfa in monocultures and alfalfa-grass mixtures (conventional alfalfa variety with smooth brome grass; low-lignin alfalfa with smooth brome grass; low-lignin alfalfa with tall fescue; low-lignin alfalfa with tall fescue and smooth brome grass; and conventional alfalfa with smooth brome grass and tall fescue). No significant differences were observed due to nitrogen application. In the third cut in 2016, the NDF was significantly ($P<0.05$) lower in the low-lignin alfalfa monoculture than in these mixtures: A+SB, A+TF, RRA+SB, A+SB+TF. Nitrogen fertilizer application had a significant effect on NDF concentration; the mean of NDF was significantly ($P<0.05$) lower with nitrogen than without nitrogen (with nitrogen application NDF: 484 g kg⁻¹ DM, without NDF: 496 g kg⁻¹ DM). In the fourth cut of 2016, NDF was significantly ($P<0.05$) higher in grass monocultures than in the other treatments (SB: 588 g kg⁻¹ DM, TF: 585 g kg⁻¹ DM). The low-lignin alfalfa had a significantly ($P<0.05$) lower NDF than the grasses and mixtures, except for the mixture low-lignin alfalfa with tall fescue (LLA: 465 g kg⁻¹ DM, LLA+TF: 487 g kg⁻¹ DM). With nitrogen application, NDF was significantly ($P<0.05$) higher than without nitrogen fertilizer application in 2016.

In first cut in 2017, tall fescue had a significantly ($P<0.05$) higher NDF concentration than all other treatments, except smooth brome grass. There were no significant differences due to nitrogen application. In the second cut in 2017, no significant differences were observed in

NDF among combinations or due to nitrogen application. In the third cut in 2017, the low-lignin alfalfa variety, the conventional variety, and two mixtures (low-lignin alfalfa with smooth bromegrass and Roundup Ready alfalfa with tall fescue) had a significantly lower NDF concentration than smooth bromegrass and tall fescue. Nitrogen fertilizer application did not affect NDF. In the fourth cut, low-lignin alfalfa had the lowest NDF and grasses had the highest NDF (ALL: 413 g kg⁻¹ DM, SB: 521 g kg⁻¹ DM, TF: 523 g kg⁻¹ DM). Nitrogen fertilizer application did not affect NDF.

Based on our average results for 2016 and 2017, the low-lignin alfalfa had the lowest NDF compared to mixtures and pure grasses. A higher fiber concentration usually occurs in grasses than in leguminous plants (Fulkerson et al., 2007; Kammes and Allen, 2012; Ergon et al., 2016). Planting grasses as a mixture with alfalfa might improve forage quality by reducing the fiber content. Our results showed that the low-lignin alfalfa monoculture had significantly lower ADF and NDF. Also, grass mixtures with low-lignin alfalfa had a relatively lower fiber content, which could be a benefit to the producer.

Relative Feed Value (RFV)

The mean RFV indexes are shown in Table 2.7. There was no interaction between species treatments and nitrogen fertilizer application in all cuts of both years for RFV.

The RFV in the first cut in 2016 was significantly ($P < 0.05$) higher in low-lignin alfalfa (LLA: 129) than in grasses (SB: 91, TF: 99), and alfalfa-grass mixtures such as conventional alfalfa and smooth bromegrass, Roundup Ready and smooth bromegrass, low-lignin alfalfa and smooth bromegrass, conventional alfalfa with both grasses, roundup ready alfalfa with both

grasses, and low-lignin alfalfa with both grasses (A+SB:110, RRA+SB:108, LLA+SB:109, A+SB+TF: 103, RRA+SB+TF: 106, LLA+SB+TF:109). The RFV with nitrogen fertilizer application was significantly ($P<0.05$) higher than in the control (113, 109, respectively). In the second cut in 2016, the RFV of reduced-lignin alfalfa was significantly ($P<0.05$) higher than the RFV of tall fescue and a mixture of conventional alfalfa with tall fescue (LLA: 115, TF: 96, A+TF: 94). No significant differences in RFV were observed due to nitrogen application. In the third cut in 2016, low-lignin alfalfa had a significantly ($P<0.05$) higher RFV value than that of the mixtures of conventional alfalfa with smooth brome grass and tall fescue (LLA: 125, A+SB+TF: 108). Also, nitrogen application had a significant effect on RFV; RFV was higher with nitrogen than without nitrogen (with nitrogen: 115, without 110). In the fourth cut in 2016, the highest RFV was in the low-lignin alfalfa (123) compared to other treatments. The smooth brome grass and tall fescue had significantly lower RFV than the other treatments (SB: 89, TF: 89). No significant differences were observed in RFV values due to nitrogen fertilizer application.

The RFV values in first cut in 2017 were significantly ($P<0.05$) higher in low-lignin alfalfa, conventional alfalfa, and the mixture of reduced-lignin alfalfa with smooth brome grass than monocultures of tall fescue and smooth brome grass (LLA: 129, RRA: 129, LLA+SB: 127, SB: 106, TF: 103). No significant differences in RFV values were observed due to nitrogen fertilizer application. In the second cut in 2017, smooth brome and tall fescue did not have enough biomass to harvest. No statistical differences in RFV values among the treatments and nitrogen application were observed, probably due to the smaller portion of grasses in alfalfa-grass mixtures. In the third cut in 2017, the RFV values were significantly ($P<0.05$) higher in the low-lignin alfalfa and the conventional variety of alfalfa than in the smooth brome grass and

tall fescue (A: 133, ALL: 139, SB: 108, TF: 109). No significant differences were observed in RFV with nitrogen application. In 2017 in the fourth cut, the highest RFV value was in the low - lignin alfalfa and low-lignin alfalfa with tall fescue (LLA: 146, LLA+TF: 133). Nitrogen fertilizer application did not affect the RFV values. On average in 2016 and 2017, RFV was highest in LLA and lowest in monocultures of smooth brome grass and tall fescue. The average RFV of LLA in 2016 was 123; in 2017, it was 140. The RFV of SB in 2016 was 93 and for TF it was 95. In 2017, the RFV of SB was 107 and the RFV of TF was 107. In both years, there were no significant differences due to fertilizer application.

RFV is an index that was developed by Rohweder et al. (1978) and has been used to compare forage quality when hay is sold; the higher the number is the greater the quality of the forage. According to Van Soest (1982), RFV does not measure nutritional content directly, but is used for calculation of hay quality, usually when buying or selling alfalfa hay. Forages are classified as follows: RFV value 151-170 – prime category, 150-125 – premium, 124-103 – good, 102-87 – fair (Uzun, 2010). Based on the average RFV for two years, the highest RFV was found in low-lignin alfalfa and the lowest in monoculture grasses. In 2016 the low-lignin alfalfa was in the good hay category, and the smooth brome grass and tall fescue were in the fair hay category; all alfalfa-grass mixtures, except the A+SB+TF, were in the good hay category. In 2017 alfalfa monocultures were in the premium category and grass monocultures were in the good hay category; the alfalfa-grass mixtures were in the good hay category, except LLA+SB and LLA+TF.

Conclusions

Forage yields and quality of alfalfa-grass mixtures were higher than those in monocultures of smooth brome grass and tall fescue and were equal to alfalfa monocultures. All treatments had higher dry matter yield with nitrogen fertilizer application than without nitrogen application. The dry matter yield of the low-lignin alfalfa variety was not significantly different from the dry matter yield of the other two alfalfa varieties (conventional and Roundup Ready). The lowest forage quality and yield was observed in monocultures of smooth brome grass and tall fescue. Planting two grasses such as smooth brome grass and tall fescue with alfalfa species appears to be a more desirable practice than planting monoculture grasses.

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Table 2.1. Rainfall and maximum and minimum temperature at Ashland Bottoms Research Farm, Kansas State University during the study period (2015 – 2017).

Climate Characteristics	month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2015												
Monthly rain, mm				68	219	107	128	81	105	15	111	83
Mean max. temp., °C.				21	23	31	32	30	30	22	16	9
Mean min. temp., °C.				7	12	19	21	17	17	8	3	-2
2016												
Monthly rain, mm	13	10	11	215	177	39	155	186	106	70	8	21
Mean max. temp., °C.	5	12	18	21	24	33	32	30	28	24	17	6
Mean min. temp., °C.	-6	-3	2	8	11	19	21	20	16	9	4	-7
2017												
Monthly rain, mm	25	12	107	127	97	72	34	155	21	93	2	3
Mean max. temp., °C.	6	13	15	19	25	31	33	29	29	21	14	6
Mean min. temp., °C.	-5	-1	3	8	11	17	21	16	15	7	1	-5

Table 2.2. Composition of alfalfa and grasses as monocultures and legume-grass mixtures.

Treatment	Species	Abbreviation
1	Gunner conventional alfalfa	A
2	Low-lignin Hi-Gest 360 LL alfalfa	LLA
3	Roundup ready RR Tonica alfalfa	RRA
4	SmoothBromegrass	SB
5	Tall Fescue	TF
6	Gunner conventional alfalfa+SmoothBromegrass	A+SB
7	Gunner conventional alfalfa + Tall Fescue	A+TF
8	Low-lignin Hi-Gest 360 LL alfalfa + Smooth Bromegrass	ALL+SB
9	Low-lignin Hi-Gest 360 LL alfalfa + Tall Fescue	ALL+TF
10	Roundup ready RR Tonica alfalfa + Smooth Bromegrass	RRA+SB
11	Roundup ready RR Tonica alfalfa + Tall Fescue	RRA+TF
12	Gunner conventional alfalfa + Smooth Bromegrass + Tall Fescue	A+SB+TF
13	Low-lignin Hi-Gest 360 LL alfalfa + Smooth Bromegrass + Tall Fescue	ALL+SB+TF
14	Roundup ready RR Tonica alfalfa + Smooth Bromegrass + Tall Fescue	RRA+SB+TF

Table 2.3. Mean and total dry matter yield (Mg ha⁻¹) in 2016 and 2017.

Treatments	2016					2017				
	Cut 1	Cut 2	Cut 3	Cut 4	Total	Cut1	Cut 2	Cut 3	Cut 4	Total
N 0	4.8 b	4.7 b	4.8 a	3.7 b	18.0 b	5.0 a	5.3 a	4.7 b	3.9 a	18.9 b
N 112	5.3 a	5.2 a	4.8 a	3.9 a	19.2 a	5.5 a	5.3 a	5.0 a	4.0 a	19.8 a
A	5.3 a	5.1 a	4.9 a	3.5 ab	18.8 a	5.1 ab	5.2 a	4.8 ab	4.1 ab	19.2 a
LLA	4.9 a	5.3 a	4.7 a	3.9 ab	18.8 a	5.1 ab	5.0 a	4.8 ab	4.1 ab	19.0 a
RRA	5.0 a	5.7 a	5.1 a	3.7 ab	19.5 a	4.5 ab	5.4 a	5.0 a	4.2 a	19.1 a
SB	2.5 b	1.3 b	N/A	4.6 a	8.4 b	3.5 b	N/A	3.9 b	2.8 c	10.2 b
TF	2.3 b	1.9 b	N/A	4.3 ab	8.5 b	4.4 ab	N/A	4.5 ab	3.4 bc	12.3 b
A+SB	5.5 a	5.5 a	5.0 a	3.6 ab	19.6 a	5.6 ab	5.5 a	5.1 a	4.2 a	20.4 a
A+TF	5.7 a	5.5 a	4.8 a	3.7 ab	19.7 a	5.6 ab	5.4 a	5.0 a	4.2 a	20.2 a
LLA+SB	5.4 a	5.3 a	4.6 a	3.8 ab	19.1 a	5.8 a	4.8 a	4.9 ab	4.3 a	19.8 a
LLA+TF	5.7 a	5.6 a	4.9 a	3.9 ab	20.1 a	5.5 ab	5.2 a	5.0 a	4.2 a	19.9 a
RRA+SB	5.9 a	5.5 a	4.4 a	3.6 ab	19.5 a	5.7 a	5.7 a	5.0 a	3.8 ab	20.2 a
RRA+TF	5.9 a	5.6 a	4.7 a	3.3 b	19.5 a	5.6 ab	5.2 a	4.6 ab	4.0 ab	19.4 a
A+SB+TF	6.0 a	5.4 a	5.1 a	3.8 ab	20.3 a	5.9 a	5.2 a	5.2 a	4.0 ab	20.3 a
LLA+SB+TF	5.8 a	5.4 a	4.7 a	3.6 ab	19.5 a	5.3 ab	5.2 a	4.7 ab	3.8 ab	19.0 a
RRA+SB+TF	5.5 a	5.6 a	4.6 a	3.6 ab	19.3 a	5.7 a	5.3 a	4.7 ab	4.2 a	19.9 a
P values										
N	0.0016	0.0347	0.8406	0.0084	<.0001	0.051	0.8537	0.0495	0.145	<.0001
T	<.0001	<.0001	0.7919	0.0315	<.0001	0.0057	0.2185	0.0075	<.0001	<.0001

A – Gunner conventional alfalfa, LLA – low-lignin Hi-Gest 360 LL alfalfa, RRA – Roundup Ready RR Tonica alfalfa, SB – smooth bromegrass, TF – tall fescue, A+SB – Gunner conventional alfalfa + smooth bromegrass, A+TF – Gunner conventional alfalfa + tall fescue, ALL+SB – low-lignin Hi-Gest 360 LL alfalfa + smooth bromegrass, ALL+TF – low-lignin Hi-Gest 360 LL alfalfa + tall fescue, RRA+SB – Roundup Ready RR Tonica alfalfa + smooth bromegrass, RRA+TF – Roundup Ready RR Tonica alfalfa + tall fescue, A+SB+TF – Gunner conventional alfalfa + smooth bromegrass + tall fescue, ALL+SB+TF – low-lignin Hi-Gest 360 LL alfalfa + smooth bromegrass + tall fescue, RRA+SB+TF – roundup ready RR Tonica alfalfa + smooth bromegrass + tall fescue. N0- control without fertilizer, N112 – nitrogen application 112 kg ha⁻¹, N – nitrogen fertilizer, T – treatment. P value at 0.05 level.

Table 2.4. Mean CP concentration (g kg⁻¹ DM) in 2016 and 2017.

Treatments	2016					2017				
	Cut 1	Cut 2	Cut 3	Cut 4	Average	Cut1	Cut 2	Cut 3	Cut 4	Average
N 0	170 a	127 a	126 a	140 a	140 a	137 a	163 a	143 a	141 a	145 a
N 112	175 a	127 a	130 a	131 a	140 a	136 a	161 a	146 a	142 a	145 a
A	182 a	129 a	151 a	157 ab	155 a	145 a	163 a	147 a	139 a	148 ab
LLA	199 a	131 a	151 a	167 a	162 a	147 a	158 a	139 a	148 a	148 ab
RRA	187 a	135 a	141 a	148 ab	152 a	147 a	171 a	142 a	144 a	151 ab
SB	137 bc	120 a	N/A	65 c	107 b	119 ab	N/A	136 a	133 a	130 bc
TF	132 c	111 a	N/A	77c	106 b	107 b	N/A	132 a	135 a	125 c
A+SB	162 abc	129 a	149 a	140 ab	145 a	134 ab	153 a	144 a	142 a	143 abc
A+TF	173 ab	115 a	148 a	136 ab	143 a	145 ab	152 a	150 a	149 a	149 ab
LLA+SB	172 ab	131 a	155 a	126 b	146 a	137 ab	164 a	148 a	129 a	145 abc
LLA+TF	184 a	111 a	147 a	154 ab	154 a	137 ab	171 a	155 a	146 a	152 a
RRA+SB	168 ab	138 a	153 a	154 ab	153 a	137 ab	161 a	142 a	154 a	149 ab
RRA+TF	182 a	132 a	144 a	156 ab	153 a	149 a	163 a	152 a	138 a	151 ab
A+SB+TF	180 a	133 a	148 a	130 ab	148 a	135 ab	160 a	143 a	140 a	145 abc
LLA+SB+TF	182 a	137 a	159 a	139 ab	154 a	136 ab	161 a	151 a	145 a	148 ab
RRA+SB+TF	175 a	126 a	147 a	151 ab	150 a	138 ab	165 a	141 a	140 a	146 abc
P values										
N	0.1601	0.9075	0.161	0.1486	0.8494	0.5725	0.6211	0.3376	0.8758	0.8709
T	<.0001	0.3195	<.0001	<.0001	<.0001	0.0075	0.535	0.6692	0.203	0.0006

A – Gunner conventional alfalfa, LLA – low-lignin Hi-Gest 360 LL alfalfa, RRA – Roundup Ready RR Tonica alfalfa, SB – smooth brome grass, TF – tall fescue, A+SB – Gunner conventional alfalfa + smooth brome grass, A+TF – Gunner conventional alfalfa + tall fescue, ALL+SB – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass, ALL+TF – low-lignin Hi-Gest 360 LL alfalfa + tall fescue, RRA+SB – Roundup Ready RR Tonica alfalfa + smooth brome grass, RRA+TF – Roundup Ready RR Tonica alfalfa + tall fescue, A+SB+TF – Gunner conventional alfalfa + smooth brome grass + tall fescue, ALL+SB+TF – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass + tall fescue, RRA+SB+TF – Roundup Ready RR Tonica alfalfa + smooth brome grass + tall fescue. N0- control without fertilizer, N112 – nitrogen application 112 kg ha⁻¹, N – nitrogen fertilizer, T – treatment. P value at 0.05 level. CP – crude protein, DM – dry matter.

Table 2.5. Mean ADF concentration (g kg⁻¹ DM) in 2016 and 2017.

Treatments	2016					2017				
	Cut 1	Cut 2	Cut 3	Cut 4	Average	Cut1	Cut 2	Cut 3	Cut 4	Average
N 0	347 a	406 a	392 a	389 a	383 a	362 a	339 a	365 a	350 a	355 a
N 112	347 a	405 a	381 a	395 a	382 a	362 a	340 a	360 a	350 a	354 a
A	323 d	404 abc	398 a	380 bc	376 ab	359 a	318 ab	357 ab	354 ab	347 abc
LLA	332 bcd	364 c	381 a	352 c	357 b	355 a	330 ab	335 b	312 c	333 c
RRA	329 cd	410 abc	398 a	386 abc	379 ab	347 a	309 b	377 a	357 ab	347 abc
SB	367 a	390 abc	N/A	401 ab	386 a	364 a	N/A	371 ab	371 a	369 a
TF	357 abc	379 bc	N/A	398 ab	378 ab	360 a	N/A	363 ab	362 ab	361 a
A+SB	345 abcd	418 ab	390 a	395 ab	387 ab	374 a	347 ab	375 ab	352 ab	362 a
A+TF	349 abcd	431 a	374 a	404 ab	390 a	353 a	354 ab	372 ab	353 ab	358 ab
LLA+SB	350 abcd	413 abc	374 a	379 bc	379 ab	364 a	343 ab	345 ab	343 abc	349 abc
LLA+TF	343 abcd	407 abc	373 a	378 bc	375 ab	357 a	326 ab	339 ab	330 bc	338 bc
RRA+SB	348 abcd	407 abc	401 a	401 ab	389 a	371 a	365 a	366 ab	342 abc	361 a
RRA+TF	344 abcd	402 abc	378 a	401 ab	381 ab	370 a	338 ab	370 ab	361 ab	360 a
A+SB+TF	364 ab	428 ab	388 a	417 a	400 a	376 a	361 ab	369 ab	356 ab	365 a
LLA+SB+TF	350 abcd	402 abc	389 a	386 abc	382 ab	357 a	334 ab	358 ab	340 abc	347 abc
RRA+SB+TF	354 abcd	417 abc	392 a	409 ab	393 a	358 a	350 ab	376 ab	362 ab	361 a
P values										
N	0.9838	0.8416	0.1168	0.1327	0.5583	0.863	0.6824	0.286	0.9835	0.6704
T	0.0003	0.0018	0.8074	<.0001	0.0005	0.5159	0.0212	0.0032	<.0001	<.0001

A – Gunner conventional alfalfa, LLA – low-lignin Hi-Gest 360 LL alfalfa, RRA – Roundup Ready RR Tonica alfalfa, SB – smooth brome grass, TF – tall fescue, A+SB – Gunner conventional alfalfa + smooth brome grass, A+TF – Gunner conventional alfalfa + tall fescue, ALL+SB – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass, ALL+TF – low-lignin Hi-Gest 360 LL alfalfa + tall fescue, RRA+SB – Roundup Ready RR Tonica alfalfa + smooth brome grass, RRA+TF – Roundup Ready RR Tonica alfalfa + tall fescue, A+SB+TF – Gunner conventional alfalfa + smooth brome grass + tall fescue, ALL+SB+TF – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass + tall fescue, RRA+SB+TF – Roundup Ready RR Tonica alfalfa + smooth brome grass + tall fescue. N0- control without fertilizer, N112 – nitrogen application 112 kg ha⁻¹, N – nitrogen fertilizer, T – treatment. P value at 0.05 level. ADF – acid detergent fiber, DM – dry matter.

Table 2.6. Mean NDF concentration (g kg⁻¹ DM) in 2016 and 2017.

Treatments	2016					2017				
	Cut 1	Cut 2	Cut 3	Cut 4	Average	Cut1	Cut 2	Cut 3	Cut 4	Average
N 0	513 b	518 a	496 a	508 a	512 b	475 a	411 a	465 a	467 a	458 a
N 112	534 a	522 a	486 b	515 a	518 a	482 a	406 a	464 a	476 a	462 a
A	470 ef	503 b	476 ab	491 bc	486 de	458 c	396 a	432 b	459 bc	436 cde
LLA	460 f	489 b	441 b	466 c	465 e	443 c	398 a	422 b	412 d	419 e
RRA	470 ef	513 b	487 ab	493 bc	491 cde	450 c	388 a	481 ab	472 bc	448 bcde
SB	614 a	548 ab	N/A	601 a	588 a	534 ab	N/A	520 a	521 a	525 a
TF	574 ab	573 a	N/A	608 a	585 a	550 a	N/A	518 a	523 a	530 a
A+SB	528 bcde	512 b	508 a	501 bc	513 cd	487 bc	416 a	474 ab	483 abc	465 bc
A+TF	516 bcdef	549 ab	500 a	517 bc	520 b	471 c	424 a	463 ab	480 abc	460 bcd
LLA+SB	526 bcdef	504 b	481 ab	506 bc	504 bcd	445 c	395 a	441 b	439 cd	430 de
LLA+TF	500 cdef	505 b	473 ab	471 bc	487 de	457 c	400 a	455 ab	445 bcd	440 bcde
RRA+SB	536 bcd	520 ab	497 a	519 bc	518 bc	484 bc	415 a	459 ab	460 bc	454 bcd
RRA+TF	519 bcdef	536 ab	486 ab	476 bc	504 bcd	469 c	404 a	437 b	481 abc	448 bcde
A+SB+TF	546 bc	514 b	526 a	520 b	527 b	484 bc	420 a	478 ab	487 ab	467 b
LLA+SB+TF	526 bcdef	498 b	493 ab	492 bc	502 bcd	481 bc	420 a	459 ab	456 bcd	454 bcd
RRA+SB+TF	539 bc	518 ab	510 ab	503 bc	518 bc	486 bc	425 a	467 ab	482 abc	465 bc
N	0.0003	0.5351	0.0441	0.1593	0.0225	0.4101	0.303	0.857	0.1866	0.2194
T	<0.0001	<.0001	0.0002	<.0001	<.0001	<.0001	0.0426	<.0001	<.0001	<.0001

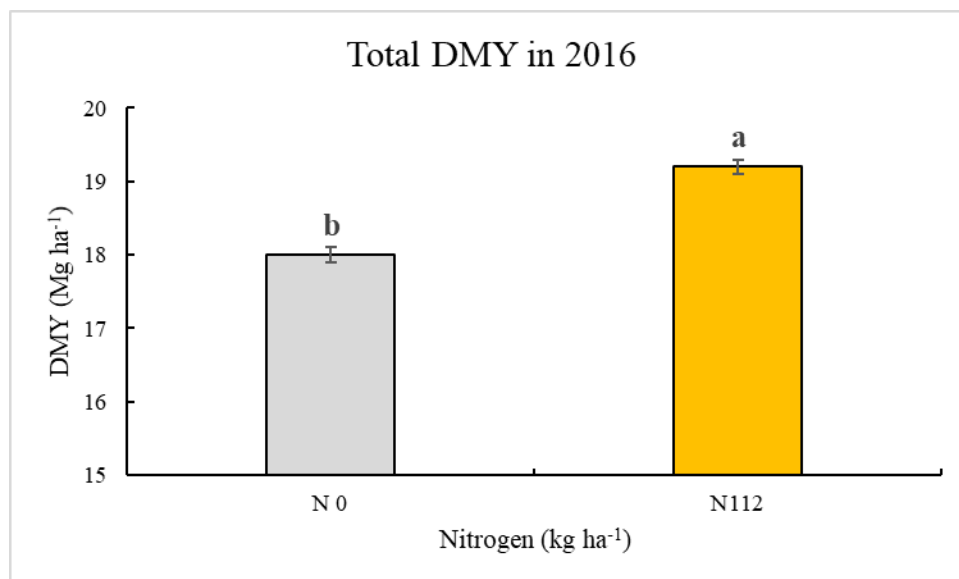
A – Gunner conventional alfalfa, LLA – low-lignin Hi-Gest 360 LL alfalfa, RRA – Roundup Ready RR Tonica alfalfa, SB – smooth brome grass, TF – tall fescue, A+SB – Gunner conventional alfalfa + smooth brome grass, A+TF – Gunner conventional alfalfa + tall fescue, ALL+SB – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass, ALL+TF – low-lignin Hi-Gest 360 LL alfalfa + tall fescue, RRA+SB – Roundup Ready RR Tonica alfalfa + smooth brome grass, RRA+TF – Roundup Ready RR Tonica alfalfa + tall fescue, A+SB+TF – Gunner conventional alfalfa + smooth brome grass + tall fescue, ALL+SB+TF – low-lignin Hi-Gest 360 LL alfalfa + smooth brome grass + tall fescue, RRA+SB+TF – Roundup Ready RR Tonica alfalfa + smooth brome grass + tall fescue. N0- control without fertilizer, N112 – nitrogen application 112 kg ha⁻¹, N – nitrogen fertilizer, T – treatment. P value at 0.05 level. NDF – neutral detergent fiber, DM – dry matter.

Table 2.7. Mean RFV indexes in 2016 and 2017.

Treatments	2016					2017				
	Cut 1	Cut 2	Cut 3	Cut 4	Average	Cut1	Cut 2	Cut 3	Cut 4	Average
N 0	109 b	104 a	110 b	108 a	108 a	120 a	142 a	122 a	124 a	126 a
N 112	113 a	103 a	115 a	106 a	107 a	118 a	143 a	123 a	121 a	125 a
A	126 ab	107 ab	114 ab	113 abc	115 ab	125 ab	151 a	133 a	124 bcd	133 ab
LLA	129 a	115 a	125 a	123 a	123 a	129 a	148 a	139 a	146 a	140 a
RRA	125 abc	104 ab	111 ab	112 abc	113 bc	129 a	156 a	115 ab	121 bcde	130 abcd
SB	91 e	100 ab	N/A	89 d	93 f	106 bc	N/A	108 b	108 e	107 e
TF	99 de	96 b	N/A	89 d	95 ef	103 c	N/A	109 b	108 e	107 e
A+SB	110 bcd	102 ab	108 ab	108 bc	107 bcd	115 abc	139 a	117 ab	119 cde	122 cd
A+TF	112 abcd	94 b	112 ab	104 c	105 cd	122 abc	135 a	121 ab	119 bcde	124 bcd
LLA+SB	109 dc	105 ab	116 ab	110 abc	110 bcd	127 a	147 a	131 ab	132 bc	134 ab
LLA+TF	116 abcd	106 ab	118 ab	118 ab	114 ab	124 ab	147 a	128 ab	133 ab	133 abc
RRA+SB	108 de	103 ab	108 ab	104 c	106 cd	116 abc	136 a	123 ab	127 bcd	125 bcd
RRA+TF	112 abcd	101 ab	114 ab	113 abc	110 bcd	120 abc	145 a	129 ab	118 cde	128 bcd
A+SB+TF	103 de	101 ab	105 b	101 dc	102 cd	116 abc	135 a	118 ab	117 de	121 d
LLA+SB+TF	109 dc	108 ab	111 ab	112 abc	110 bcd	118 abc	139 a	125 ab	128 bcd	127 bcd
RRA+SB+TF	106 de	103 ab	107 ab	106 bc	105 cd	117 abc	135 a	119 ab	117 de	122 cd
P value										
N	0.0034	0.6895	0.0334	0.0722	0.1686	0.5356	0.579	0.552	0.3967	0.6355
T	0.0001	0.0034	0.0446	<.0001	<.0001	<.0001	0.0211	0.0004	<.0001	<.0001

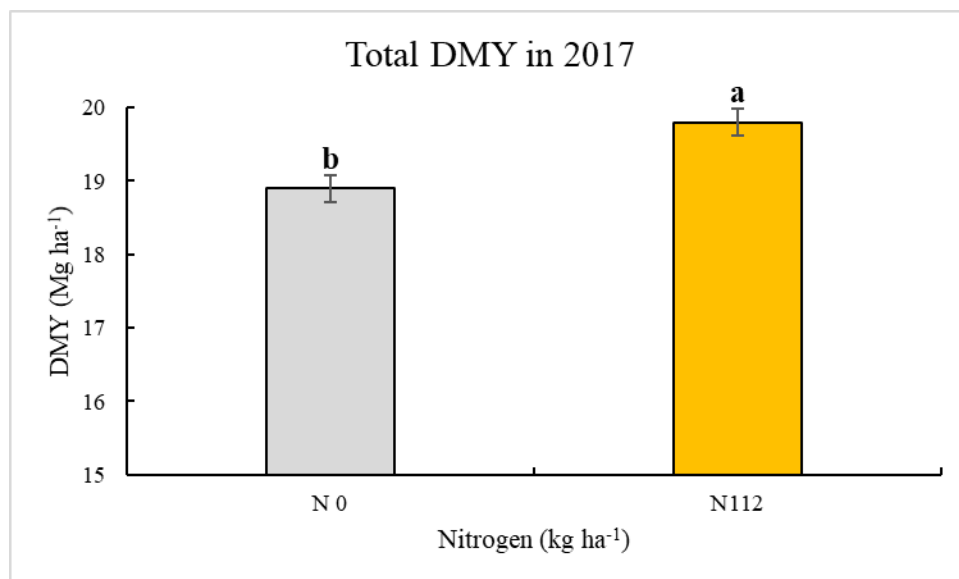
A – Gunner conventional alfalfa, LLA – low-lignin Hi-Gest 360 LL alfalfa, RRA – Roundup Ready RR Tonica alfalfa, SB – smooth bromegrass, TF – tall fescue, A+SB – Gunner conventional alfalfa + smooth bromegrass, A+TF – Gunner conventional alfalfa + tall fescue, ALL+SB – low-lignin Hi-Gest 360 LL alfalfa + smooth bromegrass, ALL+TF – low-lignin Hi-Gest 360 LL alfalfa + tall fescue, RRA+SB – Roundup Ready RR Tonica alfalfa + smooth bromegrass, RRA+TF – Roundup Ready RR Tonica alfalfa + tall fescue, A+SB+TF – Gunner conventional alfalfa + smooth bromegrass + tall fescue, ALL+SB+TF – low-lignin Hi-Gest 360 LL alfalfa + smooth bromegrass + tall fescue, RRA+SB+TF – Roundup Ready RR Tonica alfalfa + smooth bromegrass + tall fescue. N0- control without fertilizer, N112 – nitrogen application 112 kg ha⁻¹, N – nitrogen fertilizer, T – treatment. P value at 0.05 level. RFV – relative feed value index.

Figure 2.1. Total dry matter yield (Mg ha^{-1}) with and without nitrogen fertilizer application in 2016.



P value at 0.05 level, DMY- dry matter yield, N0- no nitrogen, N112 - with applied nitrogen 112 kg ha^{-1} .

Figure 2.2. Total dry matter yield (Mg ha^{-1}) with and without nitrogen fertilizer application in 2017.



P value at 0.05 level, DMY- dry matter yield, N0- no nitrogen, N112 - with applied nitrogen 112 kg ha^{-1} .

Chapter 3 - Effect of a Last Fall Cutting Date on Dry Matter Yield, Nutritive Value, and Stand Persistence of Alfalfa

Abstract

Information is lacking about the effect of date of a fall cut of alfalfa (*Medicago sativa* L.) on dry matter yield, nutritive value, and stand persistence. The objective of this study was to determine the effect of timing of a fall cut on dry matter yield (DMY), nutritive value, and stand persistence of alfalfa in Northeastern Kansas in the United States. A field study was planted on April 23, 2015. The experimental design was a split plot in randomized complete block with four replications. In 2015, data were collected from the last cut on the following dates: September 15, September 30, October 15, and October 30. In 2016, the three cuts were harvested based on stage of maturity, and the last (fourth) cut was done on following dates: September 15, September 30, October 15, and October 30. In 2017, the four cuts were harvested based on stage of maturity, and the last (fifth) cut was done on following dates: September 15, September 30, October 15, and October 30. In 2018, data were collected from the first cut on May 10. The persistence of the alfalfa stands was determined each fall after the last cut, and each spring after the first cut, by counting the number of live plants in a randomly placed quadrat (0.18 m²) in each plot. Samples from each plot were collected at each harvest to estimate DMY and forage nutritive value (crude protein, CP; acid detergent fiber, ADF; neutral detergent fiber, NDF; and relative feed value, RFV). The DMY of first cut in 2016 was significantly higher in the Roundup Ready variety than in the low-lignin variety. In the second cut of 2016, DMY of the conventional alfalfa was significantly higher than that of Roundup Ready. There were no significant differences in DMY between alfalfa varieties in the remaining seasonal cuttings in 2016 and 2017 and in the annual total yield in both years. The DMY of the last cut in the fall was the highest in 2015, 2016, and

2017 in plots that were cut on September 30. In 2017 highest DMY in the first cut was found in plots that were cut on October 15 the previous year. Alfalfa cut on September 15 and September 30 had a higher stand persistence compared to alfalfa cut on October 15 and October 30. Based on the 3-year data, the last cutting of alfalfa in the fall could be done by September 30 – October 15 without harmful effects on DMY.

Keywords: stand persistence, nutritive value, forage quality, last fall cut.

Introduction

Alfalfa is known as the “Queen of the Forages.” It has the highest yield potential of any perennial forage legume adapted to the United States (Hancock et al., 2015). Alfalfa is highly advantageous for use as feed for ruminants (Barnhart, 1997). Changes in climatic conditions have extended warm or cold periods and often tempt a producer to cut alfalfa during the resting period, which is 4-6 weeks before the first killing frost, but doing this initiates regrowth and reduces root reserves during a critical time (Smith, 1972). Recommendations concerning the length of the fall resting period in alfalfa production are still under question. The date of the last cut in the fall is questionable, and its effect on dry matter yield and stand persistence need study (Tesar and Yager, 1985; Sheaffer et al., 1986; Belanger et al., 1992).

Sheaffer and Marten (1990), Brink et al. (2010), and Dhont et al. (2002, 2003, and 2004) reported that extending the last cut in the fall increases total dry matter yield for the year, but it also has a negative impact on yield in the first cut of the next year. Frequent, seasonal harvests of alfalfa can also impact stand persistence (Macolino et al., 2002; Davies and Peoples, 2003). Sheaffer and Marten (1990) documented that, if the last cut in the fall is before first killing frost, the harvest does not have much of a negative effect on stand persistence for several years after the alfalfa has been planted. In contrast to these results, other studies have documented no effect of harvest time on stand persistence of alfalfa (Hoveland et al., 1996; Borreani et., 2000). Belanger et al. (1992) reported that dry matter yield did not change in a third and last cut in the fall. In a study done in Michigan, Tesar (1981) reported that a producer could make the last cut in the fall in October without damaging stand persistence.

Hendershot and Volenec (1993), Volenec et al., (1996), Avice et al., (1997), and Dhont et al. (2003) documented that root nitrogen (N) reserves and storage proteins have a close relation with spring regrowth. Alfalfa persistence is affected not only by root reserves, but it also depends on the soil temperature, amount of snow during winter (McKenzie and McLeah 1980; Leep et al., 2001), content of moisture and nutrients in the soil (Twamley 1960; Paquin and Mehuys 1980; Macolino et al., 2013), age of alfalfa stands (Suzuki, 1991), and the frequency of cuttings during the season and the stage of maturity (Walgenbach 1983).

Many factors interact with harvest time in the fall, which influence dry matter yield and stand persistence of alfalfa. Weather conditions vary from fall to fall, causing producers to harvest at different times. Sometimes they have a late harvest right before the first killing frost, and they do not know if it might negatively affect yield and stand persistence. This raises the question of how to manage the forage and when is the best time to cut in the fall. The objective of this study was to evaluate the effect of the timing of the last fall harvest on dry matter yield, nutritive value, and stand persistence of alfalfa.

Material and Methods

Study Site

The experiment was conducted starting on April 23, 2015, at the Kansas State University Agronomy Research Farm in Manhattan, Kansas (39°20' N, 96°59'W). The soil type at the study site was a Wymore silty clay and Smolan silt loam (fine, smectic, mesic Pachic Argiustoll) with soil pH 6.9, P₂O₅, 54 ppm, K₂O 284 ppm (Soil Survey Staff et al., 2017). Weather data were collected from an automated Kansas Mesonet Station located at the Agronomy Research Farm, which is part of the Weather Data Library and the State Climate Office (Kansas Mesonet, 2017).

Average maximum and minimum temperatures and precipitation are reported in Table 3.1 for the study period, April 23, 2015 to May 15, 2018.

Three different alfalfa varieties were planted (low-lignin *Hi – Gest 360 LL*, Roundup Ready *RR Tonica*, and conventional *Gunner* alfalfa) on April 23, 2015. The seeding rate of each alfalfa variety was 20.18 kg ha⁻¹. The experimental design was a split plot in a randomized complete block design with four replications. The varieties were considered as the main factor and the last date of the cut in the fall was the sub-factor. Plot size was 1 m wide and 3 m long, for a total of 48 plots. The four different last cutting dates in the fall of 2015, 2016, and 2017 were September 15, September 30, October 15, and October 30. During the first, second, and third cuts in the seeding year (2015), samples were collected at the same time, which was the 1/10 bloom stage of maturity. In 2016, there were three cuts before the last cut, and they were on May 23, June 25, and August 6. In 2017, there were four cuts before the last cut, and they were on May 20, June 23, July 25, and August 29. Forage samples were collected by clipping plants with shears within a 0.18 m² quadrat, randomly placed, and the number of the live plants per quadrat in each plot were counted in the fall of 2015, in the spring and fall of 2016, in the spring and fall of 2017, and in the spring of 2018 (on May 10, 2018). The biomass was collected from each plot for estimation of yield and stand persistence. The samples collected during 2016 and 2017 were also analyzed for forage quality (CP, ADF, NDF, and RFV), as described below.

Dry Matter Yield and Stand Persistence

Samples were collected, placed into paper bags, and put in a cooler; bags were taken out of the cooler, weighed, and placed in a dryer at 60 °C for 72 hours and dried to constant weight

to determine percent moisture (dry matter) and dry matter yield. The dry matter yield (DMY) was calculated as follows:

$$\text{DMY (\%)} = (\text{dry weight of sample/original fresh weight of sample}) \times 100$$

To evaluate stand persistence, stand density was used, which is the common method to determine stand persistence. Every fall and spring during the study, plants were counted in the randomly placed quadrat (0.18 m²) in each plot.

Nutritive Values

The samples were dried and ground in a Wiley mill with a 1 mm screen and were analyzed for acid detergent fiber (ADF) and neutral detergent fiber (NDF) using the method of Van Soest et al. (1991). Crude protein (CP) was calculated by multiplying the total nitrogen in the forage samples by 6.25 (AOAC,1990). The dry samples were ground in a Wiley mill with a 1 mm screen. Total nitrogen in the samples was determined by the Soil Testing Laboratory at Kansas State University. The laboratory digests the samples using a sulfuric peroxide acid digestion, and then the digest is analyzed for nitrogen by a colorimetric procedure using the Rapid Flow Analyzer (Model RFA-300) and RFA Methodology No. A303-S072 from Alpkem Corporation, Clackamas, OR. Crude protein (CP) in percent was calculated by multiplying the total nitrogen (%) by 6.25.

The wet chemistry methods of Van Soest et al. (1991), described below, were used to determine acid detergent fiber (ADF) and neutral detergent fiber (NDF).

The relative feed value (RFV) was calculated from digestible dry matter and dry matter intake estimated using ADF and NDF (Rohweder et al.1978). RFV was calculated as follows:

$$\text{Dry matter digestibility (DMD, \%)} = 88.9 - (0.779 \times \text{ADF})$$

Dry matter intake (DMI, %) = 120/ (NDF)

Relative feed value (RFV) = (DMD x DMI)/1.29

Following the protocol of ANKOM Technology (Macedon, New York), the forage samples were prepared for ADF and NDF analysis.

Statistical Analysis

Statistical analyses were done using a mixed effects model in PROC GLIMMIX (SAS 9.3, 2011). An ANOVA for variables was conducted for each year and each cut, with the three varieties and four last cutting dates in the fall as a fixed effect. The varieties were considered as the main factor, and the last date of the cut in the fall was the sub-factor. Mean separation was performed using the Bonferroni correction. All statistical comparisons were made at the $\alpha = 0.05$ probability level.

Results and Discussion

The study evaluated the effect of the timing of a fall cut in Kansas on dry matter yield, nutritive value, stand persistence of alfalfa. The environmental conditions at Kansas in 2016 and 2017 (Table 3.1) were similar, except precipitation in the summer of 2017 was less than during the summer of 2016.

Dry matter yield last cut in the fall and first cut in spring and stand persistence

For the last fall cut in 2015, 2016, and 2017, a last cut x year interaction occurred for dry matter yield and stand persistence. There also was a first cut x year interaction for dry matter yield and stand persistence for the first cut in 2016, 2017, and 2018 (Table 3.2).

In 2016 the field was cut four times, and in 2017 it was cut five times. Belanger et al. (1999) observed that taking an additional fall cut will decrease winter survival and dry matter yield in the following year. In the last cut in the fall and the first cut in the following year, no significant difference was found in dry matter yield among Roundup Ready alfalfa, Gunner alfalfa, and reduced-lignin alfalfa (Table 3.2). A significantly ($P<0.05$) higher yield was observed with a last cut of September 30 (3.3 Mg ha^{-1}) than in other cutting dates. The lowest yield was found in the last cut on October 30 (2.2 Mg ha^{-1}) (Table 3.3).

In 2016, differences in dry matter yield in the first cut in the spring were not seen, even though plots had been cut on four different dates in the last cut in the previous year. However, it was observed that dry matter yield decreased as the years progressed. This was true both for the last cuts on September 15, September 30, October 15, and October 30 in 2015, 2016, 2017 and the first cuts of each year in 2016, 2017, 2018 (Table 3.3, Fig. 3.1 and Fig. 3.2). In first cut of 2016, the dry matter yield was higher than dry matter yield of first cut in 2017 and 2018 (Table 3.3, Fig. 3.1, and Fig. 3.2). A similar observation was made by Dhont et al. (2004), who found that a fall cut had a negative impact on stand persistence and yield the next year. Taking an additional cut not only increases the risk of winterkill but also decreases dry matter yield in the next year. In general, an additional cut increases the total DMY for the year, but this increases the risk of winterkill.

Our results showed that dry matter yield in first cut in the spring in 2017 and 2018 in plots that been harvested in the fall of the previous year on October 30 was lower than dry matter yield in other plots (Table 3.2). In 2015 the highest yield was in plots that been cut on September 30 (3.5 Mg ha^{-1}). In 2016 the significantly highest yield was in plots that were harvested on September 30 (4.4 Mg ha^{-1}), which was the highest dry matter yield for the three years of data.

In the last cuts of 2017, a significantly higher number of live plants were in plots that were harvested on September 15 (19 live plants), and the lowest stand persistence was observed in plots that were harvested on October 15 and October 30 (October 15 –15 live plants and October 30 – 14 live plants) (Table 3.4, Fig. 3.3). In first cuts in the springs of 2016 and 2017, the higher number of live plants were found in plots that been cut in the fall of the previous year on September 15. In the spring of 2018, the highest number of live plants was found in the plots that were cut on September 15 and September 30 in the previous year, and they each had the same number of live plants (14 per 0.18 m²). The lowest number was found in plots that were cut on October 30 in the previous year (10 per 0.18 m²) (Table 3.4, Fig. 3.4).

Several studies (Hendershot and Volenec, 1993; Volenec et al., 1996; Avise et al., 1997) have shown that a fall cut has a close relationship with storage of root reserves and regrowth of alfalfa in the spring (Reynolds, 1971). However, in our study, we did not measure root reserves. Our results agree with those of Schoner (1981) and Sheaffer et al. (1986), who reported that dry matter yield and stand persistence decreases if the last fall cut was delayed. Parsons and Davis (1960) observed in Ohio that, when alfalfa was harvested five times per year, plants were damaged more than plants that been cut three times per year. Similar studies were done in Minnesota by Trimble et al. (1987) and by Brink and Marten (1989). Min (2016) in Kansas recommended reducing five cuttings to four.

McKenzie and McLean (1980) documented that, as alfalfa plants get older, they are more susceptible to winter kill than the younger alfalfa plants. Similar observation was made in our study in first cut of 2018, when the stand persistence decreased by 36% in plots that were harvested on September 15, and by 26% in plots were harvested on September 30. The highest reduction in stand persistence of 47% was observed in plots that were harvested on October 30.

Differences in stand persistence and dry matter yield among the alfalfa varieties were not found in our study. The first killing frost in Kansas varies tremendously, but, based on 30 years of weather data, it ranges from mid-September to November. In 2015 the first freeze in Manhattan, Kansas, was on October 30; in 2016 it was on November 12; and in 2017 it was on October 27. So, if producers are tempted to cut forages by September 30-October 15, the cutting during those times will not have a harmful effect on dry matter yield. If producers want to maintain the longer life of stand persistence in an alfalfa field, they should try not to cut the alfalfa after September 30. A better understanding of the importance of the last cutting date before the first killing frost will help a producer manage alfalfa stands so they will live longer and produce more forage.

Annual total dry matter yield (DMY) in the first and second production years

The means of each cutting and total yield in 2016 and 2017 are shown in Table 3.5.

In first cut in 2016, a higher dry matter yield was observed in Roundup Ready alfalfa (7.3 Mg ha^{-1}) compared to low-lignin alfalfa (6.1 Mg ha^{-1}). Plots harvested in 2015 on September 15, September 30, October 15, and October 30 showed no differences in yield in the first and second cuts of 2016. Conventional ‘Gunner’ alfalfa had significantly ($P < 0.05$) higher dry matter yield in the second cut of 2016 (4.1 Mg ha^{-1}) than Roundup Ready alfalfa (2.1 Mg ha^{-1}). In the third cut, no significant differences were found in dry matter yield among the varieties and the dates of the last cuttings in the fall. In the fourth cut of 2016 in plots that were harvested on September 30, the dry matter yield was significantly ($P < 0.05$) higher (4.3 Mg ha^{-1}) than in plots that were harvested on October 30 (2.6 Mg ha^{-1}), but no significant differences were found among the alfalfa varieties.

In 2017, no significant differences were observed for plots harvested on September 15, September 30, October 15, and October 30, and no significant differences were observed in dry matter yield among the three varieties at these harvest times. In the second cut of 2017, no significant differences in yield among the alfalfa varieties were found, but the plots that were harvested in the fall on September 15 had a significantly higher dry matter yield (3.2 Mg ha^{-1}) than plots that were harvested on October 30 (2.6 Mg ha^{-1}) (Table 4). In the third cut of 2017, no significant differences were found in dry matter yield among the varieties, and the dates of last cuttings in the fall did not affect dry matter yield. In the fourth cut of 2017, the plots that were harvested on October 30 had a significantly ($P < 0.05$) lower DMY, which was similar to the fourth cut in 2016 (2.7 Mg ha^{-1}). The highest yield was found in plots that were harvested in the fall on September 15 (3.7 Mg ha^{-1}) (Table 3.5).

Based on two years of data (2016 and 2017), no significant differences in total dry matter yield were found among the alfalfa varieties. The total dry matter yield in 2017 decreased by 12% in Roundup Ready 'RR Tonica' alfalfa, 21% in 'Gunner' conventional alfalfa, and 19% in reduced-lignin 'Hi-Gest 360 LL' alfalfa compared to the total of yield in 2016 (Table 3.5). A significantly lower total dry matter yield was found in plots harvested on October 30 in both years 2016 and 2017. The highest total dry matter yield was in plots that were harvested on September 30 in both years. Two of the main factors that control dry matter yield of alfalfa and nutritive value are frequency of shoot removal (Kalu and Fick, 1983; Kallenbach et al., 2002; Brink et al., 2010) and stand persistence (Brink and Marten, 1989; Vertroni et al., 2010). In our study we observed that, in the first cuttings in 2016 and 2017, the dry matter yield was the highest and decreased by end of the year. During the four seasonal cuttings in 2016 the dry matter was higher compared to five seasonal cuttings in 2017. Frequent cuttings reduced the stand persistence of

alfalfa. Based on the results of this study, it appears that the last cutting of alfalfa can be done by September 30 – October 15 without yield reduction.

Nutritive Value

Crude Protein (CP)

The means and average CP of each cut in 2016 and 2017 are shown in Table 3.6. In the first cut, second cut, and third cut in 2016, no significant ($P<0.05$) differences in CP were found among the alfalfa varieties. No differences in CP were found among the plots harvested on September 15, September 30, October 15, and October 30. For the fourth cut in 2016, conventional ‘Gunner’ alfalfa had the lower CP concentration ($164 \text{ g kg}^{-1}\text{DM}$) than reduced-lignin ‘Hi – Gest 360 LL’ alfalfa ($181 \text{ g kg}^{-1}\text{DM}$). Alfalfa harvested in the fall on October 30 had a significantly ($P<0.05$) lower CP concentration compared to plots harvested on other dates. It has been reported that with frequent cuttings, CP is higher at an earlier stage of maturity, and, as the cutting is delayed, the CP concentration decreases with the higher maturity of alfalfa (Hall et al., 2000; Palmonari et al., 2014; Min, 2016).

In 2017, no significant differences in CP were found among the varieties for the first, second, third and fourth cuts. No significant differences in CP were found in alfalfa harvested on September 15, September 30, October 15 and October 30. In the fifth cut in 2017, no significant ($P<0.05$) differences were found among the alfalfa varieties, but significant ($P<0.05$) differences in CP concentration were observed for alfalfa in the last cut. The highest CP concentration ($351 \text{ g kg}^{-1}\text{DM}$) was in plots that were cut on September 15, and the lowest CP ($235 \text{ g kg}^{-1}\text{DM}$) was in plots that were cut on October 30.

The average CP concentration in 2016 was higher ($184 \text{ g kg}^{-1}\text{DM}$) in Roundup Ready ‘RR Tonica’ alfalfa, compared to CP concentration in conventional ‘Gunner’ alfalfa ($176 \text{ g kg}^{-1}\text{DM}$). In the plots that were cut on September 15, September 30, October 15 and October 30, no differences in CP were found. In 2017 no differences were found among alfalfa varieties in CP concentration. Rimi et al. (2010) noted that alfalfa harvested an early stage of maturity provided a higher nutritive value than alfalfa harvested at a later stage of maturity. Similar results were found in our study for the data of 2017. The results showed that the highest CP content ($278 \text{ g kg}^{-1}\text{DM}$) was found in plots that were cut on September 15. Min (2016) observed that cutting frequency affects the nutritive values of alfalfa, and our results agree with his. In 2016, the alfalfa was harvested four times, and in 2017 it was harvested five times. Because of the number of harvests, crude protein concentration was much higher in 2017 than in 2016.

Acid Detergent Fiber (ADF)

The means and average ADF of each cut in 2016 and 2017 are shown in Table 3.7. There was a varietal difference in ADF. The ADF concentration in the first cut in 2016 was significantly ($P < 0.05$) higher in conventional ‘Gunner’ alfalfa ($326 \text{ g kg}^{-1}\text{DM}$), and the lowest ADF concentration was found in low-lignin ‘Hi – Gest 360 LL’ alfalfa ($279 \text{ g kg}^{-1}\text{DM}$). Similar results were found in the second cut in 2016. A higher ADF concentration ($346 \text{ g kg}^{-1}\text{DM}$) was found in ‘Gunner’ alfalfa, and the reduced-lignin ‘Hi – Gest 360 LL’ alfalfa had the lowest ADF concentration ($297 \text{ g kg}^{-1}\text{DM}$). The last date of cuttings in the fall did not affect the ADF content in the first and second cuts in 2016. In the third and fourth cuts in 2016, the ADF concentration was significantly ($P < 0.05$) lower in reduced-lignin ‘Hi – Gest 360 LL’ alfalfa compared to other two varieties of alfalfa. In the third cut, the plots that been cut on September 15 in the previous

year had an ADF concentration that was significantly ($P<0.05$) higher than ADF concentration in plots that had been cut on October 15. In the fourth cut of 2016, the lowest ADF concentration was found in plots that were cut on September 15 ($329 \text{ g kg}^{-1}\text{DM}$), and the highest ADF concentration was in plots that been cut on October 15 ($348 \text{ g kg}^{-1}\text{DM}$) or October 30 ($356 \text{ g kg}^{-1}\text{DM}$).

In 2017 in the first cut, the lowest ADF concentration was found in the low-lignin ‘Hi – Gest 360 LL’ alfalfa ($272 \text{ g kg}^{-1}\text{DM}$). In the second, third, fourth and fifth cuts of 2017, the reduced-lignin ‘Hi – Gest 360 LL’ alfalfa had the lowest ADF concentration, and the conventional variety ‘Gunner’ had the highest ADF concentration. In the first, second, and third cuts, no differences in ADF concentration were observed, but in the fourth cut, the plots that were cut on September 15 had a significantly ($P<0.05$) lower ADF concentration ($301 \text{ g kg}^{-1}\text{DM}$), than plots that were cut on October 30 ($316 \text{ g kg}^{-1}\text{DM}$). In the fifth cut of 2017, the plots that were cut on September 15 and September 30 had the lowest ADF concentration, and the highest ADF concentration was in plots that were cut on October 30.

It has been documented that forage quality decreases if the dry matter yield of alfalfa increases, and they are related to the stage of maturity of alfalfa (Kallenbach et al., 2002; Brink et al., 2010). The effect stage of maturity when alfalfa is harvested on forage nutritive values has been noted by Smith (1972). Hall et al. (2000) and Kallenbach et al. (2002) documented that, as plants mature, the stem mass increases more than the leaf mass, which leads to a reduction of the nutritive value of the alfalfa. In 2016 and 2017, ADF concentrations were found to be lowest in plots that were cut in the fall of the previous year on September 15 and September 30 and the highest in plots that were cut on October 15 and October 30.

According to Grev et al. (2017) the low-lignin alfalfa can be harvested with a delay in five days and still maintain a higher forage quality compared to other varieties of alfalfa. In our study, we found a significantly ($P<0.05$) lower ADF concentration in low-lignin ‘Hi – Gest 360 LL’ alfalfa, and the highest ADF concentration was in the conventional ‘Gunner’ alfalfa. The Roundup Ready ‘RR Tonica’ alfalfa had a slightly lower ADF concentration than the conventional ‘Gunner’ alfalfa, and a higher ADF concentration than the low-lignin ‘Hi – Gest 360 LL’ alfalfa. Even in 2016 when the alfalfa was harvested four times per season, the reduced-lignin ‘Hi- Gest 360 LL’ alfalfa variety still maintained the lowest ADF concentration. In 2016 the average ADF was $299 \text{ g kg}^{-1}\text{DM}$, and in 2017 the average ADF under five cuttings was $263 \text{ g kg}^{-1}\text{DM}$. The ADF difference between alfalfa varieties was probably due to differences in rainfall during seasonal cuttings in 2016 and 2017, and a drier 2017 compared to 2016 (Table 3.1).

Neutral Detergent Fiber (NDF)

The means and average NDF of each cut in 2016 and 2017 are shown in Table 3.8. The NDF concentration in first cut in 2016 was significantly ($P<0.05$) lower in the low-lignin ‘Hi – Gest 360 LL’ alfalfa ($369 \text{ g kg}^{-1}\text{DM}$) than in other two varieties. In the second cut, the low-lignin ‘Hi-Gest 360 LL’ alfalfa had the lowest NDF, and the highest was found in conventional ‘Gunner’ alfalfa. Results for the second cut in 2016 were similar to the third cut 2016, and the low-lignin variety of alfalfa had a significantly ($P<0.05$) lower NDF concentration than conventional ‘Gunner’ alfalfa and Roundup Ready ‘RR Tonica’ alfalfa. In the fourth cut, the lowest NDF concentration was observed in the reduced-lignin alfalfa ($410 \text{ g kg}^{-1}\text{DM}$). For the plots that were cut in the last harvest in the fall on September 15 and September 30 in the

previous year, in the first and second cuts in 2016 the highest NDF concentrations were found, and the lowest NDF concentrations were in plots that were cut on October 15 and October 30. In the third cut in 2016 greater NDF was found in plots that had a last cut in the fall on September 15 (429 g kg⁻¹DM) compared to plots that were cut on October 15 (416 g kg⁻¹DM). In the fourth cut in 2016, no significant differences in NDF concentration were found among the plots that were cut on September 15, September 30, October 15, and October 30. This was probably influenced by temperature and rain fall in September 2016 (Table 3.1) and frequency of cutting per season. A previous study documented that NDF concentration increases if alfalfa was cut four times per year (Kallenbach et al., 2002). Alfalfa gets more mature when cutting interval is extended; as alfalfa gets mature the nutritive value of alfalfa decreases (Kalu and Fick, 1983; Sheaffer et al., 2000).

In 2017 in the first cut, the results showed that the reduced-lignin ‘Hi – Gest 360 LL’ alfalfa had a lower NDF concentration (371 g kg⁻¹ DM) than conventional ‘Gunner’ alfalfa and Roundup Ready ‘RR Tonica’ alfalfa. In the second, third, fourth and fifth cuts, the reduced-lignin ‘Hi – Gest 360 LL’ alfalfa had the lowest NDF, and the highest NDF was found in conventional ‘Gunner’ alfalfa. For the plots that were cut in the fall on four different dates, no differences in NDF were found for the first, and second cuts in 2017. In third cut in 2017, the highest NDF concentration (410 g kg⁻¹ DM) was found in plots that had the last cut in the fall of the previous year on October 30, with lower NDF found in plots that were cut on September 30 and October 15. In last (fifth) cut in 2017, the results showed that alfalfa harvested on September 15 and September 30 had an NDF concentration that was significantly lower than that in alfalfa harvested on October 15 and October 30. Min (2016) observed that cutting frequency affects the nutritive values of alfalfa, and our results agree with his. Based on the average concentrations of

NDF and ADF in 2016 and 2017, NDF and ADF concentrations were higher in 2016 with four seasonal cuts than in 2017 with five seasonal cuts. A significantly lower NDF concentration was found in reduced-lignin ‘Hi – Gest 360 LL’ alfalfa, and the highest NDF concentration was found in the conventional ‘Gunner’ variety. The average data of 2016 show that the NDF concentration of plots that were cut in the fall on September 15 and September 30 was higher than in plots that were cut on October 15 and October 30. However, in 2017, the average NDF concentration was higher in the plots that were cut on October 15 and October 30.

Relative Feed Value (RFV)

The means and average RFV indexes of all seasonal cuttings are shown in Table 3.9. The highest RFV index was found in first cut in 2016 in the low-lignin ‘Hi – Gest 360 LL’ alfalfa – 170. In the second, third, and fourth cuts, the RFV index was lower compared to the rest of the seasonal cuttings but low-lignin ‘Hi-Gest 360 LL’ alfalfa had the highest RFV index compared to the RFV indexes of conventional ‘Gunner’ alfalfa and Roundup Ready ‘RR Tonica’ alfalfa. For the plots that had the last cut on October 15 and October 30 in the previous year of 2016, the first, second, and third cuts had a significantly higher ($P<0.05$) RFV index than plots that were cut on September 15 and September 30. This might be due to slower regrowth during those three cuttings. In the fourth cut of 2016, differences in RFV due to cutting dates were not found.

In 2017 for all five cuttings, the results showed that low-lignin ‘Hi- Gest 360 LL’ alfalfa had a significantly ($P<0.05$) higher RFV index than the other alfalfa varieties. The conventional ‘Gunner’ alfalfa had the lowest RFV index. In 2017, no significant differences in RFV indexes were found in the first, second, and fourth cuts among the plots that had their last cut in the fall on four different cutting dates. In the third cut in 2017, the plots that been cut the previous year

on September 30 had a significantly higher RFV index than the plots that been cut on October 30. In fifth cut in 2017, which was the last cut for the season, the RFV index was highest in plots that were cut on September 15 (175) and September 30 (172), and the lowest RFV index was found in plots that were cut on October 15 (162) and October 30(158).

Based on average data of 2016 and 2017, the significantly ($P<0.05$) highest RFV values were found in the reduced-lignin ‘Hi – Gest 360 LL’ alfalfa, and the lowest RFV was found in conventional ‘Gunner’ alfalfa. In 2016, the average data showed that the plots that were cut on October 15 and October 30 had a significantly ($P<0.05$) higher RFV value than plots that were cut on September 15 and September 30. In 2017 the average RFV was significantly ($P<0.05$) higher in plots that were cut on September 15 and September 30 compared to the RFV values in plots that were cut on October 15 and October 30.

Rohweder et al. (1978) developed the RFV index that has been used to compare forage quality. An RFV value of 100 represents full bloom alfalfa. The higher the number, the greater is the quality of the forage. The more mature the alfalfa is at harvest, the higher the ADF and NDF concentrations will be, and the RFV index gets lower. According to Van Soest (1982), the RFV index does not measure nutritional content directly, but it is used for calculation of hay quality, usually when buying or selling alfalfa hay. Based on USDA alfalfa hay classification for Kansas premium hay has an RFV index of 160-195. If the RFV index is 130 -170, the hay is considered to be good enough for feeding during early lactation of cows. If the RFV value is less than 140 – 125, the hay could be fed to cows in late lactation. Based on 2-year average data our study showed that planting a newly developed low-lignin alfalfa could be beneficial for the producer, since the forage RFV index in 2016 under four cuttings was significantly higher compared to the Roundup Ready and conventional alfalfa variety. In 2017 under five cuttings,

the hay of the low-lignin alfalfa variety was in the premium hay grading category, and the Roundup Ready and conventional alfalfa varieties had hay in the good grading category. The low-lignin alfalfa variety could provide a higher forage quality, and, at the same time, the producer can have a wide harvesting window that will not impact forage nutritive values (Grev et al., 2017).

Conclusion

Our results suggest that, based on three years of data, producers in Kansas could cut alfalfa by September 30 - October 15. Cutting during this time will not have harmful effects on dry matter yield. Our recommendation is to reduce the five cuttings per year to four. Future research requires an investigation of the root carbohydrates in low-lignin alfalfa, because it is a new variety and producers lack information about it.

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Table 3.1. Rainfall and maximum and minimum temperature at North Farm, Kansas State University during the study period (2015 – 2018).

Climate Characteristics	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2015												
Monthly rain, mm				75	274	137	139	96	82	18	114	70
Mean max. temp., °C.				20	23	31	32	31	30	23	16	10
Mean min. temp., °C.				7	12	19	21	18	17	9	3	2
2016												
Monthly rain, mm	14	9	9	202	151	32	177	150	160	55	11	19
Mean max. temp., °C.	5	12	18	21	24	33	32	30	29	24	17	6
Mean min. temp., °C.	-6	-2	3	8	12	20	22	20	17	10	4	-6
2017												
Monthly rain, mm	34	12	101	115	92	74	39	144	33	64	3	3
Mean max. temp., °C.	6	14	15	19	25	31	34	29	29	22	14	7
Mean min. temp., °C.	-5	-1	3	8	12	18	21	17	16	8	2	-5
2018												
Monthly rain, mm	14	15	15	37	57							
Mean max. temp., °C.	6	0	14	16	30							
Mean min. temp., °C.	-7	-7	1	2	15							

Table 3.2. Yield and number of the plants per 0.18 m² in falls 2015, 2016, and 2017 and spring 2016, and 2017, 2018.

Last cut in fall			First cut in spring		
Variety	Yield (Mg ha ⁻¹)	Plants number	Variety	Yield (Mg ha ⁻¹)	Plants number
RA	2.6 a	19 a	RA	4.4 a	16 b
A	2.7 a	18 a	A	4.4 a	17 a
LA	2.5 a	18 a	LA	4.2 a	15 b
Last cut in fall			First cut in spring		
15-Sep	2.4 bc	21 a	15-Sep	4.4 a	18 a
30-Sep	3.3 a	18 b	30-Sep	4.5 a	17 b
15-Oct	2.6 b	16 b	15-Oct	4.4 a	14 c
30-Oct	2.2 c	18 b	30-Oct	4.1 a	14 c
Year			Year		
Fall 2015	2.7 b	20 a	Spring 2016	6.8 a	19 a
Fall 2016	3.5 a	19 b	Spring 2017	3.4 b	16 b
Fall 2017	1.7 c	16 c	Spring 2018	2.8 c	12 c
P value					
Variety	0.3204	0.2904	Variety	0.2674	0.0147
Last cut	<.0001	0.0028	Last cut	0.5238	<.0001
Year	<.0001	<.0001	Year	<.0001	<.0001
Last cut*Year	<.0001	<.0001	Last cut*Year	0.7583	<.0001

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – reduced-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level.

Table 3.3. Dry matter yield (Mg ha⁻¹) in fall 2015, 2016, and 2017 and spring 2016, 2017, and 2018.

Last cut in fall				First cut in spring			
Date	2015	2016	2017	Date	2016	2017	2018
15-Sep	2.6 c	3.3 b	1.2 f	15-Sep	6.9 a	3.4 bc	2.8 c
30-Sep	3.5 b	4.4 a	2.0 de	30-Sep	7.1 a	3.3 bc	3.0 c
15-Oct	2.4 cd	3.7 ab	1.8 e	15-Oct	6.4 a	3.8 b	2.9 c
30-Oct	2.3 cd	2.6 c	1.7 e	30-Oct	6.7 a	3.3 bc	2.3 d

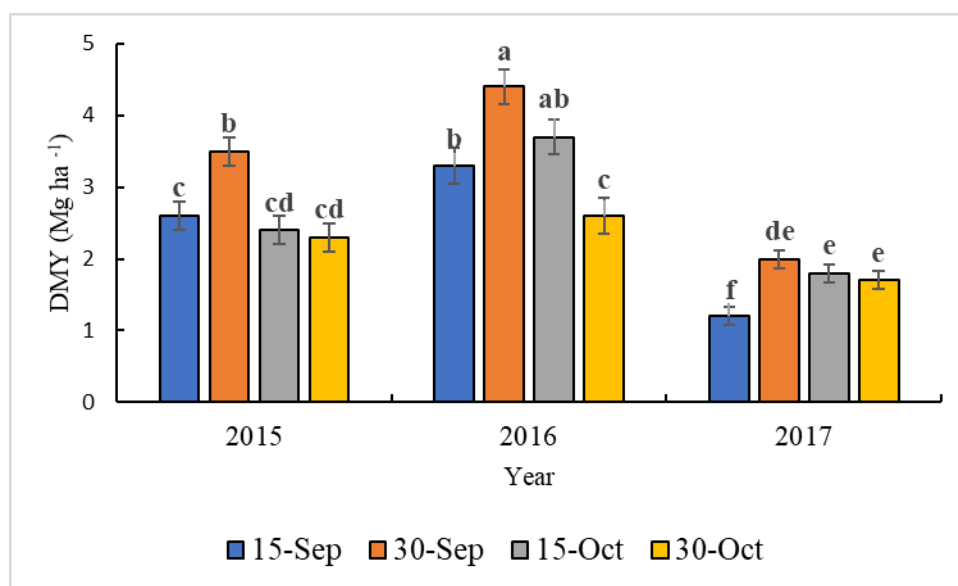
P value at 0.05 level, last cut P <0.0001, year P <0.0001, last cut*year P<0.0001, first cut P < 0.0001, year P <0.0001, last cut*year P <0.0001

Table 3.4. Number of the plants per 0.18 m² in fall 2015, 2016, and 2017 and spring 2016, 2017, and 2018.

Last cut in fall				First cut in spring			
Date	2015	2016	2017	Date	2016	2017	2018
15-Sep	22 a	22 a	19c	15-Sep	22 a	20 b	14 d
30-Sep	19 bc	19 c	17 c	30-Sep	19 bc	17 c	14 d
15-Oct	18 c	17 c	14 d	15-Oct	17 c	15 d	12 e
30-Oct	21 ab	18 c	13 d	30-Oct	18 bc	14 d	10 f

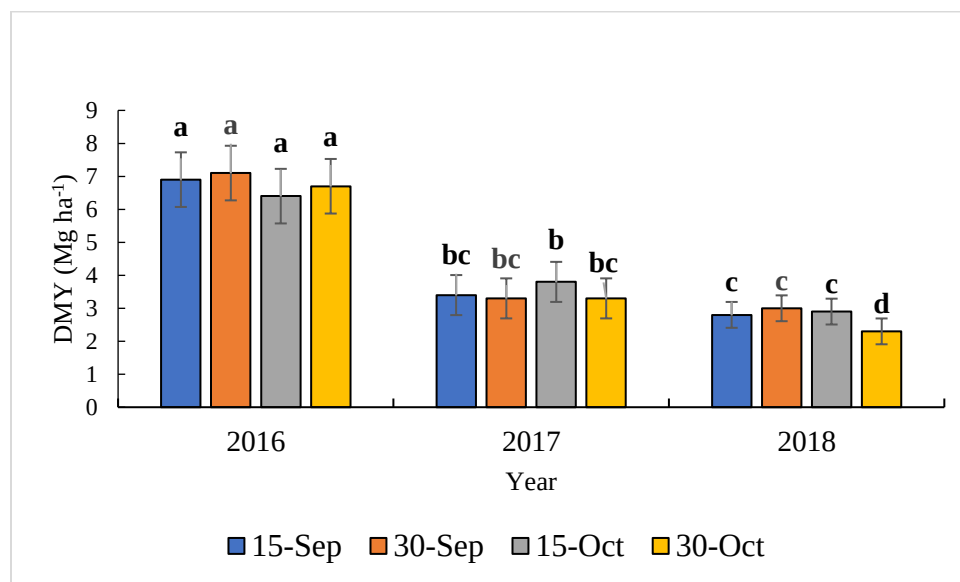
P value at 0.05 level, last cut P <0.0028, year P <0.0001, last cut*year P<0.0001, last cut P < 0.0001, year P <0.0001, last cut*year P <0.0001

Figure 3.1 Dry matter yield (Mg ha^{-1}) in last cut in 2015, 2016 and 2017.



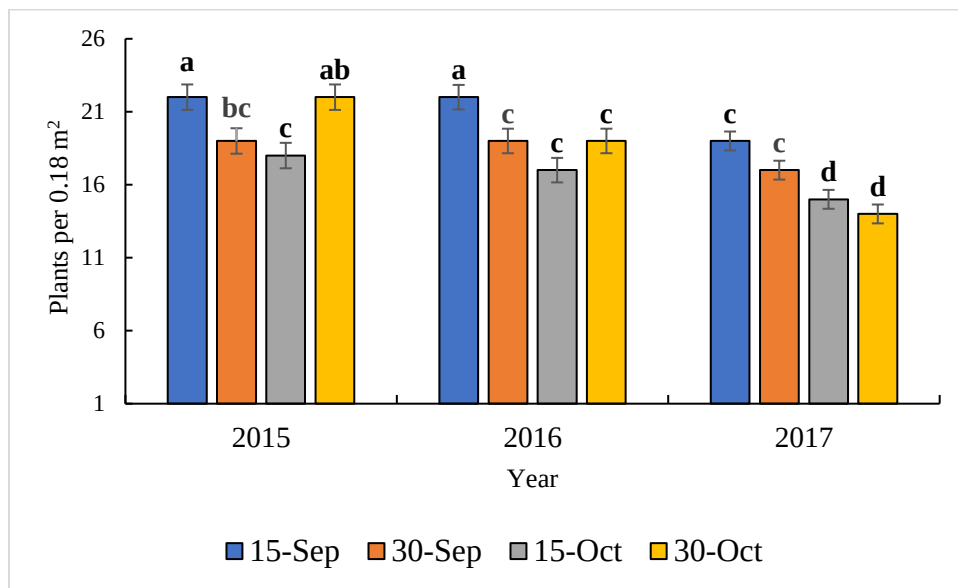
P value at 0.05 level, DMY – dry matter yield

Figure 3.2 Dry matter yield (Mg ha^{-1}) in first cut in 2016, 2017 and 2018.



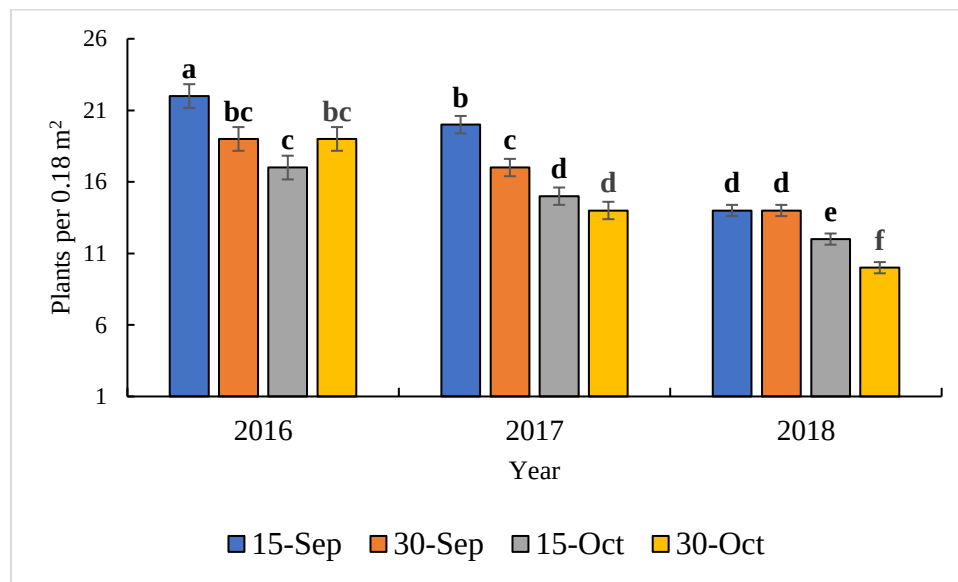
P value at 0.05 level, DMY – dry matter yield

Figure 3.3 Stand persistence in the fall in 2015, 2016, and 2017.



P value at 0.05 level

Figure 3.4 Stand persistence in the spring in 2016, 2017, and 2018.



P value at 0.05 level

Table 3.5. Mean and total dry matter yield (Mg ha⁻¹) in 2016 and 2017.

2016						2017					
Variety	Cut 1	Cut 2	Cut 3	Cut 4	Total	Cut1	Cut 2	Cut 3	Cut 4	Cut 5	Total
RA	7.3 a	2.1 b	2.9 a	3.3 a	15.6 a	3.4 a	2.9 a	2.6 a	3.2 a	1.7 a	13.8 a
A	7.0 ab	4.1 a	2.7 a	3.7 a	17.5 a	3.3 a	3.0 a	2.6 a	3.3 a	1.7 a	13.9 a
LA	6.1 b	3.5 ab	3.7 a	3.5 a	16.8 a	3.6 a	2.8 a	2.4 a	3.2 a	1.6 a	13.6 a
Last cut											
15-Sep	6.9 a	3.2 a	3.2 a	3.3 bc	16.6 ab	3.4 a	3.2 a	2.7 a	3.7 a	1.2 c	14.2 ab
30-Sep	7.1 a	3.6 a	3.2 a	4.3 a	18.2 a	3.3 a	3.1 ab	2.8 a	3.6 ab	2.0 a	14.8 a
15-Oct	6.4 a	2.9 a	3.0 a	3.7 ab	16.0 ab	3.8 a	2.9 ab	2.2 a	3.1 bc	1.8 ab	13.8 ab
30-Oct	6.7 a	3.2 a	3.0 a	2.6 c	15.5 b	3.3 a	2.6 b	2.3 a	2.7 c	1.7 b	12.6 b
P value											
V	0.0575	0.0447	0.1264	0.6183	0.5133	0.8704	0.9047	0.8271	0.8983	0.8135	0.9695
Last cut	0.8103	0.3353	0.4383	0.0065	0.0141	0.524	0.0215	0.2496	0.0166	<.0001	0.1334

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – low-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level.

Table 3.6. Mean CP concentration (g kg⁻¹ DM) in 2016 and 2017

Variety	2016					2017					
	Cut 1	Cut 2	Cut 3	Cut 4	average	Cut1	Cut 2	Cut 3	Cut 4	Cut 5	average
RA	192 a	178 a	191 a	177 ab	184 a	224 a	281 a	268 a	259 a	287 a	264 a
A	197 a	162 ab	179 a	164 b	176 b	217 a	255 a	255 a	251 a	280 a	252 a
LA	199 a	173 a	179 a	181 a	183 ab	228 a	281 a	268 a	252 a	289 a	264 a
Last cut											
15-Sep	190 a	173 a	175 a	181 a	180 a	225 a	281 a	262 a	269 a	351 a	278 a
30-Sep	197 a	174 a	185a	178 a	183 a	226 a	265 a	259 a	258 a	288 b	259 b
15-Oct	198 a	172 a	180 a	177 a	182 a	215 a	260 a	260 a	245 a	268 c	250 b
30-Oct	197 a	166 a	192 a	159 b	179 a	225 a	280 a	274 a	244 a	235 d	252 b
P value											
V	0.2907	0.0822	0.1755	0.0536	0.0671	0.6340	0.1034	0.4190	0.6381	0.2911	0.2627
Last cut	0.6241	0.8017	0.7211	0.0481	0.5542	0.7262	0.1440	0.3765	0.3344	<.0001	0.0014

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – low-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level. CP – crude protein concentration, DM – dry matter yield.

Table 3.7. Mean ADF concentration (g kg⁻¹ DM) in 2016 and 2017

2016						2017					
Variety	Cut 1	Cut 2	Cut 3	Cut 4	average	Cut1	Cut 2	Cut 3	Cut 4	Cut 5	Average
RA	310 b	327 b	339 a	361 a	334 b	322 a	304 b	314 b	318 b	278 b	307 b
A	326 a	346 a	348 a	354 a	344 a	327 a	331 a	329 a	334 a	294 a	323 a
LA	279 c	297 c	307 b	312 b	299 c	272 b	258 c	264 c	274 c	246 c	263 c
Last cut											
15-Sep	310 a	330 a	340 a	329 c	327 a	317 a	294 a	298 a	301 b	258 c	294 b
30-Sep	304 a	329 a	332 ab	337 bc	325 ab	294 a	294 a	300 a	305 ab	265 c	292 b
15-Oct	303 a	319 a	324 b	348 ba	323 b	311 a	300 a	308 a	312 ab	274 b	301 a
30-Oct	301 a	318 a	329 ab	356 a	326 a	306 a	301 a	302 a	316 a	293 a	304 a
P value											
V	<.0001	<.0001	<.0001	0.0002	<.0001	0.0025	<.0001	<.0001	<.0001	<.0001	<.0001
Last cut	0.4951	0.3321	0.0831	0.0147	0.1019	0.2824	0.4096	0.1624	0.0883	<.0001	0.0011

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – low-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level. ADF – acid detergent fiber, DM – dry matter yield

Table 3.8. Mean NDF concentration (g kg⁻¹ DM) in 2016 and 2017

Variety	2016					2017					
	Cut 1	Cut 2	Cut 3	Cut 4	average	Cut1	Cut 2	Cut 3	Cut 4	Cut 5	Average
RA	404 a	418 b	426 a	446 b	423 b	422 a	399 b	406 b	415 b	378 b	404 b
A	409 a	436 a	433 a	463 a	435 a	428 a	421 a	430 a	436 a	396 a	422 a
LA	369 b	386 c	404 b	410 c	392 c	371 b	372 c	371 c	375 c	360 c	370 c
Last cut											
15-Sep	400 a	420 a	429 a	440 a	422 a	406 a	397 a	405 ab	404 a	363 b	395 b
30-Sep	406 a	420 a	420 ab	436 a	421 a	402 a	398 a	396 b	408 a	369 b	395 b
15-Oct	386 b	406 b	416 b	443 a	413 b	413 a	392 a	400 b	409 a	388 a	400 a
30-Oct	382 b	406 b	419 ab	441 a	413 b	407 a	404 a	410 a	413 a	391 a	405 a
P value											
V	<.0039	<.0001	<.0001	<.0001	<.0001	<.0001	0.0003	<.0001	<.0001	0.0003	<.0001
Last cut	0.0012	0.0211	0.1422	0.8092	0.0101	0.4285	0.4818	0.0253	0.5292	<.0001	0.0028

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – low-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level. NDF – neutral detergent fiber, DM – dry matter yield.

Table 3.9. Mean RFV indexes in 2016 and 2017

Variety	2016					2017					
	Cut 1	Cut 2	Cut 3	Cut 4	average	Cut1	Cut 2	Cut 3	Cut 4	Cut 5	average
RA	150 b	141 b	137 b	128 b	139 b	141 b	152 b	148 b	144 b	166 b	150 b
A	145b	133 c	133 c	122 b	133 c	138 b	139 c	137 c	135 c	156 c	141 c
LA	170 a	159 a	150 a	147 a	156 a	170 a	172 a	171 a	168 a	181 a	172 a
Last cut											
15-Sep	151 b	141b	136 b	134 a	140 b	148 a	156 a	152 ab	152 a	175 a	157 a
30-Sep	150 b	141 b	140 ab	135 a	141 b	154 a	155 a	155 a	150 a	172 a	157 a
15-Oct	158 a	148 a	143 a	131 a	145 a	147 a	157 a	152 ab	148 a	162 b	153 b
30-Oct	159 a	147 a	141 a	130 a	144 a	149 a	152 a	149 b	145a	158 b	151 b
P value											
V	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Last cut	0.0037	0.0388	0.059	0.1443	0.0039	0.3493	0.3823	0.1782	0.2444	<.0001	0.0007

RA – Roundup Ready RR Tonica alfalfa, A – Gunner conventional alfalfa, LA – low-lignin Hi-Gest 360 LL alfalfa. P value at 0.05 level. RFV – relative feed value index

Appendix A - Raw Data of First Study (2016-2017)

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
101	1	0	1	1	2016	33.98173	46.45804	18.63695	125.0005	4.418299
102	2	0	1	1	2016	29.3772	40.92851	20.40945	150.0408	3.558496
103	3	0	1	1	2016	29.78677	43.23833	19.53898	141.3391	5.216218
104	4	0	1	1	2016	39.70717	60.44232	12.05647	89.21535	0.597802
105	5	0	1	1	2016	35.73303	53.68422	13.0312	105.8108	0.917735
106	6	0	1	1	2016	35.71359	56.80225	15.47873	100.0274	5.135242
107	7	0	1	1	2016	36.01715	49.39768	16.15885	114.5758	3.622469
108	8	0	1	1	2016	34.0867	52.41157	16.80302	110.6563	5.127263
109	9	0	1	1	2016	34.10437	43.84154	18.9285	132.2579	5.341239
110	10	0	1	1	2016	34.41037	52.21714	17.33563	110.6192	5.096465
111	11	0	1	1	2016	33.39199	49.95137	17.82144	117.1142	5.608374
112	12	0	1	1	2016	35.4793	56.2724	18.30951	101.2709	3.998709
113	13	0	1	1	2016	35.10369	50.75925	17.81429	112.8065	5.098224
114	14	0	1	1	2016	35.64896	54.96319	18.53089	103.4594	4.739578
115	1	50	1	1	2016	32.75414	48.41195	19.12896	121.793	4.236865
116	1	50	1	1	2016	31.28345	46.72861	19.4655	128.4611	4.014762
117	3	50	1	1	2016	34.3543	48.10195	18.63813	120.1672	4.500971
118	4	50	1	1	2016	35.45476	64.16698	16.36467	88.83907	3.673497
119	5	50	1	1	2016	36.33654	60.15809	15.5306	93.69705	3.740936
120	6	50	1	1	2016	35.14531	57.32711	14.92692	99.82988	3.39439
121	7	50	1	1	2016	31.02321	50.49127	18.74734	119.2616	6.315349
122	8	50	1	1	2016	35.39691	54.53239	19.30588	104.6117	3.659964
123	9	50	1	1	2016	33.94554	50.18053	18.63024	115.78	5.166962
124	10	50	1	1	2016	32.32417	54.4181	14.26106	108.9232	4.285571
125	11	50	1	1	2016	34.21857	51.90882	17.65823	111.544	5.394991
126	12	50	1	1	2016	36.10947	57.52409	14.21121	98.27344	4.528761
127	13	50	1	1	2016	34.96539	52.80133	18.28288	108.6336	5.003197
128	14	50	1	1	2016	33.80513	55.96848	17.03496	103.9884	5.681335
201	5	50	2	1	2016	35.97801	58.7921	12.05854	96.31595	4.536058
202	3	50	2	1	2016	33.64376	46.63315	20.68047	125.0563	4.45899

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
203	10	50	2	1	2016	32.06497	57.45596	19.4494	103.491	5.650595
204	11	50	2	1	2016	34.17427	48.33407	19.62376	119.8601	5.562825
205	1	50	2	1	2016	30.01834	54.60371	18.4987	111.613	5.580145
206	14	50	2	1	2016	38.29178	48.81896	20.37045	112.5577	5.183118
207	13	50	2	1	2016	33.51467	51.38414	20.24198	113.6756	5.923385
208	2	50	2	1	2016	34.25406	47.3264	18.71092	122.29	5.21104
209	8	50	2	1	2016	34.98147	55.5476	16.22391	103.2417	6.442207
210	9	50	2	1	2016	32.41952	47.06328	19.41673	125.7984	5.762101
211	12	50	2	1	2016	35.25925	51.08692	19.34556	111.8623	7.003195
212	6	50	2	1	2016	33.80093	53.39374	16.55692	109.0086	5.906367
213	7	50	2	1	2016	35.9641	52.42689	16.8125	108.029	6.113104
214	4	50	2	1	2016	37.05688	57.9144	12.5439	96.4257	2.237182
215	5	0	2	1	2016	34.19401	53.71343	11.74359	107.8295	1.394842
216	3	0	2	1	2016	31.5323	50.81933	20.10303	117.7657	5.012312
217	10	0	2	1	2016	33.64693	50.5126	17.51459	115.4472	6.497545
218	11	0	2	1	2016	32.26532	49.81413	19.45769	119.0758	5.469611
219	1	0	2	1	2016	32.2857	47.81578	18.17328	124.0214	5.745969
220	14	0	2	1	2016	34.03438	53.44221	15.992	108.5932	5.206299
221	13	0	2	1	2016	33.78076	52.17635	18.79479	111.5801	4.807134
222	2	0	2	1	2016	34.71199	45.61197	19.78258	126.159	5.10438
223	8	0	2	1	2016	36.54944	49.92153	15.77027	112.6009	5.495596
224	9	0	2	1	2016	35.28518	48.29161	18.77017	118.2985	4.93074
225	12	0	2	1	2016	34.51097	53.3141	20.9751	108.2064	5.398887
226	6	0	2	1	2016	34.84027	50.08148	18.05179	114.7143	5.094318
227	7	0	2	1	2016	36.47291	52.91781	19.15511	106.3301	5.69805
228	4	0	2	1	2016	35.01941	57.54907	12.32667	99.60338	1.131697
301	2	0	3	1	2016	32.1695	46.69457	0	127.1797	4.622004
302	13	0	3	1	2016	32.72937	50.4659	0	116.8716	6.161448
303	9	0	3	1	2016	34.00173	54.30736	0	106.9069	5.86016
304	4	0	3	1	2016	35.65962	58.53453	0	97.13392	2.526482

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
305	12	0	3	1	2016	35.6427	57.70813	0	98.54617	7.257879
306	5	0	3	1	2016	35.74528	52.4489	0	108.286	1.794161
307	6	0	3	1	2016	33.81481	52.22265	0	111.4339	5.965857
308	7	0	3	1	2016	33.72226	50.16961	0	116.1277	5.63389
309	3	0	3	1	2016	31.69644	45.46935	0	131.3606	5.64438
310	10	0	3	1	2016	32.74741	54.13502	0	108.9262	5.583224
311	11	0	3	1	2016	36.31034	50.44137	0	111.7839	5.516525
312	14	0	3	1	2016	34.77726	50.35452	0	114.183	4.414298
313	8	0	3	1	2016	36.70684	55.58444	0	100.924	5.674827
314	1	0	3	1	2016	32.23359	43.97579	0	134.9369	6.029238
315	2	50	3	1	2016	34.77199	45.59098	0	126.1217	4.527358
316	13	50	3	1	2016	36.29323	55.28917	0	102.005	5.113569
317	9	50	3	1	2016	35.53204	53.73468	0	105.9825	7.326411
318	4	50	3	1	2016	38.53933	61.94667	0	88.41493	5.131373
319	12	50	3	1	2016	35.43335	54.0873	0	105.4237	8.642861
320	5	50	3	1	2016	37.78276	65.18547	0	84.86301	3.055299
321	6	50	3	1	2016	31.83649	44.25792	0	134.7269	6.754486
322	7	50	3	1	2016	35.59413	53.44768	0	106.4674	5.791285
323	3	50	3	1	2016	33.16995	46.63285	0	125.7934	4.970438
324	10	50	3	1	2016	38.18749	57.04708	0	96.45553	6.966742
325	11	50	3	1	2016	36.21796	53.78059	0	104.9678	6.226205
326	14	50	3	1	2016	32.17512	55.24851	0	107.4815	6.139236
327	8	50	3	1	2016	33.86872	56.67408	0	102.6125	6.369481
328	1	50	3	1	2016	32.30852	43.33999	0	136.7911	5.445574
401	4	50	4	1	2016	35.37549	66.08078	18.97154	86.35307	2.671108
402	8	50	4	1	2016	34.14766	50.67819	15.83874	114.354	4.319815
403	14	50	4	1	2016	36.33931	58.99909	15.58354	95.53427	6.921708
404	1	50	4	1	2016	31.16632	45.2273	15.15278	132.913	5.917397
405	13	50	4	1	2016	36.97092	55.59404	18.87071	100.5623	7.293714
406	3	50	4	1	2016	33.26904	49.29306	15.19282	118.859	5.264207

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
407	11	50	4	1	2016	34.33215	55.46528	18.60173	104.2433	7.425863
408	10	50	4	1	2016	37.68791	57.04196	16.68551	97.09884	7.131878
409	5	50	4	1	2016	35.18036	58.93174	15.0436	97.06856	1.330642
410	6	50	4	1	2016	36.59828	57.55987	16.32018	97.59697	6.469348
411	7	50	4	1	2016	37.23592	55.56478	16.73274	100.2697	6.103482
412	9	50	4	1	2016	32.13649	52.44699	17.18925	113.2761	5.938827
413	2	50	4	1	2016	33.87459	42.91587	21.72222	135.4986	5.59267
414	12	50	4	1	2016	37.41932	57.23278	19.41571	97.11519	5.111595
415	4	0	4	1	2016	37.08231	64.85493	9.810953	86.07817	2.025275
416	8	0	4	1	2016	34.11772	45.87608	19.15494	126.3714	5.755167
417	14	0	4	1	2016	37.9472	53.47681	17.41738	103.2208	5.85515
418	1	0	4	1	2016	34.45343	49.87611	18.59445	115.7487	5.375556
419	13	0	4	1	2016	36.38864	52.53117	15.27521	107.2289	6.70193
420	3	0	4	1	2016	36.08452	46.10497	18.04208	122.6527	5.363536
421	11	0	4	1	2016	34.58152	55.48651	16.01596	103.8777	6.352857
422	10	0	4	1	2016	37.24936	46.0009	15.8906	121.0952	5.683297
423	5	0	4	1	2016	34.79156	56.41379	11.70302	101.9005	1.232354
424	6	0	4	1	2016	34.51708	51.10937	15.63467	112.8655	5.622222
425	7	0	4	1	2016	33.40457	48.1	16.2766	121.6029	6.054094
426	9	0	4	1	2016	36.96788	50.52425	17.345	110.6575	5.134163
427	2	0	4	1	2016	33.56594	52.59161	18.7666	110.995	5.840922
428	12	0	4	1	2016	41.51186	49.67818	15.68186	105.9138	5.98994
101	1	0	1	2	2016	41.90797	50.23204	12.67808	104.1746	5.220417
102	2	0	1	2	2016	37.89894	48.45535	13.03186	113.9898	3.459982
103	3	0	1	2	2016	38.61405	51.15802	15.48178	106.9548	5.467022
104	4	0	1	2	2016	37.74814	51.32608	13.46978	107.8271	0.633625
105	5	0	1	2	2016	37.541	54.16118	10.70313	102.46	1.194933
106	6	0	1	2	2016	44.08216	46.66043	12.25018	108.772	3.802226
107	7	0	1	2	2016	45.9694	53.43357	10.95902	92.42484	3.224466
108	8	0	1	2	2016	40.58985	52.03399	11.0603	102.4027	5.343486

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
109	9	0	1	2	2016	38.15084	52.2533	0	105.3553	4.738531
110	10	0	1	2	2016	44.13506	53.97078	13.34453	93.96779	5.778247
111	11	0	1	2	2016	38.68535	53.49252	14.16649	102.1905	5.31821
112	12	0	1	2	2016	42.55711	50.8302	11.92569	102.0232	4.84447
113	13	0	1	2	2016	43.50849	51.23559	12.81395	99.87041	5.414866
114	14	0	1	2	2016	40.08774	51.65114	13.17062	103.8661	6.323517
115	1	50	1	2	2016	40.96041	50.72659	14.05878	104.5126	4.549878
116	1	50	1	2	2016	38.64818	45.66755	12.89782	119.7595	4.163855
117	3	50	1	2	2016	38.24737	45.34597	14.61653	121.2493	6.483748
118	4	50	1	2	2016	38.62094	54.36289	11.1963	100.6403	1.659228
119	5	50	1	2	2016	35.66607	55.99622	11.69376	101.5287	2.245874
120	6	50	1	2	2016	40.83715	52.48708	11.46646	101.1772	5.426267
121	7	50	1	2	2016	45.80725	55.0845	10.11037	89.86811	5.749124
122	8	50	1	2	2016	40.6894	51.31516	11.91085	103.6966	5.409364
123	9	50	1	2	2016	40.08635	54.70366	13.27099	98.07216	5.360297
124	10	50	1	2	2016	39.5561	52.733	14.23888	102.4658	5.418344
125	11	50	1	2	2016	42.24478	57.33317	12.14771	90.8461	6.674178
126	12	50	1	2	2016	40.95995	53.28726	12.93009	99.49095	5.285456
127	13	50	1	2	2016	37.6682	47.02468	15.24733	117.8134	5.187504
128	14	50	1	2	2016	39.97409	47.08021	14.1259	114.1253	6.084576
201	5	50	2	2	2016	37.21694	59.80914	9.79685	93.17703	1.672027
202	3	50	2	2	2016	39.74954	54.58913	11.55025	98.72502	4.593042
203	10	50	2	2	2016	40.07023	51.63746	14.02633	103.9182	5.392419
204	11	50	2	2	2016	41.82506	52.46763	13.43778	99.85033	5.732598
205	1	50	2	2	2016	40.85983	54.21137	11.11663	97.92881	4.978998
206	14	50	2	2	2016	39.54359	53.66529	12.19866	100.7026	5.504461
207	13	50	2	2	2016	40.19838	52.36698	12.77781	102.2932	5.25603
208	2	50	2	2	2016	33.31994	46.6235	11.32214	125.5855	6.33214
209	8	50	2	2	2016	41.64381	48.35212	14.95704	108.6207	5.967729
210	9	50	2	2	2016	36.56439	45.68902	15.08774	123.0082	5.032383

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
211	12	50	2	2	2016	41.67762	51.32447	13.37455	102.2825	5.583306
212	6	50	2	2	2016	43.33777	54.15988	12.45137	94.70646	5.604209
213	7	50	2	2	2016	37.42725	53.76701	13.60828	103.3644	5.961841
214	4	50	2	2	2016	40.1144	57.03713	10.42258	94.02423	1.574938
215	5	0	2	2	2016	38.35321	56.18273	12.69368	97.72573	0.720559
216	3	0	2	2	2016	37.6695	48.3023	13.22429	114.6952	4.337597
217	10	0	2	2	2016	39.12553	49.50259	16.06597	109.7828	5.531549
218	11	0	2	2	2016	42.49207	55.85386	14.32711	92.93136	5.35184
219	1	0	2	2	2016	44.85788	54.4392	12.00909	92.19709	5.676531
220	14	0	2	2	2016	46.2807	62.08594	11.12217	79.18106	4.643687
221	13	0	2	2	2016	41.32564	50.48183	13.11179	104.495	5.765555
222	2	0	2	2	2016	29.51768	52.25083	13.17007	117.3334	5.422625
223	8	0	2	2	2016	44.49523	51.19773	12.97878	98.54765	5.328621
224	9	0	2	2	2016	39.70954	48.50977	13.71688	111.1572	6.172079
225	12	0	2	2	2016	44.28899	52.24182	12.96534	96.86417	5.2484
226	6	0	2	2	2016	42.46855	51.05715	12.98808	101.6954	5.996847
227	7	0	2	2	2016	44.46437	52.92529	12.37191	95.37315	6.039411
228	4	0	2	2	2016	38.75991	52.8617	12.71855	103.3078	1.47683
301	2	0	3	2	2016	39.2996	48.1328	0	112.645	5.216764
302	13	0	3	2	2016	37.75721	49.37665	0	112.0709	5.576883
303	9	0	3	2	2016	44.31999	50.93084	0	99.31339	4.984287
304	4	0	3	2	2016	38.05423	51.75652	0	106.5018	1.503849
305	12	0	3	2	2016	44.93099	50.22189	0	99.83371	5.396916
306	5	0	3	2	2016	39.05422	55.18573	0	98.57075	1.844499
307	6	0	3	2	2016	40.06835	49.82819	0	107.6943	5.953108
308	7	0	3	2	2016	44.63702	54.32016	0	92.69377	5.316613
309	3	0	3	2	2016	39.26662	49.85049	0	108.8115	5.891819
310	10	0	3	2	2016	42.81914	54.06716	0	95.56399	5.180599
311	11	0	3	2	2016	32.87767	46.64359	0	126.2185	4.94607
312	14	0	3	2	2016	39.73342	52.4995	0	102.6768	5.556822

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
313	8	0	3	2	2016	42.71805	50.29128	0	102.8846	5.551951
314	1	0	3	2	2016	40.10571	46.7238	0	114.7917	5.023385
315	2	50	3	2	2016	36.28256	51.93719	0	108.6032	5.969374
316	13	50	3	2	2016	42.98469	49.05578	0	105.0819	3.89841
317	9	50	3	2	2016	42.42992	52.49541	0	98.96252	6.377199
318	4	50	3	2	2016	38.41348	54.74206	0	100.2178	2.557538
319	12	50	3	2	2016	43.39831	52.51686	0	97.58588	6.405832
320	5	50	3	2	2016	38.12556	58.43061	0	94.24844	2.803451
321	6	50	3	2	2016	42.6742	51.46036	0	100.609	6.841024
322	7	50	3	2	2016	42.87505	57.40628	0	89.93479	6.116172
323	3	50	3	2	2016	44.98522	57.49504	0	87.13635	5.790592
324	10	50	3	2	2016	37.00233	49.562	0	112.7555	6.041785
325	11	50	3	2	2016	40.27424	53.90515	0	99.27233	5.826413
326	14	50	3	2	2016	41.8038	52.01273	0	100.7532	6.611111
327	8	50	3	2	2016	40.48128	48.71478	0	109.5414	5.815695
328	1	50	3	2	2016	39.96816	50.07504	0	107.3083	4.347287
401	4	50	4	2	2016	41.26538	59.64216	11.52729	88.51905	0.43504
402	8	50	4	2	2016	39.66877	50.08754	14.56587	107.7147	4.387128
403	14	50	4	2	2016	44.76729	53.70627	12.09733	93.57753	5.280257
404	1	50	4	2	2016	37.58768	45.87544	14.86852	120.892	6.638766
405	13	50	4	2	2016	40.79731	52.75803	13.29177	100.7123	6.300861
406	3	50	4	2	2016	46.50539	51.37861	11.92204	95.36554	6.831926
407	11	50	4	2	2016	41.18684	51.48591	13.24399	102.6525	6.22777
408	10	50	4	2	2016	38.97567	50.02399	13.8313	108.8556	6.039964
409	5	50	4	2	2016	37.68065	60.94815	10.32405	90.88439	2.572924
410	6	50	4	2	2016	45.47317	54.31941	13.1187	91.57958	5.312926
411	7	50	4	2	2016	40.27053	46.97084	12.1267	113.9336	6.392324
412	9	50	4	2	2016	42.67149	49.83903	11.22983	103.8859	6.599858
413	2	50	4	2	2016	43.83128	48.87862	12.71753	104.2077	5.686201
414	12	50	4	2	2016	44.13494	50.77566	13.09383	99.88101	5.458265

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
415	4	0	4	2	2016	39.0408	56.37868	12.90761	96.50228	0.572403
416	8	0	4	2	2016	40.25206	51.49895	13.34705	103.9419	4.940072
417	14	0	4	2	2016	41.69437	41.72141	12.74238	125.7958	5.161676
418	1	0	4	2	2016	38.10191	54.92943	12.78927	100.287	5.087502
419	13	0	4	2	2016	37.70474	46.39082	14.81009	119.3661	5.960762
420	3	0	4	2	2016	43.06109	52.01408	13.93101	98.99897	5.885037
421	11	0	4	2	2016	41.84914	57.29364	11.63597	91.40917	4.44928
422	10	0	4	2	2016	43.94639	54.35427	11.56385	93.55634	4.934875
423	5	0	4	2	2016	39.87612	58.02225	11.18388	92.72546	1.770124
424	6	0	4	2	2016	35.52979	49.94063	14.89552	114.0374	5.099498
425	7	0	4	2	2016	43.72041	65.50964	9.706387	77.87499	4.884035
426	9	0	4	2	2016	41.42673	49.84574	13.0096	105.6815	5.609634
427	2	0	4	2	2016	34.84605	46.1767	14.94504	124.4057	5.058866
428	12	0	4	2	2016	40.78111	49.81046	15.79213	106.6957	4.94221
101	1	0	1	3	2016	34.67378	47.01093	15.21545	122.4636	4.205755
102	2	0	1	3	2016	40.61746	46.56343	13.06149	114.3906	3.64557
103	3	0	1	3	2016	32.42552	44.98041	15.0225	131.6139	4.431171
104	4	0	1	3	2016	0	0	0	0	0
105	5	0	1	3	2016	0	0	0	0	0
106	6	0	1	3	2016	43.20172	53.60595	14.08153	95.86901	4.664042
107	7	0	1	3	2016	42.05971	51.35127	13.70597	101.6899	5.066903
108	8	0	1	3	2016	39.79179	47.11839	17.89645	114.3131	4.486187
109	9	0	1	3	2016	36.10333	46.22939	15.43914	122.2931	5.530747
110	10	0	1	3	2016	40.01957	50.1235	14.25962	107.1303	3.773738
111	11	0	1	3	2016	36.63271	51.2125	14.5373	109.6446	5.814783
112	12	0	1	3	2016	36.28395	56.45599	18.66301	99.90874	4.308749
113	13	0	1	3	2016	37.74581	54.37495	14.49808	101.7842	5.94484
114	14	0	1	3	2016	38.51835	55.37031	15.438	98.94347	5.091195
115	1	50	1	3	2016	46.45258	47.77025	14.66248	102.6491	4.827916
116	1	50	1	3	2016	38.48887	48.98041	15.64773	111.8951	4.440815

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
117	3	50	1	3	2016	34.84741	44.78884	14.88297	128.2584	6.247618
118	4	50	1	3	2016	0	0	0	0	0
119	5	50	1	3	2016	0	0	0	0	0
120	6	50	1	3	2016	37.40436	49.27652	15.64168	112.8176	4.680176
121	7	50	1	3	2016	31.94141	45.98779	14.47866	129.4937	4.794541
122	8	50	1	3	2016	32.39783	45.40768	16.31843	130.4197	4.295815
123	9	50	1	3	2016	35.13219	47.86028	12.64506	119.5962	5.445903
124	10	50	1	3	2016	42.4072	50.3731	16.14496	103.1647	4.187916
125	11	50	1	3	2016	36.44606	48.71191	15.41428	115.5508	5.087011
126	12	50	1	3	2016	32.42616	47.57602	15.5644	124.4325	4.081477
127	13	50	1	3	2016	39.00428	49.93413	16.41855	109.01	4.784499
128	14	50	1	3	2016	38.37509	53.15245	15.43037	103.2673	4.056662
201	5	50	2	3	2016	0	0	0	0	0
202	3	50	2	3	2016	37.32714	51.41268	14.39605	108.2389	3.943115
203	10	50	2	3	2016	38.90928	49.92634	16.66582	109.1649	4.648608
204	11	50	2	3	2016	39.70791	54.75158	14.10042	98.48719	4.126539
205	1	50	2	3	2016	39.66556	45.69817	14.96324	118.0659	5.374543
206	14	50	2	3	2016	37.56613	50.89094	14.27195	109.0083	4.305116
207	13	50	2	3	2016	38.11828	44.51055	17.22973	123.7352	4.630548
208	2	50	2	3	2016	37.55377	42.78124	15.52033	129.693	4.56506
209	8	50	2	3	2016	34.34106	45.30208	17.58609	127.6153	4.894196
210	9	50	2	3	2016	35.34161	49.02324	15.39833	116.4495	4.759554
211	12	50	2	3	2016	38.15345	51.13152	15.92035	107.663	5.115422
212	6	50	2	3	2016	33.95924	50.45662	15.37959	115.1268	4.625901
213	7	50	2	3	2016	36.69913	49.469	15.65159	113.4116	4.253049
214	4	50	2	3	2016	0	0	0	0	0
215	5	0	2	3	2016	0	0	0	0	0
216	3	0	2	3	2016	39.85006	48.43983	14.04948	111.1075	5.86919
217	10	0	2	3	2016	37.98198	46.89474	15.32643	117.655	3.355788
218	11	0	2	3	2016	37.12457	46.28743	13.82175	120.541	4.051997

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
219	1	0	2	3	2016	46.16366	54.95824	14.20699	89.60461	4.933071
220	14	0	2	3	2016	40.81984	48.15286	14.92473	110.3102	4.29343
221	13	0	2	3	2016	40.00591	48.95398	14.46065	109.7099	5.226373
222	2	0	2	3	2016	34.75054	43.85142	16.15801	131.1603	4.683538
223	8	0	2	3	2016	37.60144	49.94981	12.60189	111.0109	4.670819
224	9	0	2	3	2016	31.52669	46.70229	16.496	128.1561	4.346197
225	12	0	2	3	2016	41.26884	52.97006	13.24239	99.66415	4.558888
226	6	0	2	3	2016	43.47999	53.3524	14.51802	95.94668	4.703623
227	7	0	2	3	2016	34.49303	49.59671	14.47766	116.3429	4.655542
228	4	0	2	3	2016	0	0	0	0	0
301	2	0	3	3	2016	38.55181	43.76832	0	125.1158	4.857733
302	13	0	3	3	2016	44.58949	53.44428	0	94.27735	4.558727
303	9	0	3	3	2016	39.45876	46.71174	0	115.8249	4.145201
304	4	0	3	3	2016	0	0	0	0	0
305	12	0	3	3	2016	40.26993	53.25059	0	100.4985	6.156354
306	5	0	3	3	2016	0	0	0	0	0
307	6	0	3	3	2016	39.99499	46.06848	0	116.5987	5.058919
308	7	0	3	3	2016	38.29341	46.44762	0	118.3017	4.575238
309	3	0	3	3	2016	42.69599	54.34411	0	95.2412	5.071865
310	10	0	3	3	2016	40.5405	49.42305	0	107.8848	4.723387
311	11	0	3	3	2016	33.14595	45.73039	0	128.3138	4.460648
312	14	0	3	3	2016	40.2503	51.35494	0	104.2358	4.556232
313	8	0	3	3	2016	36.02719	49.73912	0	113.7747	5.504775
314	1	0	3	3	2016	38.88941	47.58721	0	114.5611	5.791804
315	2	50	3	3	2016	38.72549	42.74488	0	127.817	5.289745
316	13	50	3	3	2016	38.06461	49.89539	0	110.4593	4.041501
317	9	50	3	3	2016	40.95926	43.94194	0	120.6512	5.159445
318	4	50	3	3	2016	0	0	0	0	0
319	12	50	3	3	2016	45.54213	57.61567	0	86.25347	5.630934
320	5	50	3	3	2016	0	0	0	0	0

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
321	6	50	3	3	2016	44.06494	56.33825	0	90.10924	6.188935
322	7	50	3	3	2016	40.70372	54.00178	0	98.51838	4.777957
323	3	50	3	3	2016	38.60971	44.97698	0	121.6603	4.934162
324	10	50	3	3	2016	36.98357	46.92137	0	119.1301	4.209524
325	11	50	3	3	2016	38.81797	45.43097	0	120.1123	4.314948
326	14	50	3	3	2016	36.85138	47.95044	0	116.7732	5.86559
327	8	50	3	3	2016	40.17514	48.54769	0	110.3754	4.745424
328	1	50	3	3	2016	36.45728	39.99481	0	140.7154	5.276324
401	4	50	4	3	2016	0	0	0	0	0
402	8	50	4	3	2016	39.89443	50.54569	13.71861	106.4149	4.01309
403	14	50	4	3	2016	43.57102	51.59424	12.51786	99.08835	4.183338
404	1	50	4	3	2016	41.46306	49.8752	13.68099	105.5663	4.735114
405	13	50	4	3	2016	33.49872	42.86604	16.95461	136.2916	3.934637
406	3	50	4	3	2016	41.49497	49.2993	15.54368	106.7526	4.931461
407	11	50	4	3	2016	38.04266	47.54085	13.97847	115.9634	4.571369
408	10	50	4	3	2016	40.85422	53.20646	15.45086	99.78603	5.38467
409	5	50	4	3	2016	0	0	0	0	0
410	6	50	4	3	2016	28.8896	47.2971	16.39572	130.5847	4.457005
411	7	50	4	3	2016	39.36498	52.41554	14.89914	103.3506	5.385007
412	9	50	4	3	2016	38.69821	48.35967	14.56527	113.0177	5.140414
413	2	50	4	3	2016	39.35368	43.69126	15.37377	124.0065	5.313157
414	12	50	4	3	2016	35.00283	44.81927	13.28514	127.9201	4.957741
415	4	0	4	3	2016	0	0	0	0	0
416	8	0	4	3	2016	39.32628	48.63777	14.84636	111.4357	4.294218
417	14	0	4	3	2016	37.42239	49.97252	15.75629	111.2201	4.202463
418	1	0	4	3	2016	34.71543	46.06397	17.83151	124.9156	4.39465
419	13	0	4	3	2016	40.53966	50.37463	15.84318	105.8481	4.308915
420	3	0	4	3	2016	50.83161	51.37237	10.90599	89.27462	5.096177
421	11	0	4	3	2016	42.59055	49.34893	14.49349	105.0365	5.48207
422	10	0	4	3	2016	42.97138	50.82954	14.24118	101.434	5.205935

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
423	5	0	4	3	2016	0	0	0	0	0
424	6	0	4	3	2016	41.43536	50.29644	13.45042	104.7221	5.529527
425	7	0	4	3	2016	35.67433	50.8552	15.69836	111.7806	4.898862
426	9	0	4	3	2016	41.43988	49.46659	13.38191	106.4723	4.929141
427	2	0	4	3	2016	38.12525	46.28782	14.91355	118.9733	4.910348
428	12	0	4	3	2016	41.61401	57.07609	12.24591	92.05612	5.238108
101	1	0	1	4	2016	36.27812	47.20754	16.27623	119.4909	3.297059
102	2	0	1	4	2016	35.44306	46.37567	14.70886	122.9391	2.978351
103	3	0	1	4	2016	39.1908	53.01073	17.52798	102.4284	3.031833
104	4	0	1	4	2016	37.94668	59.33807	7.696584	93.02556	3.832589
105	5	0	1	4	2016	40.54839	62.50129	5.714355	85.30102	3.892391
106	6	0	1	4	2016	37.96287	49.20438	15.138	112.1604	3.39318
107	7	0	1	4	2016	37.54017	45.8314	18.28242	121.0832	3.908444
108	8	0	1	4	2016	36.03238	48.41826	11.74776	116.8707	3.809899
109	9	0	1	4	2016	35.32667	46.72995	14.09803	122.1875	3.964965
110	10	0	1	4	2016	42.87415	51.63502	16.8224	99.98809	3.70157
111	11	0	1	4	2016	41.41697	44.73817	15.34444	117.7626	3.337898
112	12	0	1	4	2016	43.12393	54.07658	14.20112	95.13891	4.850833
113	13	0	1	4	2016	40.27196	47.24066	14.54001	113.2807	3.204819
114	14	0	1	4	2016	36.96094	50.98464	18.05458	109.6681	4.16554
115	1	50	1	4	2016	38.81907	51.51498	14.65777	105.9253	4.735666
116	1	50	1	4	2016	35.99974	44.61221	14.66829	126.8945	3.520449
117	3	50	1	4	2016	41.02316	52.18562	13.00933	101.5034	3.804147
118	4	50	1	4	2016	38.92973	60.2255	7.288095	90.47198	4.45887
119	5	50	1	4	2016	37.17387	62.10384	7.853058	89.78444	4.380228
120	6	50	1	4	2016	41.85446	49.57694	14.1626	105.6293	4.342707
121	7	50	1	4	2016	42.70659	51.47002	10.34673	100.5445	4.722074
122	8	50	1	4	2016	39.19697	50.00131	11.78275	108.5842	3.539831
123	9	50	1	4	2016	36.26584	45.54632	16.87638	123.8686	4.724735
124	10	50	1	4	2016	41.23565	51.13403	13.99248	103.2898	4.519261

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
125	11	50	1	4	2016	42.04059	49.88248	11.45227	104.7119	3.970985
126	12	50	1	4	2016	41.37923	51.21485	12.32867	102.9236	3.622862
127	13	50	1	4	2016	38.26873	46.2464	14.46658	118.8551	3.726102
128	14	50	1	4	2016	42.47349	50.53107	11.56499	102.7471	4.049294
201	5	50	2	4	2016	41.07752	63.37153	6.116717	83.52458	4.734517
202	3	50	2	4	2016	40.62991	50.28836	14.27017	105.8996	3.763779
203	10	50	2	4	2016	41.93661	51.42729	13.81723	101.713	3.470855
204	11	50	2	4	2016	41.87767	50.10879	14.89616	104.4746	2.85825
205	1	50	2	4	2016	37.40758	48.58961	15.39663	114.4077	3.2309
206	14	50	2	4	2016	42.12348	49.88259	15.24105	104.5913	3.243528
207	13	50	2	4	2016	39.61654	54.79978	12.35565	98.52138	3.348791
208	2	50	2	4	2016	36.02355	46.50676	16.21303	121.688	3.102779
209	8	50	2	4	2016	37.27999	50.4498	15.95619	110.3725	3.565181
210	9	50	2	4	2016	37.80302	49.70063	16.70693	111.2736	3.398939
211	12	50	2	4	2016	39.79236	49.18364	12.6775	109.5122	3.430674
212	6	50	2	4	2016	40.62551	50.54989	14.48449	105.358	3.433601
213	7	50	2	4	2016	41.15292	50.80021	13.1857	104.0865	3.478715
214	4	50	2	4	2016	43.22993	62.37183	4.560328	82.36259	4.950721
215	5	0	2	4	2016	39.12188	62.62558	8.081064	86.78236	4.493876
216	3	0	2	4	2016	39.04759	40.83948	15.0579	133.2088	3.99633
217	10	0	2	4	2016	42.0929	52.18142	15.26397	100.026	3.407736
218	11	0	2	4	2016	40.27964	44.5763	18.82117	120.0391	1.950838
219	1	0	2	4	2016	39.46234	49.88298	14.81451	108.4563	3.474899
220	14	0	2	4	2016	41.4076	50.78364	15.20409	103.7571	2.868525
221	13	0	2	4	2016	37.89246	50.55678	16.33392	109.261	3.766927
222	2	0	2	4	2016	35.31066	46.63958	18.16842	122.4491	3.473636
223	8	0	2	4	2016	38.02324	49.87957	14.71423	110.5545	3.53265
224	9	0	2	4	2016	36.57533	43.38254	16.76461	129.5298	3.908801
225	12	0	2	4	2016	43.82038	49.90102	12.07855	102.0885	3.162262
226	6	0	2	4	2016	37.91039	48.58769	14.85773	113.6623	3.742516

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
227	7	0	2	4	2016	39.52342	56.11341	13.71597	96.33523	3.534015
228	4	0	2	4	2016	41.22886	62.14996	6.980785	84.98981	3.980003
301	2	0	3	4	2016	31.96945	47.48142	0	125.3774	5.129129
302	13	0	3	4	2016	38.77748	45.51207	0	119.9628	4.398084
303	9	0	3	4	2016	39.39653	48.49447	0	111.66	3.879507
304	4	0	3	4	2016	41.11265	56.61215	0	93.45228	4.785416
305	12	0	3	4	2016	40.77769	52.65221	0	100.9418	3.71387
306	5	0	3	4	2016	40.82865	58.37701	0	90.97955	3.670786
307	6	0	3	4	2016	38.26045	47.43686	0	115.885	2.89852
308	7	0	3	4	2016	43.06946	51.24542	0	100.4721	3.416974
309	3	0	3	4	2016	36.43893	48.84037	0	115.2574	3.63372
310	10	0	3	4	2016	36.58004	47.10751	0	119.2802	3.537602
311	11	0	3	4	2016	38.48413	51.0951	0	107.2708	3.86034
312	14	0	3	4	2016	42.58833	48.92895	0	105.9414	3.562298
313	8	0	3	4	2016	36.17018	49.85933	0	113.2926	3.468872
314	1	0	3	4	2016	41.64327	48.48427	0	108.3255	3.908671
315	2	50	3	4	2016	37.70481	46.6562	0	118.687	4.980383
316	13	50	3	4	2016	40.06514	51.90951	0	103.3807	3.924841
317	9	50	3	4	2016	38.56479	48.2856	0	113.3913	4.157696
318	4	50	3	4	2016	39.29614	57.57123	0	94.1819	3.684074
319	12	50	3	4	2016	39.31474	53.32133	0	101.6633	3.720006
320	5	50	3	4	2016	37.78459	59.85685	0	92.41553	5.226134
321	6	50	3	4	2016	40.72897	49.02557	0	108.4809	3.519968
322	7	50	3	4	2016	37.97558	52.25739	0	105.5901	3.676019
323	3	50	3	4	2016	39.36034	48.79477	0	111.0266	4.233217
324	10	50	3	4	2016	39.04376	62.02727	0	87.71071	4.198601
325	11	50	3	4	2016	40.18089	45.70544	0	117.2301	3.75356
326	14	50	3	4	2016	40.27345	49.8898	0	107.2633	4.913106
327	8	50	3	4	2016	39.98513	47.54526	0	112.9921	4.194657
328	1	50	3	4	2016	38.34249	53.61854	0	102.4137	2.925151

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
401	4	50	4	4	2016	39.13674	63.76852	7.138811	85.21005	6.23185
402	8	50	4	4	2016	37.55654	48.56525	10.85198	114.2428	3.893883
403	14	50	4	4	2016	40.21342	51.44429	15.82691	104.1067	2.683901
404	1	50	4	4	2016	35.74687	46.84108	17.92648	121.2475	3.519233
405	13	50	4	4	2016	38.28593	52.86245	10.03392	103.9561	3.549258
406	3	50	4	4	2016	38.21594	50.34685	13.28619	109.251	4.008993
407	11	50	4	4	2016	38.34172	47.06416	15.63023	116.6775	2.976419
408	10	50	4	4	2016	36.45777	48.43383	17.55894	116.1967	2.843011
409	5	50	4	4	2016	42.6192	59.22567	9.443321	87.48508	4.453017
410	6	50	4	4	2016	40.90909	53.97269	14.47382	98.29574	3.832012
411	7	50	4	4	2016	41.18305	52.19785	14.3366	101.2577	3.671867
412	9	50	4	4	2016	38.65024	43.6681	13.41605	125.2395	3.396208
413	2	50	4	4	2016	32.84043	46.52349	17.78259	126.6023	4.162716
414	12	50	4	4	2016	46.79834	54.15168	12.97834	90.08992	4.167714
415	4	0	4	4	2016	39.72674	58.92838	5.2504	91.48334	5.077311
416	8	0	4	4	2016	38.86656	59.87571	10.51187	91.07696	4.763498
417	14	0	4	4	2016	41.39407	49.77647	14.85658	105.8762	3.573033
418	1	0	4	4	2016	39.1048	51.38877	15.57664	105.7825	3.183104
419	13	0	4	4	2016	35.72135	44.63554	15.90808	127.2801	3.030629
420	3	0	4	4	2016	35.0779	50.22413	15.53678	114.0456	2.836628
421	11	0	4	4	2016	38.46501	47.81466	17.29934	114.6593	3.690905
422	10	0	4	4	2016	40.45061	51.48249	14.74124	103.6956	3.4791
423	5	0	4	4	2016	39.4391	58.32789	9.249115	92.78252	3.46849
424	6	0	4	4	2016	37.73644	52.84393	10.67249	104.746	3.462667
425	7	0	4	4	2016	40.15822	53.511	11.43611	100.1607	3.439639
426	9	0	4	4	2016	39.62118	51.08424	14.48117	105.6806	3.426903
427	2	0	4	4	2016	36.91815	45.53534	17.00608	122.8604	3.394853
428	12	0	4	4	2016	38.88122	51.63837	13.71091	105.585	3.405888
101	1	0	1	1	2017	37.80786	46.79451	18.0625	118.1766	2.582172
102	2	0	1	1	2017	33.65884	43.93715	21.25	132.7049	2.307193

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
103	3	0	1	1	2017	33.90061	45.03875	19.5625	129.0701	4.963755
104	4	0	1	1	2017	37.93851	48.12368	16.6875	114.7158	2.005082
105	5	0	1	1	2017	35.34301	47.93415	13.875	119.0932	2.902215
106	6	0	1	1	2017	33.11533	51.14129	17.6875	114.7813	5.170578
107	7	0	1	1	2017	33.90305	40.44294	21.3125	143.7329	5.383002
108	8	0	1	1	2017	32.14946	41.83484	20.1875	141.9882	5.41102
109	9	0	1	1	2017	35.60492	45.02706	19.625	126.3607	5.194472
110	10	0	1	1	2017	36.14222	48.62805	18.75	116.2028	6.396954
111	11	0	1	1	2017	35.61401	45.88879	19.1875	123.9735	5.281548
112	12	0	1	1	2017	40.18406	47.13188	22	113.6773	5.985098
113	13	0	1	1	2017	36.15175	50.33735	18.125	112.2432	5.404249
114	14	0	1	1	2017	37.44761	46.4146	17.25	119.7063	6.215255
115	1	50	1	1	2017	33.13515	42.82415	16.1875	137.0401	4.238388
116	1	50	1	1	2017	31.40114	42.76041	19.8125	140.1829	2.540586
117	3	50	1	1	2017	35.98227	45.04542	20.6875	125.7022	5.379308
118	4	50	1	1	2017	37.13863	58.64545	14.5625	95.12268	4.401632
119	5	50	1	1	2017	34.10083	54.3592	11.875	106.6728	4.866725
120	6	50	1	1	2017	35.8051	44.18608	19.8125	128.4374	4.975075
121	7	50	1	1	2017	34.49002	48.42313	17.375	119.1671	4.779002
122	8	50	1	1	2017	37.63344	46.59164	18.8125	118.9624	5.793326
123	9	50	1	1	2017	37.00378	47.09597	18.4375	118.6574	5.793369
124	10	50	1	1	2017	39.924	50.89891	19.1875	105.6343	5.999358
125	11	50	1	1	2017	37.25933	45.97785	19.75	121.1402	5.617683
126	12	50	1	1	2017	34.62066	46.27117	16.875	124.5047	5.982541
127	13	50	1	1	2017	34.39635	42.01086	19.375	137.5176	5.481515
128	14	50	1	1	2017	34.70801	44.12833	19.4375	130.4071	6.002969
201	5	50	2	1	2017	36.71555	57.65286	16.5	97.29216	5.701666
202	3	50	2	1	2017	33.53769	44.26684	19.9375	131.9149	3.707584
203	10	50	2	1	2017	38.35481	53.81481	15.6875	102.0236	5.103679
204	11	50	2	1	2017	41.50675	53.52163	17.8125	98.31494	5.719471

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
205	1	50	2	1	2017	39.53119	45.7001	19	118.2741	5.688161
206	14	50	2	1	2017	35.16083	50.05573	18.5625	114.3093	5.094841
207	13	50	2	1	2017	35.59043	50.19938	16.5	113.362	5.475619
208	2	50	2	1	2017	34.21322	44.87574	20.8125	129.0341	5.782192
209	8	50	2	1	2017	36.57777	46.7518	18.6875	120.1912	6.241915
210	9	50	2	1	2017	34.82564	46.91869	18.75	122.4698	6.402027
211	12	50	2	1	2017	39.19831	54.17872	16.0625	100.2102	6.524021
212	6	50	2	1	2017	34.5652	47.56142	18.625	121.2116	5.864711
213	7	50	2	1	2017	35.03077	46.98712	22.1875	121.9751	5.370735
214	4	50	2	1	2017	33.23904	48.39645	17.9375	121.1059	2.005073
215	5	0	2	1	2017	36.11858	55.5747	12.9375	101.7087	4.349773
216	3	0	2	1	2017	29.71764	39.37956	17.875	155.316	2.105801
217	10	0	2	1	2017	35.17187	45.0396	19.5	127.0223	5.520329
218	11	0	2	1	2017	32.46666	43.27635	22.1875	136.7275	5.368384
219	1	0	2	1	2017	38.5277	46.85363	19.8125	116.9142	5.855556
220	14	0	2	1	2017	36.38531	56.54783	13.125	99.61659	6.496718
221	13	0	2	1	2017	39.66378	49.21344	16.625	109.6352	5.261933
222	2	0	2	1	2017	34.02861	44.2213	19.1875	131.2463	5.642824
223	8	0	2	1	2017	35.31819	40.26084	16.0625	141.8359	5.858785
224	9	0	2	1	2017	36.39524	46.02334	20.4375	122.381	5.555464
225	12	0	2	1	2017	36.68148	47.18376	18.5625	118.9316	6.632652
226	6	0	2	1	2017	41.454	46.73987	17.5	112.6618	5.470694
227	7	0	2	1	2017	32.57055	43.72415	19.75	135.155	6.297492
228	4	0	2	1	2017	32.62377	48.72059	16.75	121.2153	2.030356
301	2	0	3	1	2017	37.1086	44.5552	0	125.2533	6.182094
302	13	0	3	1	2017	36.30022	47.51224	0	118.6908	2.416969
303	9	0	3	1	2017	33.63766	45.0826	0	129.3672	3.940949
304	4	0	3	1	2017	41.56241	54.26145	0	96.90015	4.16084
305	12	0	3	1	2017	42.98454	54.27151	0	94.98332	4.605987
306	5	0	3	1	2017	37.71041	55.63571	0	99.52382	4.11906

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
307	6	0	3	1	2017	40.75242	51.44344	0	103.3492	5.663705
308	7	0	3	1	2017	34.34748	46.98967	0	123.0222	5.569566
309	3	0	3	1	2017	40.31082	52.94053	0	101.0311	4.65919
310	10	0	3	1	2017	36.75748	48.23023	0	116.2369	4.737565
311	11	0	3	1	2017	35.55598	47.68641	0	119.3883	5.36904
312	14	0	3	1	2017	36.54849	49.74163	0	113.0095	5.395065
313	8	0	3	1	2017	35.99372	43.00851	0	131.6362	5.729522
314	1	0	3	1	2017	37.11569	49.08153	0	113.6919	5.796244
315	2	50	3	1	2017	35.40628	43.01345	0	132.6108	5.559876
316	13	50	3	1	2017	36.36044	50.13747	0	112.3891	6.103532
317	9	50	3	1	2017	37.3015	42.75712	0	130.1937	5.600753
318	4	50	3	1	2017	35.1422	57.08001	0	100.266	5.707099
319	12	50	3	1	2017	35.50003	42.98141	0	132.5516	5.88425
320	5	50	3	1	2017	35.02177	57.28375	0	100.0617	4.719997
321	6	50	3	1	2017	34.65123	46.71151	0	123.2836	6.221138
322	7	50	3	1	2017	36.6889	55.00089	0	102.0184	6.268752
323	3	50	3	1	2017	33.40628	42.67385	0	137.0623	4.601576
324	10	50	3	1	2017	38.63514	47.76812	0	114.5129	5.895322
325	11	50	3	1	2017	42.12981	52.34516	0	99.66206	6.014866
326	14	50	3	1	2017	34.14154	48.22922	0	120.1698	5.862252
327	8	50	3	1	2017	43.30595	46.45457	0	110.4648	7.07308
328	1	50	3	1	2017	39.91603	52.22052	0	102.9719	6.623948
401	4	50	4	1	2017	35.22864	52.32682	15.8125	109.2541	4.814756
402	8	50	4	1	2017	34.54963	48.78961	17.0625	118.1834	5.416975
403	14	50	4	1	2017	35.15069	48.98594	20.8125	116.8206	5.889218
404	1	50	4	1	2017	33.05142	44.70987	20.625	131.3959	5.851177
405	13	50	4	1	2017	35.74278	45.74336	18.375	124.1637	6.048184
406	3	50	4	1	2017	33.77625	43.32598	21.3125	134.3805	5.170746
407	11	50	4	1	2017	37.19507	43.00379	20.75	129.6263	5.994415
408	10	50	4	1	2017	37.06998	46.27474	18.8125	120.6595	6.29117

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
409	5	50	4	1	2017	37.43699	57.97753	15.5	95.8456	3.948595
410	6	50	4	1	2017	37.68061	49.60152	16.4375	111.6748	6.015719
411	7	50	4	1	2017	36.35643	46.69022	17.375	120.6933	5.27539
412	9	50	4	1	2017	35.05444	45.63522	14.5	125.5509	5.379192
413	2	50	4	1	2017	38.89689	45.49569	15.6875	119.8157	5.76718
414	12	50	4	1	2017	34.60103	48.02008	17.0625	119.9998	5.646436
415	4	0	4	1	2017	38.36311	59.66198	13.75	92.01471	2.662806
416	8	0	4	1	2017	36.06396	42.7244	18.75	132.3924	4.689148
417	14	0	4	1	2017	36.6036	45.07413	21.25	124.6232	4.943554
418	1	0	4	1	2017	32.525	40.64341	20.75	145.4809	5.421813
419	13	0	4	1	2017	31.60777	49.97484	19.75	119.6463	6.543846
420	3	0	4	1	2017	36.8964	47.54444	18.5625	117.7018	5.356613
421	11	0	4	1	2017	35.88049	43.86217	19.25	129.2614	5.462986
422	10	0	4	1	2017	34.54221	47.00323	17.625	122.6865	5.578832
423	5	0	4	1	2017	35.61185	53.75862	14.8125	105.8277	4.382822
424	6	0	4	1	2017	41.41282	52.2225	16.8125	100.891	5.559829
425	7	0	4	1	2017	38.65584	48.83739	18.25	111.975	5.670042
426	9	0	4	1	2017	35.92571	47.1989	17.8125	120.0538	5.758414
427	2	0	4	1	2017	35.62242	44.14014	20.5625	128.871	5.800048
428	12	0	4	1	2017	36.72155	46.92258	17.8125	119.5317	5.600691
101	1	0	1	2	2017	33.02193	39.75853	20	147.8131	5.123608
102	2	0	1	2	2017	29.41403	39.58753	21.5625	155.0558	4.743949
103	3	0	1	2	2017	30.71606	39.89538	25.375	151.4943	4.23105
104	4	0	1	2	2017	0	0	0	0	0
105	5	0	1	2	2017	0	0	0	0	0
106	6	0	1	2	2017	38.95076	46.97036	17.1875	115.9709	5.2092
107	7	0	1	2	2017	33.35262	40.60139	21.5	144.1543	4.663115
108	8	0	1	2	2017	31.80195	37.51602	23.8125	159.005	4.9761
109	9	0	1	2	2017	34.22076	41.89212	21.875	138.2111	5.283278
110	10	0	1	2	2017	36.5513	40.16737	21.75	139.9413	5.229054

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
111	11	0	1	2	2017	34.02407	41.34426	20.5625	140.3873	5.220899
112	12	0	1	2	2017	34.21071	43.97943	20.8125	131.668	5.504498
113	13	0	1	2	2017	34.24374	43.50204	20.9375	133.0579	5.949033
114	14	0	1	2	2017	34.62712	43.6072	22.625	132.1	5.553309
115	1	50	1	2	2017	31.13629	39.27258	22.9375	153.1214	5.838965
116	1	50	1	2	2017	34.60359	40.82117	23.0625	141.1575	4.984784
117	3	50	1	2	2017	27.32865	36.15083	23	173.9765	5.428751
118	4	50	1	2	2017	0	0	0	0	0
119	5	50	1	2	2017	0	0	0	0	0
120	6	50	1	2	2017	34.63875	38.01527	20.375	151.5093	5.667167
121	7	50	1	2	2017	33.75698	39.27672	21.3125	148.2701	5.920386
122	8	50	1	2	2017	35.2583	38.04534	21.875	150.2095	4.753944
123	9	50	1	2	2017	34.29878	39.87719	21.25	145.0529	5.477185
124	10	50	1	2	2017	34.28032	41.35284	19.9375	139.9091	5.753256
125	11	50	1	2	2017	32.06108	41.98254	23.1875	141.6412	5.203029
126	12	50	1	2	2017	37.67075	44.37131	19.25	124.8544	5.216374
127	13	50	1	2	2017	38.73756	42.64169	18.6875	128.1058	4.956006
128	14	50	1	2	2017	35.28772	41.66844	21.625	137.0975	5.409711
201	5	50	2	2	2017	0	0	0	0	0
202	3	50	2	2	2017	29.75225	36.28312	22.9375	168.5017	5.411962
203	10	50	2	2	2017	34.23179	40.14474	23	144.2071	5.660306
204	11	50	2	2	2017	38.09228	42.95845	19.75	128.2496	5.53338
205	1	50	2	2	2017	35.53575	44.0641	18.9375	129.2359	5.530245
206	14	50	2	2	2017	36.93349	43.00484	17.125	130.0639	5.044536
207	13	50	2	2	2017	33.73379	41.24156	21.4375	141.2469	5.261329
208	2	50	2	2	2017	39.30638	44.96106	20.5625	120.5805	5.506045
209	8	50	2	2	2017	35.13882	39.94029	20.625	143.2996	5.36155
210	9	50	2	2	2017	28.84412	39.30955	24.1875	157.2029	4.905707
211	12	50	2	2	2017	36.79677	42.79633	20.5	130.9291	5.249083
212	6	50	2	2	2017	35.96477	39.71504	23.8125	142.6053	5.123642

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
213	7	50	2	2	2017	33.77444	41.88902	23.4375	138.9934	5.556576
214	4	50	2	2	2017	0	0	0	0	0
215	5	0	2	2	2017	0	0	0	0	0
216	3	0	2	2	2017	30.14301	40.52136	20.6875	150.1788	5.838719
217	10	0	2	2	2017	40.38417	46.57828	18.1875	114.7171	5.599534
218	11	0	2	2	2017	31.38808	35.19061	22.625	170.3644	5.354045
219	1	0	2	2	2017	35.04112	40.54393	20.625	141.3407	5.979268
220	14	0	2	2	2017	35.97879	43.14854	23	131.2341	5.070672
221	13	0	2	2	2017	33.99444	42.10495	20.3125	137.902	5.56032
222	2	0	2	2	2017	33.35799	38.05394	20.875	153.7943	5.509458
223	8	0	2	2	2017	33.40067	42.60764	21.0625	137.2849	5.057836
224	9	0	2	2	2017	36.41359	42.45036	19.25	132.6503	5.309084
225	12	0	2	2	2017	37.29394	42.62428	22.5625	130.6124	4.815963
226	6	0	2	2	2017	34.99746	43.16313	22.1875	132.8373	5.164445
227	7	0	2	2	2017	35.08821	44.54864	17.5625	128.5583	4.876767
228	4	0	2	2	2017	0	0	0	0	0
301	2	0	3	2	2017	30.71913	38.41845	0	157.3125	5.310715
302	13	0	3	2	2017	29.71701	39.41817	0	155.165	4.777815
303	9	0	3	2	2017	34.13251	40.46494	0	143.2438	5.842879
304	4	0	3	2	2017	0	0	0	0	0
305	12	0	3	2	2017	33.82109	42.34391	0	137.4204	5.628388
306	5	0	3	2	2017	0	0	0	0	0
307	6	0	3	2	2017	31.81494	40.42502	0	147.5397	5.914896
308	7	0	3	2	2017	37.7127	44.18143	0	125.3222	5.650284
309	3	0	3	2	2017	37.57673	43.86447	0	126.4523	5.890239
310	10	0	3	2	2017	38.73244	43.1784	0	126.522	4.91914
311	11	0	3	2	2017	33.26458	43.75463	0	133.9114	5.335355
312	14	0	3	2	2017	33.59681	43.272	0	134.8487	5.103505
313	8	0	3	2	2017	34.94805	39.19218	0	146.3877	4.446288
314	1	0	3	2	2017	28.799	38.72108	0	159.6765	5.146089

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
315	2	50	3	2	2017	31.2239	37.33431	0	160.9009	5.742999
316	13	50	3	2	2017	28.65799	41.91981	0	147.736	4.604421
317	9	50	3	2	2017	36.16414	41.4376	0	136.3286	5.424183
318	4	50	3	2	2017	0	0	0	0	0
319	12	50	3	2	2017	36.27652	44.8477	0	125.7809	6.28617
320	5	50	3	2	2017	0	0	0	0	0
321	6	50	3	2	2017	30.70911	38.76919	0	155.9081	5.7681
322	7	50	3	2	2017	34.38136	40.21673	0	143.6795	5.833938
323	3	50	3	2	2017	32.36272	39.09042	0	151.5614	6.344789
324	10	50	3	2	2017	38.7443	42.28817	0	129.1651	6.848688
325	11	50	3	2	2017	34.83996	39.6967	0	144.7245	4.532255
326	14	50	3	2	2017	33.11041	42.43854	0	138.3275	5.09768
327	8	50	3	2	2017	33.23017	37.39315	0	156.7597	4.817466
328	1	50	3	2	2017	30.12855	39.08114	0	155.7401	4.891188
401	4	50	4	2	2017	0	0	0	0	0
402	8	50	4	2	2017	34.03434	43.13883	20.875	134.53	4.482722
403	14	50	4	2	2017	33.57599	40.54221	25.5625	143.9655	5.530042
404	1	50	4	2	2017	28.8469	35.65259	23.125	173.3219	4.987607
405	13	50	4	2	2017	35.77994	44.72444	22.1875	126.9322	5.042933
406	3	50	4	2	2017	30.12386	39.07134	21.875	155.7878	5.063106
407	11	50	4	2	2017	34.60895	39.20007	20.25	146.9851	5.548759
408	10	50	4	2	2017	37.73056	40.00366	22.0625	138.3778	5.915833
409	5	50	4	2	2017	0	0	0	0	0
410	6	50	4	2	2017	36.07985	43.94704	18.625	128.683	5.417168
411	7	50	4	2	2017	38.29042	42.97751	19.25	127.8587	5.304583
412	9	50	4	2	2017	30.15645	40.12943	22.75	151.6213	4.009393
413	2	50	4	2	2017	33.9704	41.35176	20.8125	140.4559	3.5748
414	12	50	4	2	2017	34.99819	35.37171	22	162.0962	3.645253
415	4	0	4	2	2017	0	0	0	0	0
416	8	0	4	2	2017	36.64371	38.48898	23.3125	145.8697	4.85036

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
417	14	0	4	2	2017	36.92938	42.4334	21.875	131.8225	5.307475
418	1	0	4	2	2017	29.69335	38.09897	23.1875	160.5827	4.657639
419	13	0	4	2	2017	32.35717	40.7197	25.125	145.507	5.060401
420	3	0	4	2	2017	28.92045	35.81476	23.25	172.3882	5.204653
421	11	0	4	2	2017	32.02758	39.17889	24.25	151.839	5.094823
422	10	0	4	2	2017	31.39604	38.18173	23.625	157.0031	5.928485
423	5	0	4	2	2017	0	0	0	0	0
424	6	0	4	2	2017	34.38185	41.93576	20.5625	137.7889	5.955983
425	7	0	4	2	2017	36.48801	45.58393	18.5	123.4132	5.102284
426	9	0	4	2	2017	26.96008	36.8487	27.1875	171.4063	4.960764
427	2	0	4	2	2017	34.48834	39.19437	21.9375	147.2295	4.738584
428	12	0	4	2	2017	38.04521	40.00493	22.8125	137.8034	5.3545
101	1	0	1	3	2017	39.71413	40.69836	22.0625	132.4839	3.900171
102	2	0	1	3	2017	35.22585	39.19379	16.1875	145.8681	4.029149
103	3	0	1	3	2017	38.79182	46.59014	18.25	117.1646	5.555679
104	4	0	1	3	2017	37.56732	44.18365	19.375	125.5543	4.869718
105	5	0	1	3	2017	37.33417	49.05661	16.25	113.427	4.815532
106	6	0	1	3	2017	38.92864	47.40916	17.9375	114.9314	5.405202
107	7	0	1	3	2017	37.90619	49.9133	16.6875	110.6497	4.856382
108	8	0	1	3	2017	38.16507	47.76308	15.125	115.2382	5.835932
109	9	0	1	3	2017	31.41797	49.3775	20.5	121.3723	5.134749
110	10	0	1	3	2017	35.69135	46.05286	19.0625	123.4101	4.666145
111	11	0	1	3	2017	40.82152	47.4436	17.1875	111.9567	4.252355
112	12	0	1	3	2017	40.90186	46.58355	17.25	113.8988	4.733065
113	13	0	1	3	2017	35.09599	40.6065	19.75	141.025	4.973547
114	14	0	1	3	2017	35.30286	43.97703	20.4375	129.8755	5.04705
115	1	50	1	3	2017	38.42907	47.2256	18.875	116.1446	5.154056
116	1	50	1	3	2017	34.67598	40.70469	20	141.4326	4.65218
117	3	50	1	3	2017	34.05921	44.88764	21.1875	129.2486	4.867152
118	4	50	1	3	2017	34.70959	55.16038	18.4375	104.3237	4.614578

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
119	5	50	1	3	2017	36.56083	55.56527	19	101.1492	4.436685
120	6	50	1	3	2017	35.16301	47.95462	19.625	119.3144	5.403147
121	7	50	1	3	2017	38.48517	47.50662	17.625	115.372	5.238028
122	8	50	1	3	2017	36.03141	44.57008	17.1875	126.9629	5.64005
123	9	50	1	3	2017	32.32022	42.21454	21.0625	140.4179	4.738318
124	10	50	1	3	2017	35.60769	38.78483	19.3125	146.6927	5.197174
125	11	50	1	3	2017	39.30651	46.15291	17.125	117.4664	5.10757
126	12	50	1	3	2017	39.33262	47.32032	18.625	114.5285	5.098209
127	13	50	1	3	2017	32.68126	39.97057	20.9375	147.6465	4.992042
128	14	50	1	3	2017	40.91619	44.18537	16.3125	120.0572	5.270741
201	5	50	2	3	2017	36.61258	51.30448	20.25	109.4765	4.931762
202	3	50	2	3	2017	37.98959	48.92087	17.25	112.7708	5.983
203	10	50	2	3	2017	37.495	48.34539	20.0625	114.8545	5.79813
204	11	50	2	3	2017	36.26812	44.34209	20.75	127.2289	4.876946
205	1	50	2	3	2017	34.80776	40.65837	20.5625	141.3588	5.48414
206	14	50	2	3	2017	34.94835	43.79905	21.875	130.9898	5.008983
207	13	50	2	3	2017	35.85407	49.69473	19.1875	114.1288	4.319964
208	2	50	2	3	2017	32.64816	42.93529	18.8125	137.5073	4.671454
209	8	50	2	3	2017	34.76226	49.79903	18.5625	115.4785	5.340191
210	9	50	2	3	2017	35.25964	47.47938	18.5625	120.3612	5.785883
211	12	50	2	3	2017	35.58171	50.3988	18.5	112.926	5.751737
212	6	50	2	3	2017	36.78508	49.02819	20.875	114.3043	4.736678
213	7	50	2	3	2017	35.71068	39.04177	23	145.5361	5.91069
214	4	50	2	3	2017	38.79381	49.3879	18.9375	110.5244	3.028055
215	5	0	2	3	2017	36.45836	46.7989	15.125	120.2551	4.647968
216	3	0	2	3	2017	36.008	48.13547	18.1875	117.594	5.665487
217	10	0	2	3	2017	37.53357	47.22869	15.6875	117.5111	5.254619
218	11	0	2	3	2017	36.28027	39.00866	21.4375	144.6016	4.841196
219	1	0	2	3	2017	38.81305	49.50546	18.875	110.2338	4.951181
220	14	0	2	3	2017	39.76302	53.78535	16.375	100.1822	3.581206

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
221	13	0	2	3	2017	38.62883	48.55861	19	112.6582	4.176302
222	2	0	2	3	2017	33.02838	43.22899	20.625	135.9357	5.000552
223	8	0	2	3	2017	33.96082	46.4031	21.625	125.1811	4.354532
224	9	0	2	3	2017	34.46686	45.54153	20.875	126.7442	4.43378
225	12	0	2	3	2017	34.1472	40.19069	22.25	144.1947	4.782515
226	6	0	2	3	2017	39.56575	47.18424	16.75	114.5008	4.810809
227	7	0	2	3	2017	34.5569	43.29088	24.375	133.1827	5.010416
228	4	0	2	3	2017	40.97879	52.43915	13.875	101.074	3.494679
301	2	0	3	3	2017	35.8324	44.1031	0	128.6342	5.261298
302	13	0	3	3	2017	38.41064	47.90418	0	114.5273	5.293109
303	9	0	3	3	2017	30.82846	40.71641	0	148.2395	5.612081
304	4	0	3	3	2017	36.61471	57.75813	0	97.24135	3.628072
305	12	0	3	3	2017	34.24197	54.95852	0	105.3234	5.237864
306	5	0	3	3	2017	37.44256	49.82459	0	111.521	3.624148
307	6	0	3	3	2017	38.58713	51.3882	0	106.5137	5.043474
308	7	0	3	3	2017	37.91193	46.43587	0	118.9269	4.567436
309	3	0	3	3	2017	39.30269	48.49557	0	111.7977	4.96284
310	10	0	3	3	2017	36.29682	43.66629	0	129.1503	4.284021
311	11	0	3	3	2017	36.36033	42.23731	0	133.4108	4.802571
312	14	0	3	3	2017	37.66086	48.00559	0	115.4172	4.759115
313	8	0	3	3	2017	34.51157	42.81447	0	134.7414	4.203907
314	1	0	3	3	2017	33.54882	43.1449	0	135.3265	4.616918
315	2	50	3	3	2017	31.09883	38.27033	0	157.2024	4.277889
316	13	50	3	3	2017	35.73916	49.40162	0	114.9745	4.554206
317	9	50	3	3	2017	35.84546	49.49299	0	114.6066	4.92021
318	4	50	3	3	2017	35.93893	55.58927	0	101.9162	4.750705
319	12	50	3	3	2017	38.85641	47.41906	0	115.0177	5.477696
320	5	50	3	3	2017	34.13378	51.66667	0	112.1857	5.282841
321	6	50	3	3	2017	35.58609	45.97557	0	123.7835	4.477226
322	7	50	3	3	2017	39.15263	50.60129	0	107.3603	5.151283

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
323	3	50	3	3	2017	37.68147	48.7233	0	113.6864	4.722956
324	10	50	3	3	2017	36.8016	51.23038	0	109.3674	5.082849
325	11	50	3	3	2017	35.25172	43.66876	0	130.8773	4.226263
326	14	50	3	3	2017	38.88186	46.34179	0	117.6517	4.787333
327	8	50	3	3	2017	33.55676	42.5683	0	137.146	4.702148
328	1	50	3	3	2017	31.42246	34.45049	0	173.9521	4.892581
401	4	50	4	3	2017	35.81451	51.38371	20.5625	110.4331	3.41421
402	8	50	4	3	2017	35.06377	41.16608	23.375	139.1648	4.807206
403	14	50	4	3	2017	34.15525	45.00903	19.375	128.7454	4.993255
404	1	50	4	3	2017	35.15464	47.39863	17.0625	120.7268	4.645271
405	13	50	4	3	2017	35.26711	48.53325	18.625	117.7364	4.820304
406	3	50	4	3	2017	39.36062	48.78884	21.25	111.0397	4.525568
407	11	50	4	3	2017	34.85252	39.19138	23.1875	146.5673	4.538958
408	10	50	4	3	2017	38.93016	47.23045	18.0625	115.3639	5.303189
409	5	50	4	3	2017	36.856	52.12379	18.9375	107.4172	5.097396
410	6	50	4	3	2017	39.75352	44.29775	19.5625	121.6546	5.879411
411	7	50	4	3	2017	36.14431	46.49679	19.75	121.5259	5.093699
412	9	50	4	3	2017	35.89037	45.84173	19.625	123.6639	4.893787
413	2	50	4	3	2017	33.36631	43.90762	19.75	133.2769	5.468109
414	12	50	4	3	2017	36.02327	46.4181	18	121.9209	4.347648
415	4	0	4	3	2017	36.27507	49.94959	17.9375	112.9357	3.295552
416	8	0	4	3	2017	30.05859	37.9606	22.25	160.4708	4.612778
417	14	0	4	3	2017	38.99926	48.75821	18.8125	111.6465	4.299115
418	1	0	4	3	2017	35.10016	44.68785	19.6875	128.1384	4.640865
419	13	0	4	3	2017	34.66395	42.93754	23.1875	134.0981	4.181187
420	3	0	4	3	2017	38.72535	50.19702	17.5625	108.8417	4.014013
421	11	0	4	3	2017	36.54536	47.79091	22.0625	117.6271	4.416751
422	10	0	4	3	2017	34.43606	44.70499	21.6875	129.1658	4.755097
423	5	0	4	3	2017	34.71843	57.85239	16.375	99.45816	3.231085
424	6	0	4	3	2017	35.43784	46.17457	20.8125	123.4827	5.087599

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
425	7	0	4	3	2017	37.72275	46.98931	18.6875	117.818	4.171197
426	9	0	4	3	2017	35.28139	43.29148	23.3125	131.9682	4.543685
427	2	0	4	3	2017	32.95325	43.81874	18	134.2304	5.061949
428	12	0	4	3	2017	35.96719	49.14639	19.4375	115.2353	5.861726
101	1	0	1	4	2017	39.9055	46.18736	17.6875	116.439	4.250786
102	2	0	1	4	2017	33.50166	44.90026	20.0625	130.1121	3.438307
103	3	0	1	4	2017	39.82512	47.15888	17.3125	114.1638	3.942113
104	4	0	1	4	2017	38.39393	57.04785	15.875	96.192	2.708744
105	5	0	1	4	2017	39.61331	50.44365	17.0625	107.034	2.961168
106	6	0	1	4	2017	36.33812	48.83099	16.125	115.4292	4.389787
107	7	0	1	4	2017	38.75619	48.68883	18.5625	112.1673	4.316376
108	8	0	1	4	2017	32.60535	43.02115	6.8125	137.305	4.960036
109	9	0	1	4	2017	32.51311	43.53348	19.9375	135.8426	3.802285
110	10	0	1	4	2017	36.53021	45.76979	19.25	122.8453	3.555539
111	11	0	1	4	2017	37.52491	46.5765	17.5	119.17	3.732586
112	12	0	1	4	2017	37.01473	52.51034	17.6875	106.4074	3.325471
113	13	0	1	4	2017	35.24695	44.55333	19.4375	128.2866	3.817832
114	14	0	1	4	2017	37.62492	48.94866	18.1875	113.2467	5.121584
115	1	50	1	4	2017	35.21868	47.40494	18.6875	120.6128	4.519796
116	1	50	1	4	2017	29.93233	43.21153	19.3125	141.1826	3.11755
117	3	50	1	4	2017	37.6378	47.41108	19.0625	116.8997	4.314983
118	4	50	1	4	2017	38.28465	47.31776	19.875	116.1396	3.100521
119	5	50	1	4	2017	37.32049	52.57839	18	105.8483	3.149948
120	6	50	1	4	2017	34.65495	50.32552	17.625	114.4249	4.26439
121	7	50	1	4	2017	33.74975	46.96819	21.4375	124.0007	4.329139
122	8	50	1	4	2017	35.52263	43.88093	18	129.7971	3.929624
123	9	50	1	4	2017	35.83476	43.38589	17.1875	130.7567	4.902197
124	10	50	1	4	2017	33.28751	44.14564	20.5	132.6877	3.102851
125	11	50	1	4	2017	39.92269	50.80434	16.4375	105.8328	4.344261
126	12	50	1	4	2017	35.35152	45.63831	18.5625	125.0707	3.702717

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
127	13	50	1	4	2017	34.7999	45.3062	15.625	126.8698	4.208638
128	14	50	1	4	2017	36.62468	48.01832	18.375	116.9503	4.00018
201	5	50	2	4	2017	35.13805	57.58058	17.1875	99.39957	3.428046
202	3	50	2	4	2017	34.967	46.20936	20.0625	124.1281	4.269418
203	10	50	2	4	2017	36.38795	50.03915	20.8125	112.5701	4.14501
204	11	50	2	4	2017	35.451	47.29106	19.75	120.5472	3.926184
205	1	50	2	4	2017	36.86294	44.72766	17.0625	125.1684	4.573274
206	14	50	2	4	2017	36.08473	51.97957	18.875	108.7905	3.745954
207	13	50	2	4	2017	31.91771	42.90959	21.5625	138.8232	3.696307
208	2	50	2	4	2017	32.4476	41.66946	23.3125	142.0332	3.809292
209	8	50	2	4	2017	33.30134	44.35515	19.375	132.0384	4.77041
210	9	50	2	4	2017	30.54287	45.47203	19.25	133.1912	3.933431
211	12	50	2	4	2017	37.32664	50.57981	16.8125	110.0219	4.023016
212	6	50	2	4	2017	33.4011	48.33423	18.8125	121.0188	3.539362
213	7	50	2	4	2017	36.3423	46.33535	20.6875	121.6397	4.214635
214	4	50	2	4	2017	34.13923	56.11109	16.625	103.2927	2.380104
215	5	0	2	4	2017	34.73061	49.76334	19.0625	115.6074	3.441883
216	3	0	2	4	2017	34.70004	45.81931	20.625	125.607	4.420577
217	10	0	2	4	2017	34.9637	49.01423	20.3125	117.0297	3.926029
218	11	0	2	4	2017	38.91165	54.15645	17.1875	100.6349	3.637517
219	1	0	2	4	2017	35.0839	44.7635	19.8125	127.9482	4.005945
220	14	0	2	4	2017	36.95771	47.18167	20.125	118.5126	3.997128
221	13	0	2	4	2017	33.87711	46.29612	18.8125	125.6014	3.973713
222	2	0	2	4	2017	32.58401	39.12977	18.1875	150.9992	4.932714
223	8	0	2	4	2017	34.0305	41.87542	21.125	138.5954	4.246879
224	9	0	2	4	2017	32.73004	48.45007	20.5625	121.7332	3.835539
225	12	0	2	4	2017	35.34335	46.23104	19.75	123.48	3.994953
226	6	0	2	4	2017	35.53443	45.84153	20.875	124.2271	4.012008
227	7	0	2	4	2017	34.61788	49.26434	21.125	116.9442	4.351617
228	4	0	2	4	2017	35.30655	48.6895	18.125	117.2999	2.488642

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
301	2	0	3	4	2017	30.70637	39.12712	0	154.4869	4.174988
302	13	0	3	4	2017	34.8687	43.31273	0	132.5939	3.583653
303	9	0	3	4	2017	34.26281	46.09606	0	125.5402	4.153387
304	4	0	3	4	2017	34.05208	50.78094	0	114.259	3.175058
305	12	0	3	4	2017	36.02568	46.32261	0	122.1685	4.495488
306	5	0	3	4	2017	34.65192	47.60627	0	120.9654	2.930718
307	6	0	3	4	2017	36.04061	51.88772	0	109.0447	4.892072
308	7	0	3	4	2017	35.15335	49.76224	0	114.9944	3.880637
309	3	0	3	4	2017	37.13056	49.03719	0	113.7728	4.004667
310	10	0	3	4	2017	34.30393	46.274	0	124.9931	3.792851
311	11	0	3	4	2017	34.75422	48.59527	0	118.351	4.184504
312	14	0	3	4	2017	32.37269	46.41711	0	127.6227	4.115664
313	8	0	3	4	2017	35.50703	43.46931	0	131.0522	3.921532
314	1	0	3	4	2017	34.11167	46.95277	0	123.4828	4.122063
315	2	50	3	4	2017	31.86401	41.68199	0	143.0051	4.113839
316	13	50	3	4	2017	31.93899	46.73117	0	127.4375	3.28482
317	9	50	3	4	2017	34.45223	45.14662	0	127.8763	4.79847
318	4	50	3	4	2017	40.97133	49.92968	0	106.1648	3.273013
319	12	50	3	4	2017	37.67484	52.49155	0	105.5342	4.690335
320	5	50	3	4	2017	35.17296	54.8678	0	104.268	4.162244
321	6	50	3	4	2017	34.20511	49.69367	0	116.5358	4.739851
322	7	50	3	4	2017	35.09052	48.63039	0	117.7644	4.237288
323	3	50	3	4	2017	35.23336	47.87239	0	119.4128	3.752649
324	10	50	3	4	2017	34.66184	45.98729	0	125.2084	4.535833
325	11	50	3	4	2017	35.77223	49.70854	0	114.2164	3.916292
326	14	50	3	4	2017	37.95028	51.96892	0	106.2115	4.082989
327	8	50	3	4	2017	36.1559	46.2444	0	122.171	3.99014
328	1	50	3	4	2017	38.19572	46.50802	0	118.3002	4.6628
401	4	50	4	4	2017	37.56632	57.77289	16.75	96.02288	3.08126
402	8	50	4	4	2017	36.41793	43.91634	18.9375	128.2151	4.614685

Plot	Treatment	Fertilizer (lb/acre)	Block	Cut	Year	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
403	14	50	4	4	2017	37.23692	45.50186	16.125	122.4431	4.922685
404	1	50	4	4	2017	34.39167	46.35738	19.75	124.6311	4.271918
405	13	50	4	4	2017	35.65771	51.62454	19	110.1381	3.955992
406	3	50	4	4	2017	34.88667	49.65991	19.1875	115.6204	4.7775
407	11	50	4	4	2017	33.25572	43.07601	19	136.036	4.498257
408	10	50	4	4	2017	30.81497	40.84395	22.5625	147.8005	4.134619
409	5	50	4	4	2017	35.12748	53.7889	19.8125	106.4207	3.674217
410	6	50	4	4	2017	35.8863	47.98262	20.4375	118.1524	4.20256
411	7	50	4	4	2017	33.98267	48.12186	18.25	120.6771	4.124632
412	9	50	4	4	2017	33.4132	44.73637	18.125	130.732	4.317031
413	2	50	4	4	2017	28.6057	43.12139	18.875	143.7071	4.110549
414	12	50	4	4	2017	33.10213	49.46732	18.9375	118.6848	4.232233
415	4	0	4	4	2017	38.04956	49.60272	19.0625	111.1331	2.398083
416	8	0	4	4	2017	31.1948	44.22176	19.1875	135.8886	3.693005
417	14	0	4	4	2017	34.83041	45.55213	20.1875	126.1363	3.828416
418	1	0	4	4	2017	35.57203	47.03942	16.6875	121.0057	3.457343
419	13	0	4	4	2017	33.67289	44.36767	21.9375	131.3943	3.524432
420	3	0	4	4	2017	31.1406	44.31985	19.3125	135.6765	3.915597
421	11	0	4	4	2017	33.02097	44.82843	20.5625	131.0976	4.032732
422	10	0	4	4	2017	32.25904	45.73086	20.125	129.7179	3.49701
423	5	0	4	4	2017	37.58517	52.13069	16.9375	106.3894	3.070675
424	6	0	4	4	2017	35.61046	43.78631	19.625	129.9322	3.676013
425	7	0	4	4	2017	34.40178	46.67964	19.375	123.755	4.094288
426	9	0	4	4	2017	30.39864	39.01855	21.5	155.4883	3.630653
427	2	0	4	4	2017	27.91157	39.19945	19.3125	159.3684	3.881804
428	12	0	4	4	2017	32.85144	46.52648	20.5	126.577	3.919472

Appendix B - Raw Data of Second Study (last fall cut in 2015, 2016 and 2017)

Plot	Variety	Date	Plant	Block	Cut	Yield (Mg/ha)
101	1	1	24	1	2015	3.696971
102	2	1	17	1	2015	3.923978
103	3	1	21	1	2015	3.324031
101	1	2	19	1	2015	3.194313
102	2	2	25	1	2015	3.259172
103	3	2	19	1	2015	3.78345
101	1	3	22	1	2015	3.680756
102	2	3	19	1	2015	2.502482
103	3	3	21	1	2015	3.134858
101	1	4	21	1	2015	3.183503
102	2	4	23	1	2015	3.35646
103	3	4	26	1	2015	2.62139
201	1	1	22	2	2015	1.589049
202	2	1	20	2	2015	2.172781
203	3	1	26	2	2015	2.837587
201	1	2	17	2	2015	2.475457
202	2	2	19	2	2015	3.415915
203	3	2	18	2	2015	2.956496
201	1	3	18	2	2015	2.264665
202	2	3	20	2	2015	2.383573
203	3	3	21	2	2015	2.680844
201	1	4	27	2	2015	2.043063
202	2	4	23	2	2015	2.340334
203	3	4	26	2	2015	1.572834
301	3	1	19	3	2015	1.924154
302	2	1	24	3	2015	1.91875
303	1	1	22	3	2015	1.691743
301	3	2	17	3	2015	3.021355
302	2	2	19	3	2015	3.04838
303	1	2	19	3	2015	4.086126

Plot	Variety	Date	Plant	Block	Cut	Yield (Mg/ha)
301	3	3	17	3	2015	2.021443
302	2	3	16	3	2015	1.670123
303	1	3	16	3	2015	2.464647
301	3	4	18	3	2015	1.924154
302	2	4	19	3	2015	2.345739
303	1	4	20	3	2015	1.702552
401	3	1	26	4	2015	2.064683
402	2	1	23	4	2015	2.864612
403	1	1	24	4	2015	2.907851
401	3	2	17	4	2015	3.178098
402	2	2	20	4	2015	4.405017
403	1	2	23	4	2015	5.24278
401	3	3	15	4	2015	1.929559
402	2	3	17	4	2015	2.118732
403	1	3	14	4	2015	1.756602
401	3	4	17	4	2015	2.188996
402	2	4	21	4	2015	2.151161
403	1	4	19	4	2015	2.297094
101	1	1	23	1	2016	3.534823
102	2	1	17	1	2016	3.459154
103	3	1	21	1	2016	2.702464
101	1	2	19	1	2016	4.226654
102	2	2	23	1	2016	3.815879
103	3	2	19	1	2016	4.4969
101	1	3	21	1	2016	4.642833
102	2	3	19	1	2016	4.053696
103	3	3	21	1	2016	3.664541
101	1	4	20	1	2016	2.788943
102	2	4	22	1	2016	2.734894
103	3	4	23	1	2016	3.167288

Plot	Variety	Date	Plant	Block	Cut	Yield (Mg/ha)
201	1	1	22	2	2016	2.416003
202	2	1	20	2	2016	2.572746
203	3	1	26	2	2016	2.432218
201	1	2	17	2	2016	3.432129
202	2	2	18	2	2016	5.140087
203	3	2	17	2	2016	5.61572
201	1	3	18	2	2016	3.161883
202	2	3	20	2	2016	4.918485
203	3	3	21	2	2016	2.459242
201	1	4	21	2	2016	2.043063
202	2	4	19	2	2016	2.853802
203	3	4	21	2	2016	2.129542
301	3	1	19	3	2016	2.956496
302	2	1	24	3	2016	3.237552
303	1	1	22	3	2016	3.788855
301	3	2	17	3	2016	6.410245
302	2	2	19	3	2016	3.632112
303	1	2	19	3	2016	3.37808
301	3	3	13	3	2016	3.918573
302	2	3	14	3	2016	5.226566
303	1	3	16	3	2016	4.383397
301	3	4	16	3	2016	2.913256
302	2	4	14	3	2016	2.497077
303	1	4	18	3	2016	2.243045
401	3	1	25	4	2016	5.031988
402	2	1	23	4	2016	4.296918
403	1	1	24	4	2016	3.469964
401	3	2	17	4	2016	3.183503
402	2	2	20	4	2016	4.826601
403	1	2	23	4	2016	4.14558

Plot	Variety	Date	Plant	Block	Cut	Yield (Mg/ha)
401	3	3	15	4	2016	2.416003
402	2	3	16	4	2016	3.437534
403	1	3	13	4	2016	2.437623
401	3	4	14	4	2016	3.080809
402	2	4	20	4	2016	2.502482
403	1	4	18	4	2016	2.464647
101	1	1	20	1	2017	2.032253
102	2	1	17	1	2017	0.999912
103	3	1	19	1	2017	1.026936
101	1	2	17	1	2017	1.956584
102	2	2	20	1	2017	2.659225
103	3	2	19	1	2017	2.172781
101	1	3	18	1	2017	2.221425
102	2	3	16	1	2017	2.697059
103	3	3	18	1	2017	1.356637
101	1	4	15	1	2017	1.394471
102	2	4	14	1	2017	1.707957
103	3	4	15	1	2017	1.616074
201	1	1	18	2	2017	1.394471
202	2	1	20	2	2017	1.086391
203	3	1	18	2	2017	1.010722
201	1	2	17	2	2017	2.097112
202	2	2	17	2	2017	1.540405
203	3	2	16	2	2017	1.89713
201	1	3	16	2	2017	1.389067
202	2	3	15	2	2017	1.626883
203	3	3	16	2	2017	2.048468
201	1	4	16	2	2017	1.816056
202	2	4	14	2	2017	2.026848
203	3	4	15	2	2017	1.951179

Plot	Variety	Date	Plant	Block	Cut	Yield (Mg/ha)
301	3	1	19	3	2017	0.891813
302	2	1	18	3	2017	1.372852
303	1	1	20	3	2017	0.805334
301	3	2	17	3	2017	1.880915
302	2	2	17	3	2017	1.945774
303	1	2	15	3	2017	2.243045
301	3	3	13	3	2017	1.934964
302	2	3	12	3	2017	1.91875
303	1	3	15	3	2017	1.837676
301	3	4	14	3	2017	1.880915
302	2	4	12	3	2017	1.610669
303	1	4	13	3	2017	1.626883
401	3	1	20	4	2017	1.043151
402	2	1	19	4	2017	1.10801
403	1	1	22	4	2017	1.318802
401	3	2	17	4	2017	1.756602
402	2	2	19	4	2017	1.648503
403	1	2	20	4	2017	1.929559
401	3	3	15	4	2017	1.307993
402	2	3	12	4	2017	1.91875
403	1	3	12	4	2017	1.248538
401	3	4	11	4	2017	1.48095
402	2	4	14	4	2017	1.410686
403	1	4	14	4	2017	1.670123

Appendix C - Raw Data of Second Study (first cut in 2016, 2017 and 2018)

Plot	Variety	Date	Plant	Block	Year	Yield (Mg/ha)
101	1	1	23	1	2016	3.102429
102	2	1	17	1	2016	4.069911
103	3	1	21	1	2016	3.805069
101	1	2	19	1	2016	4.367182
102	2	2	23	1	2016	3.605087
103	3	2	19	1	2016	4.264488
101	1	3	21	1	2016	4.329348
102	2	3	19	1	2016	4.448256
103	3	3	21	1	2016	4.345562
101	1	4	20	1	2016	7.853361
102	2	4	22	1	2016	8.31278
103	3	4	23	1	2016	3.324031
201	1	1	22	2	2016	9.718061
202	2	1	20	2	2016	7.13991
203	3	1	26	2	2016	7.215579
201	1	2	17	2	2016	12.67996
202	2	2	18	2	2016	8.161442
203	3	2	17	2	2016	8.150632
201	1	3	18	2	2016	7.404752
202	2	3	20	2	2016	7.134505
203	3	3	21	2	2016	7.734452
201	1	4	21	2	2016	7.280438
202	2	4	19	2	2016	6.842639
203	3	4	21	2	2016	6.442674
301	3	1	19	3	2016	6.750755
302	2	1	24	3	2016	9.972093
303	1	1	22	3	2016	8.588431
301	3	2	17	3	2016	7.453396
302	2	2	19	3	2016	7.350702
303	1	2	19	3	2016	8.377639

Plot	Variety	Date	Plant	Block	Year	Yield (Mg/ha)
301	3	3	13	3	2016	7.285843
302	2	3	14	3	2016	7.51285
303	1	3	16	3	2016	7.156125
301	3	4	16	3	2016	6.658872
302	2	4	14	3	2016	8.091178
303	1	4	18	3	2016	6.815614
401	3	1	25	4	2016	7.415562
402	2	1	23	4	2016	7.345297
403	1	1	24	4	2016	7.442586
401	3	2	17	4	2016	6.658872
402	2	2	20	4	2016	7.037217
403	1	2	23	4	2016	7.626354
401	3	3	15	4	2016	5.107657
402	2	3	16	4	2016	8.074963
403	1	3	13	4	2016	6.739945
401	3	4	14	4	2016	5.167111
402	2	4	20	4	2016	6.642657
403	1	4	18	4	2016	7.188555
101	1	1	20	1	2017	4.464471
102	2	1	17	1	2017	3.151073
103	3	1	20	1	2017	2.486267
101	1	2	17	1	2017	3.583467
102	2	2	22	1	2017	3.691566
103	3	2	19	1	2017	2.907851
101	1	3	18	1	2017	3.361865
102	2	3	16	1	2017	3.172693
103	3	3	20	1	2017	4.804981
101	1	4	15	1	2017	4.259083
102	2	4	14	1	2017	3.907763
103	3	4	16	1	2017	3.583467

Plot	Variety	Date	Plant	Block	Year	Yield (Mg/ha)
201	1	1	21	2	2017	4.199629
202	2	1	20	2	2017	3.302411
203	3	1	20	2	2017	1.535
201	1	2	17	2	2017	3.734805
202	2	2	17	2	2017	4.848221
203	3	2	16	2	2017	1.318802
201	1	3	16	2	2017	3.042975
202	2	3	15	2	2017	4.059101
203	3	3	17	2	2017	3.534823
201	1	4	16	2	2017	2.605175
202	2	4	14	2	2017	2.518697
203	3	4	15	2	2017	2.070088
301	3	1	19	3	2017	5.129277
302	2	1	21	3	2017	1.216109
303	1	1	20	3	2017	2.864612
301	3	2	17	3	2017	4.950914
302	2	2	17	3	2017	2.799753
303	1	2	15	3	2017	4.199629
301	3	3	13	3	2017	5.588696
302	2	3	12	3	2017	3.76183
303	1	3	15	3	2017	3.659136
301	3	4	14	3	2017	3.869929
302	2	4	12	3	2017	4.075316
303	1	4	13	3	2017	3.578062
401	3	1	21	4	2017	5.761653
402	2	1	19	4	2017	2.902446
403	1	1	22	4	2017	3.756425
401	3	2	17	4	2017	3.297006
402	2	2	19	4	2017	3.151073
403	1	2	20	4	2017	1.632288

Plot	Variety	Date	Plant	Block	Year	Yield (Mg/ha)
401	3	3	15	4	2017	3.242957
402	2	3	12	4	2017	3.934788
403	1	3	12	4	2017	3.097024
401	3	4	11	4	2017	3.183503
402	2	4	14	4	2017	2.356549
403	1	4	14	4	2017	2.99433
101	1	1	15	1	2018	3.351055
102	2	1	13	1	2018	3.41051
103	3	1	13	1	2018	2.334929
101	1	2	12	1	2018	2.783538
102	2	2	16	1	2018	2.66463
103	3	2	14	1	2018	3.053784
101	1	3	14	1	2018	2.853802
102	2	3	13	1	2018	2.59977
103	3	3	12	1	2018	2.437623
101	1	4	8	1	2018	1.989014
102	2	4	10	1	2018	2.253855
103	3	4	8	1	2018	2.124137
201	1	1	14	2	2018	3.280791
202	2	1	15	2	2018	2.588961
203	3	1	14	2	2018	3.42132
201	1	2	15	2	2018	2.540316
202	2	2	15	2	2018	3.605087
203	3	2	14	2	2018	3.124049
201	1	3	13	2	2018	3.864524
202	2	3	13	2	2018	2.98352
203	3	3	12	2	2018	3.3997
201	1	4	10	2	2018	2.734894
202	2	4	12	2	2018	3.286196
203	3	4	10	2	2018	2.497077

Plot	Variety	Date	Plant	Block	Year	Yield (Mg/ha)
301	3	1	13	3	2018	3.280791
302	2	1	17	3	2018	2.016038
303	1	1	15	3	2018	2.151161
301	3	2	15	3	2018	2.205211
302	2	2	15	3	2018	3.632112
303	1	2	12	3	2018	3.74021
301	3	3	11	3	2018	2.507887
302	2	3	11	3	2018	2.98352
303	1	3	12	3	2018	3.961812
301	3	4	9	3	2018	1.697147
302	2	4	11	3	2018	2.729489
303	1	4	10	3	2018	2.426813
401	3	1	13	4	2018	3.259172
402	2	1	14	4	2018	3.02676
403	1	1	13	4	2018	2.388978
401	3	2	14	4	2018	2.799753
402	2	2	16	4	2018	3.307816
403	1	2	14	4	2018	2.951091
401	3	3	12	4	2018	2.243045
402	2	3	11	4	2018	2.145757
403	1	3	11	4	2018	2.432218
401	3	4	9	4	2018	1.697147
402	2	4	12	4	2018	2.497077
403	1	4	11	4	2018	1.978204

Appendix D - Raw Data of Second Study (2016)

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
101	1	1	15-Sep	23	1	1	30.16673	39.43573	19.45901	154.2695	3.102429
102	2	1	15-Sep	17	1	1	35.26452	43.88934	17.84905	130.1984	4.069911
103	3	1	15-Sep	21	1	1	29.51358	39.60905	19.86053	154.7894	3.805069
101	1	2	30-Sep	19	1	1	33.72736	42.59053	17.7241	136.7842	4.367182
102	2	2	30-Sep	23	1	1	31.76559	41.18128	19.80802	144.9171	3.605087
103	3	2	30-Sep	19	1	1	27.75131	38.47234	20.59187	162.6822	4.264488
101	1	3	15-Oct	21	1	1	30.233	41.41597	18.79442	146.7775	4.329348
102	2	3	15-Oct	19	1	1	31.64741	39.25605	20.29828	152.2424	4.448256
103	3	3	15-Oct	21	1	1	28.87821	37.40642	17.91905	165.1349	4.345562
101	1	4	30-Oct	20	1	1	32.12797	40.91407	18.28414	145.2217	7.853361
102	2	4	30-Oct	22	1	1	30.51012	38.46027	18.6228	157.5352	8.31278
103	3	4	30-Oct	23	1	1	29.43794	36.76915	19.84949	166.8938	3.324031
201	1	1	15-Sep	22	2	1	33.30666	43.46497	0	134.7337	9.718061
202	2	1	15-Sep	20	2	1	35.36779	41.79805	0	136.5335	7.13991
203	3	1	15-Sep	26	2	1	27.55883	36.30294	0	172.788	7.215579
201	1	2	30-Sep	17	2	1	33.8384	44.12928	0	131.8323	12.67996
202	2	2	30-Sep	18	2	1	30.80749	43.61208	0	138.4318	8.161442
203	3	2	30-Sep	17	2	1	27.43501	37.27729	0	168.5124	8.150632
201	1	3	15-Oct	18	2	1	32.11003	39.35586	0	151.0044	7.404752
202	2	3	15-Oct	20	2	1	31.34305	44.43124	0	135.0061	7.134505
203	3	3	15-Oct	21	2	1	28.00766	37.85112	0	164.8614	7.734452
201	1	4	30-Oct	21	2	1	29.04391	39.78057	0	154.9776	7.280438
202	2	4	30-Oct	19	2	1	35.37383	39.88568	0	143.0688	6.842639
203	3	4	30-Oct	21	2	1	27.39877	35.48524	0	177.0965	6.442674
301	3	1	15-Sep	19	3	1	29.93111	38.44259	17.61229	158.6991	6.750755
302	2	1	15-Sep	24	3	1	31.7255	39.19518	19.30388	152.3344	9.972093
303	1	1	15-Sep	22	3	1	31.97488	41.58512	15.71616	143.145	8.588431
301	3	2	30-Sep	17	3	1	27.47944	35.88274	19.04189	174.9718	7.453396
302	2	2	30-Sep	19	3	1	34.26582	45.03199	17.73984	128.5018	7.350702
303	1	2	30-Sep	19	3	1	30.62827	38.58602	19.27083	156.8	8.377639

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
301	3	3	15-Oct	13	3	1	26.99289	35.71494	19.58542	176.781	7.285843
302	2	3	15-Oct	14	3	1	32.4005	39.1458	21.65835	151.2771	7.51285
303	1	3	15-Oct	16	3	1	29.24492	38.23398	19.13872	160.8656	7.156125
301	3	4	30-Oct	16	3	1	29.03108	35.37858	21.00944	174.287	6.658872
302	2	4	30-Oct	14	3	1	32.47609	39.90476	20.05439	148.2626	8.091178
303	1	4	30-Oct	18	3	1	29.51461	39.47035	19.17494	155.3315	6.815614
401	3	1	15-Sep	25	4	1	27.77975	37.46452	19.85274	167.0035	7.415562
402	2	1	15-Sep	23	4	1	31.06739	39.04756	20.01971	154.1317	7.345297
403	1	1	15-Sep	24	4	1	28.68079	39.59085	21.42419	156.3849	7.442586
401	3	2	30-Sep	17	4	1	26.42436	37.16634	21.76027	170.986	6.658872
402	2	2	30-Sep	20	4	1	31.1331	41.88192	20.84139	143.5871	7.037217
403	1	2	30-Sep	23	4	1	30.00636	41.8322	20.65748	145.7096	7.626354
401	3	3	15-Oct	15	4	1	27.0335	35.19309	20.76281	179.3188	5.107657
402	2	3	15-Oct	16	4	1	32.80882	37.88923	20.7703	155.5131	8.074963
403	1	3	15-Oct	13	4	1	31.06334	37.99358	19.31623	158.4151	6.739945
401	3	4	30-Oct	14	4	1	25.7524	35.27155	20.36393	181.5519	5.167111
402	2	4	30-Oct	20	4	1	33.11305	40.24097	19.23389	145.8768	6.642657
403	1	4	30-Oct	18	4	1	30.11972	37.41785	20.98094	162.6801	7.188555
101	1	1	15-Sep	23	1	2	34.22058	44.0784	17.32512	131.3562	1.043151
102	2	1	15-Sep	17	1	2	34.5748	45.32603	16.65163	127.1742	3.253767
103	3	1	15-Sep	21	1	2	30.61575	39.98534	16.1086	151.3353	3.540228
101	1	2	30-Sep	19	1	2	35.92248	42.84238	16.42152	132.2672	2.232235
102	2	2	30-Sep	23	1	2	35.84795	45.07476	15.368	125.8363	4.350967
103	3	2	30-Sep	19	1	2	30.56032	38.64765	21.5289	156.6773	4.89146
101	1	3	15-Oct	21	1	2	34.85968	40.3762	18.23324	142.2535	1.124225
102	2	3	15-Oct	19	1	2	36.51042	42.1123	18.07999	133.5485	3.199718
103	3	3	15-Oct	21	1	2	31.8845	40.28621	17.49268	147.9229	4.54014
101	1	4	30-Oct	20	1	2	32.63561	43.04946	20.03616	137.1637	1.313398
102	2	4	30-Oct	22	1	2	33.07054	40.9854	20.02431	143.3024	3.669946
103	3	4	30-Oct	23	1	2	30.74088	37.22306	15.26858	162.3221	5.123872

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
201	1	1	15-Sep	22	2	2	32.86977	43.74613	0	134.5915	3.486179
202	2	1	15-Sep	20	2	2	35.66574	43.23685	0	131.4908	3.237552
203	3	1	15-Sep	26	2	2	32.81189	38.87203	0	151.5756	1.329612
201	1	2	30-Sep	17	2	2	32.6049	43.38226	0	136.1628	2.945686
202	2	2	30-Sep	18	2	2	35.55612	42.07763	0	135.302	4.588784
203	3	2	30-Sep	17	2	2	27.67977	38.93619	0	160.8773	2.183591
201	1	3	15-Oct	18	2	2	30.97101	41.83807	0	144.0183	2.870017
202	2	3	15-Oct	20	2	2	33.67977	42.89217	0	135.9026	4.107745
203	3	3	15-Oct	21	2	2	26.18399	36.84371	0	172.956	0.978292
201	1	4	30-Oct	21	2	2	34.49291	40.48153	0	142.5399	3.167288
202	2	4	30-Oct	19	2	2	32.80982	42.75593	0	137.8101	4.194224
203	3	4	30-Oct	21	2	2	27.48538	37.943	0	165.4597	2.65382
301	3	1	15-Sep	19	3	2	28.84274	39.17362	18.65417	157.7509	5.129277
302	2	1	15-Sep	24	3	2	35.02248	46.10993	16.9995	124.3086	6.875069
303	1	1	15-Sep	22	3	2	32.71876	39.13964	18.25695	150.7116	1.399876
301	3	2	30-Sep	17	3	2	30.77382	38.70156	19.98653	156.0593	4.021267
302	2	2	30-Sep	19	3	2	35.21739	45.40691	16.36948	125.9221	4.961724
303	1	2	30-Sep	19	3	2	31.37966	41.85121	16.51653	143.2656	1.556619
301	3	3	15-Oct	13	3	2	30.0674	39.26593	16.57345	155.12	3.723996
302	2	3	15-Oct	14	3	2	35.26171	44.90347	14.47297	127.2624	3.983432
303	1	3	15-Oct	16	3	2	30.7062	41.27046	18.6792	146.464	1.280968
301	3	4	30-Oct	16	3	2	30.66023	38.40805	15.87713	157.4662	4.091531
302	2	4	30-Oct	14	3	2	33.76908	40.18333	15.21689	144.9031	3.832094
303	1	4	30-Oct	18	3	2	34.77385	42.72188	17.4629	134.5886	0.897218
401	3	1	15-Sep	25	4	2	30.67903	39.75221	16.49557	152.1075	5.204946
402	2	1	15-Sep	23	4	2	35.72355	43.66032	14.7201	130.1194	4.037481
403	1	1	15-Sep	24	4	2	32.18658	41.02983	20.20486	144.7084	0.540493
401	3	2	30-Sep	17	4	2	31.7384	40.61613	17.58433	146.982	3.188908
402	2	2	30-Sep	20	4	2	35.06474	45.28154	16.71409	126.5151	3.999647
403	1	2	30-Sep	23	4	2	31.95239	41.70494	15.70866	142.7729	4.394207

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
401	3	3	15-Oct	15	4	2	25.54397	36.13393	17.26161	177.6369	3.269982
402	2	3	15-Oct	16	4	2	33.58514	40.37684	16.0855	144.5387	3.324031
403	1	3	15-Oct	13	4	2	32.3346	40.94959	18.05974	144.7301	3.059189
401	3	4	30-Oct	14	4	2	28.92744	37.04674	14.52972	166.6418	3.086214
402	2	4	30-Oct	20	4	2	32.99882	46.47547	13.90894	126.4862	3.869929
403	1	4	30-Oct	18	4	2	31.14705	40.21327	17.28062	149.5201	3.042975
101	1	1	15-Sep	23	1	3	35.93752	43.68183	13.82161	129.7004	1.805246
102	2	1	15-Sep	17	1	3	36.14334	44.42227	15.04625	127.2028	3.848309
103	3	1	15-Sep	21	1	3	32.04637	40.0475	16.45841	148.5117	4.983344
101	1	2	30-Sep	19	1	3	31.80342	41.46963	21.40084	143.8433	1.821461
102	2	2	30-Sep	23	1	3	36.6894	45.06003	16.59732	124.5242	2.805158
103	3	2	30-Sep	19	1	3	30.84125	43.02838	16.33026	140.2528	4.934699
101	1	3	15-Oct	21	1	3	31.03553	42.51695	17.34525	141.6088	1.999823
102	2	3	15-Oct	19	1	3	33.12127	40.18732	18.3757	146.0568	3.313221
103	3	3	15-Oct	21	1	3	30.81699	39.42641	16.66799	153.1108	3.205122
101	1	4	30-Oct	20	1	3	33.59464	42.65933	18.61117	136.789	2.405193
102	2	4	30-Oct	22	1	3	35.56565	41.37323	17.7923	137.5889	3.107834
103	3	4	30-Oct	23	1	3	29.06506	40.94835	19.76588	150.5205	3.318626
201	1	1	15-Sep	22	2	3	35.94348	41.5991	0	136.1837	3.983432
202	2	1	15-Sep	20	2	3	36.53388	44.03841	0	127.6689	1.751197
203	3	1	15-Sep	26	2	3	32.59613	40.66372	0	145.2815	4.037481
201	1	2	30-Sep	17	2	3	35.00009	45.24135	0	126.731	3.572658
202	2	2	30-Sep	18	2	3	35.39078	42.67493	0	133.689	1.924154
203	3	2	30-Sep	17	2	3	31.74455	39.83077	0	149.8689	3.805069
201	1	3	15-Oct	18	2	3	33.27131	43.05883	0	136.064	3.42132
202	2	3	15-Oct	20	2	3	35.04344	45.00999	0	127.3126	1.826866
203	3	3	15-Oct	21	2	3	30.72304	39.57328	0	152.7146	4.675263
201	1	4	30-Oct	21	2	3	35.70926	43.31975	0	131.1663	3.140263
202	2	4	30-Oct	19	2	3	34.14002	42.69064	0	135.7629	2.053873
203	3	4	30-Oct	21	2	3	31.01572	41.41533	0	145.4102	4.54014

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
301	3	1	15-Sep	19	3	3	31.85646	40.50893	15.94028	147.1598	3.38889
302	2	1	15-Sep	24	3	3	35.66565	46.15849	18.24739	123.1681	1.610669
303	1	1	15-Sep	22	3	3	32.76996	44.69718	19.45252	131.8895	3.810474
301	3	2	30-Sep	17	3	3	29.12597	38.92689	21.36881	158.2236	3.42132
302	2	2	30-Sep	19	3	3	33.09752	42.67072	20.9362	137.5967	2.551126
303	1	2	30-Sep	19	3	3	32.29567	40.95414	22.14232	144.7829	3.405105
301	3	3	15-Oct	13	3	3	29.99656	40.44091	16.78648	150.74	2.529506
302	2	3	15-Oct	14	3	3	32.01078	43.35486	20.40204	137.2419	2.253855
303	1	3	15-Oct	16	3	3	33.40047	41.03053	20.58902	142.5621	3.107834
301	3	4	30-Oct	16	3	3	30.74257	40.05002	17.80958	150.8614	3.361865
302	2	4	30-Oct	14	3	3	33.92629	43.84522	19.04973	132.5411	2.394383
303	1	4	30-Oct	18	3	3	34.1107	40.90387	19.58571	141.7453	3.221337
401	3	1	15-Sep	25	4	3	27.27185	41.20418	21.58412	152.7396	4.080721
402	2	1	15-Sep	23	4	3	34.97716	44.8933	18.30852	127.7506	2.772728
403	1	1	15-Sep	24	4	3	36.39779	43.2741	18.65952	130.1517	3.075404
401	3	2	30-Sep	17	4	3	31.2841	40.9457	15.15236	146.603	3.151073
402	2	2	30-Sep	20	4	3	35.92184	42.80121	15.89875	132.3955	3.799665
403	1	2	30-Sep	23	4	3	34.88939	40.10657	16.67127	143.1562	3.215932
401	3	3	15-Oct	15	4	3	31.56457	39.5949	17.73273	151.0911	2.702464
402	2	3	15-Oct	16	4	3	34.56972	41.29852	13.50179	139.5853	4.188819
403	1	3	15-Oct	13	4	3	32.9759	43.81716	20.82571	134.1978	2.740299
401	3	4	30-Oct	14	4	3	29.80916	40.45944	18.86396	151.0066	3.113239
402	2	4	30-Oct	20	4	3	33.44251	42.54948	21.34124	137.4013	2.378168
403	1	4	30-Oct	18	4	3	33.39006	42.47308	20.26288	137.7379	2.751108
101	1	1	15-Sep	23	1	4	33.72069	46.24681	19.27795	125.9804	3.534823
102	2	1	15-Sep	17	1	4	32.63125	44.97468	16.4982	131.2992	3.459154
103	3	1	15-Sep	21	1	4	31.6833	40.72656	18.72933	146.6815	2.702464
101	1	2	30-Sep	19	1	4	35.47814	45.3401	16.38897	125.6909	4.226654
102	2	2	30-Sep	23	1	4	34.65017	46.0825	17.91065	124.968	3.815879
103	3	2	30-Sep	19	1	4	31.18861	40.17209	15.46443	149.5984	4.4969

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
101	1	3	15-Oct	21	1	4	35.85845	46.28943	16.55025	122.5178	4.642833
102	2	3	15-Oct	19	1	4	37.11232	47.85471	15.52244	116.6117	4.053696
103	3	3	15-Oct	21	1	4	31.67248	42.17013	18.12049	141.6789	3.664541
101	1	4	30-Oct	20	1	4	37.94078	46.14057	14.3969	119.6428	2.788943
102	2	4	30-Oct	22	1	4	37.98551	44.38501	15.313	124.3019	2.734894
103	3	4	30-Oct	23	1	4	32.82154	41.89812	16.67491	140.6113	3.167288
201	1	1	15-Sep	22	2	4	31.85985	44.49452	0	133.9725	2.416003
202	2	1	15-Sep	20	2	4	30.87533	45.75644	0	131.8368	2.572746
203	3	1	15-Sep	26	2	4	28.69708	41.91432	0	147.6877	2.432218
201	1	2	30-Sep	17	2	4	33.79508	43.58005	0	133.5658	3.432129
202	2	2	30-Sep	18	2	4	35.74736	45.0692	0	126.0136	5.140087
203	3	2	30-Sep	17	2	4	31.71767	41.01707	0	145.5819	5.61572
201	1	3	15-Oct	18	2	4	34.11302	45.43344	0	127.61	3.161883
202	2	3	15-Oct	20	2	4	35.0082	45.3449	0	126.4287	4.918485
203	3	3	15-Oct	21	2	4	32.14285	42.08932	0	141.1411	2.459242
201	1	4	30-Oct	21	2	4	35.16438	42.27208	0	135.3512	2.043063
202	2	4	30-Oct	19	2	4	39.16592	49.23301	0	110.3245	2.853802
203	3	4	30-Oct	21	2	4	32.9298	42.67915	0	137.8543	2.129542
301	3	1	15-Sep	19	3	4	29.12744	41.91856	19.9201	146.9288	2.956496
302	2	1	15-Sep	24	3	4	35.81715	46.1296	17.82833	123.0072	3.237552
303	1	1	15-Sep	22	3	4	36.11799	42.3994	18.16854	133.3149	3.788855
301	3	2	30-Sep	17	3	4	30.68063	37.78296	17.989	160.0322	6.410245
302	2	2	30-Sep	19	3	4	37.60136	49.99459	15.22941	110.9116	3.632112
303	1	2	30-Sep	19	3	4	34.90046	43.05711	19.55172	133.3276	3.37808
301	3	3	15-Oct	13	3	4	31.3218	38.07498	21.31021	157.5846	3.918573
302	2	3	15-Oct	14	3	4	37.19377	46.17912	14.54424	120.7151	5.226566
303	1	3	15-Oct	16	3	4	36.04569	45.35549	17.45361	124.7415	4.383397
301	3	4	30-Oct	16	3	4	33.52222	42.21536	13.08914	138.3519	2.913256
302	2	4	30-Oct	14	3	4	37.6368	45.01782	16.94828	123.116	2.497077
303	1	4	30-Oct	18	3	4	34.35947	41.3302	17.22116	139.847	2.243045

Plot	Variety	Fall cut	Date	Plant	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
401	3	1	15-Sep	25	4	4	29.28823	39.86887	17.72714	154.1903	5.031988
402	2	1	15-Sep	23	4	4	36.09901	45.63823	17.16915	123.884	4.296918
403	1	1	15-Sep	24	4	4	38.49467	48.35477	17.80947	113.3342	3.469964
401	3	2	30-Sep	17	4	4	29.52597	40.67271	20.44966	150.7194	3.183503
402	2	2	30-Sep	20	4	4	35.62328	47.21084	15.7906	120.4876	4.826601
403	1	2	30-Sep	23	4	4	33.77774	43.17709	20.31541	134.8414	4.14558
401	3	3	15-Oct	15	4	4	30.9346	41.58732	21.14303	144.9501	2.416003
402	2	3	15-Oct	16	4	4	37.1931	43.74422	18.76769	127.4355	3.437534
403	1	3	15-Oct	13	4	4	38.48562	47.06765	16.38069	116.4473	2.437623
401	3	4	30-Oct	14	4	4	31.30456	42.04749	16.38734	142.7262	3.080809
402	2	4	30-Oct	20	4	4	37.78592	47.68515	15.12024	116.0027	2.502482
403	1	4	30-Oct	18	4	4	36.38044	43.74164	18.32188	128.7893	2.464647

Appendix E - Raw Data of Second Study (2017)

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
101	1	1	1	1	31.70581	43.49216	23.125	137.3168	4.464471
102	2	1	1	1	34.67344	41.78858	22.5	137.7686	3.151073
103	3	1	1	1	27.63619	35.10838	22.6875	178.5074	2.486267
101	1	2	1	1	33.10088	44.68257	23.0625	131.396	3.583467
102	2	2	1	1	34.01988	44.06841	23.25	131.7159	3.691566
103	3	2	1	1	26.73763	36.91892	22.25	171.517	2.907851
101	1	3	1	1	32.30312	43.10162	21.625	137.5567	3.361865
102	2	3	1	1	34.50288	42.87808	19.6875	134.5562	3.172693
103	3	3	1	1	31.12539	38.10649	21.375	157.8278	4.804981
101	1	4	1	1	34.08438	43.53717	20.125	133.2158	4.259083
102	2	4	1	1	36.28762	44.38676	17.75	127.069	3.907763
103	3	4	1	1	29.36114	37.53152	22	163.652	3.583467
201	1	1	2	1	34.98149	43.29679	0	132.4539	4.199629
202	2	1	2	1	34.47855	42.55595	0	135.6162	3.302411
203	3	1	2	1	28.18934	36.78504	0	169.2814	1.535
201	1	2	2	1	28.32405	41.83748	0	148.6051	3.734805
202	2	2	2	1	34.59285	40.44125	0	142.5028	4.848221
203	3	2	2	1	21.16957	35.51376	0	189.6648	1.318802
201	1	3	2	1	34.47539	45.77284	0	126.0901	3.042975
202	2	3	2	1	35.37123	43.28962	0	131.8234	4.059101
203	3	3	2	1	28.50562	38.6659	0	160.4542	3.534823
201	1	4	2	1	26.05346	41.30617	0	154.4999	2.605175
202	2	4	2	1	30.47778	42.30929	0	143.2591	2.518697
203	3	4	2	1	25.44957	38.34675	0	167.5647	2.070088
301	3	1	3	1	29.17379	35.75808	21.1875	172.1481	5.129277
302	2	1	3	1	31.70465	44.97234	20.625	132.7991	1.216109
303	1	1	3	1	33.64145	40.4095	24.1875	144.3209	2.864612
301	3	2	3	1	30.92571	38.19217	21.0625	157.8526	4.950914
302	2	2	3	1	26.554	43.13384	17.8125	147.1125	2.799753
303	1	2	3	1	29.54554	40.69611	24	150.5979	4.199629

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
301	3	3	3	1	27.22887	37.74944	20.625	166.8005	5.588696
302	2	3	3	1	28.63096	41.52295	20.625	149.1951	3.76183
303	1	3	3	1	30.99662	41.22215	20.375	146.1252	3.659136
301	3	4	3	1	27.00389	37.92045	21.9375	166.4782	3.869929
302	2	4	3	1	33.04634	40.69184	22.9375	144.3793	4.075316
303	1	4	3	1	32.804	40.77493	24.5625	144.5158	3.578062
401	3	1	4	1	26.93929	38.06244	25.3125	165.9801	5.761653
402	2	1	4	1	33.28071	41.82342	22.25	140.0669	2.902446
403	1	1	4	1	34.43406	42.56755	20.3125	135.655	3.756425
401	3	2	4	1	23.44395	34.66982	26.1875	189.5279	3.297006
402	2	2	4	1	30.20678	43.18086	24.8125	140.8223	3.151073
403	1	2	4	1	34.59371	39.37658	21.3125	146.3543	1.632288
401	3	3	4	1	26.48717	36.74956	24.4375	172.8013	3.242957
402	2	3	4	1	30.72235	43.43074	23.75	139.1519	3.934788
403	1	3	4	1	32.84178	43.30197	21.4375	136.0189	3.097024
401	3	4	4	1	25.98476	38.17951	24.25	167.2829	3.183503
402	2	4	4	1	34.62521	43.59723	23.875	132.1333	2.356549
403	1	4	4	1	31.76634	40.12778	25.125	148.7203	2.99433
101	1	1	1	2	30.23596	38.26005	31.6875	158.8789	4.756337
102	2	1	1	2	31.34678	43.1262	26	139.0853	4.188819
103	3	1	1	2	26.54329	37.21918	28.125	170.5117	3.832094
101	1	2	1	2	27.02871	38.98321	27.875	161.8935	3.821284
102	2	2	1	2	35.93361	40.66641	26.0625	139.3247	3.459154
103	3	2	1	2	24.9659	37.41161	26.4375	172.69	3.999647
101	1	3	1	2	31.38091	40.36944	27.3125	148.5219	3.480774
102	2	3	1	2	32.38792	41.42607	20.625	142.9721	3.059189
103	3	3	1	2	26.30836	34.78086	31.1875	182.9549	2.988925
101	1	4	1	2	31.22729	42.31537	28.375	141.955	2.216021
102	2	4	1	2	32.49677	42.38227	26.5	139.5604	3.78345
103	3	4	1	2	26.32844	43.68832	24.9375	145.6196	3.156478

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
201	1	1	2	2	29.65751	39.81815	0	153.7146	2.145757
202	2	1	2	2	30.11789	42.04003	0	144.797	2.416003
203	3	1	2	2	25.96287	37.14128	0	172.0018	2.25926
201	1	2	2	2	28.0885	39.16251	0	159.1913	2.870017
202	2	2	2	2	34.19288	42.04187	0	137.7669	3.3997
203	3	2	2	2	24.39997	36.9746	0	175.8402	3.091619
201	1	3	2	2	33.18038	40.21792	0	145.8391	3.210527
202	2	3	2	2	32.5184	41.16035	0	143.6654	3.02676
203	3	3	2	2	25.945	37.42555	0	170.7299	2.783538
201	1	4	2	2	30.66916	39.38876	0	153.5292	2.64301
202	2	4	2	2	34.55703	42.24918	0	136.4663	2.340334
203	3	4	2	2	26.51191	35.4527	0	179.0718	2.351144
301	3	1	3	2	25.60315	35.11752	26.875	182.6562	2.778133
302	2	1	3	2	32.8977	44.98363	25.9375	130.8439	3.394295
303	1	1	3	2	30.01881	39.70931	27.9375	153.4766	4.118555
301	3	2	3	2	27.57714	36.96405	23.875	169.6618	2.988925
302	2	2	3	2	33.27646	41.68661	23.25	140.534	2.702464
303	1	2	3	2	30.40222	38.6783	26.75	156.8494	3.307816
301	3	3	3	2	24.95831	35.63263	27.9375	181.3271	2.134947
302	2	3	3	2	32.94386	40.56568	20.9375	145.0114	2.940281
303	1	3	3	2	31.45707	40.10591	27.1875	149.3602	3.297006
301	3	4	3	2	27.67239	37.12832	29.375	168.7253	2.124137
302	2	4	3	2	33.22536	42.10718	27	139.2182	2.805158
303	1	4	3	2	31.34055	40.16389	30.8125	149.3548	2.388978
401	3	1	4	2	26.90146	37.70238	28.875	167.638	2.837587
402	2	1	4	2	32.0547	43.06979	28.0625	138.0763	2.99433
403	1	1	4	2	31.96471	38.31947	29.0625	155.3633	2.394383
401	3	2	4	2	24.16248	39.56734	31.1875	164.7528	2.556531
402	2	2	4	2	34.28649	41.74506	25.875	138.5839	3.194313
403	1	2	4	2	29.10335	43.43802	26.75	141.8294	1.664718

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
401	3	3	4	2	25.14434	35.99966	28.5	179.1039	2.605175
402	2	3	4	2	33.53824	42.21412	27.375	138.3285	2.815968
403	1	3	4	2	30.18235	40.20388	26.625	151.2939	2.475457
401	3	4	4	2	24.53229	36.78927	29.9375	176.4654	2.853802
402	2	4	4	2	33.87163	42.87535	28.375	135.6317	2.264665
403	1	4	4	2	29.78519	39.83214	26.8125	153.4284	2.064683
101	1	1	1	3	31.74371	39.64706	25.3125	150.5649	3.767235
102	2	1	1	3	32.52058	42.0027	25.375	140.7805	2.61058
103	3	1	1	3	25.72282	39.08787	26.8125	163.881	2.907851
101	1	2	1	3	33.82703	39.64716	24.625	146.7567	3.345651
102	2	2	1	3	32.71211	44.35944	22.0625	132.9882	3.156478
103	3	2	1	3	25.41437	35.3623	27.0625	181.7787	1.951179
101	1	3	1	3	31.75992	40.98827	24.8125	145.6095	1.832271
102	2	3	1	3	33.61362	43.19127	26.25	135.0725	2.443028
103	3	3	1	3	25.41624	37.49409	26.5	171.4397	1.702552
101	1	4	1	3	30.41836	39.90246	27.25	152.0081	2.059278
102	2	4	1	3	32.31867	43.71188	23.8125	135.6105	2.594366
103	3	4	1	3	27.80972	38.81663	30.8125	161.1302	3.03757
201	1	1	2	3	30.35136	39.04863	0	155.4562	1.913345
202	2	1	2	3	33.01106	43.69368	0	134.5187	2.513292
203	3	1	2	3	26.84085	38.11836	0	165.9238	2.670035
201	1	2	2	3	31.36841	39.5218	0	151.7302	3.361865
202	2	2	2	3	32.2632	40.15828	0	147.7108	2.891637
203	3	2	2	3	28.38955	37.66478	0	164.9423	2.475457
201	1	3	2	3	32.91244	39.80897	0	147.8251	2.28088
202	2	3	2	3	34.78341	41.19365	0	139.5648	3.064594
203	3	3	2	3	26.51101	34.36157	0	184.76	2.086302
201	1	4	2	3	32.92674	42.93535	0	137.0369	1.718767
202	2	4	2	3	33.23864	43.88603	0	133.5533	1.443116
203	3	4	2	3	25.70976	39.6921	0	161.4101	2.588961

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
301	3	1	3	3	26.40551	36.96953	25	171.9332	2.151161
302	2	1	3	3	32.979	43.86753	25.5625	134.0386	2.778133
303	1	1	3	3	31.34434	42.87386	27.8125	139.908	3.567253
301	3	2	3	3	25.24932	35.7684	25.3125	180.0492	2.740299
302	2	2	3	3	32.604	43.10925	26.625	137.0266	3.723996
303	1	2	3	3	30.48146	41.2519	24.5625	146.9247	3.426724
301	3	3	3	3	26.80712	37.09707	24.375	170.5576	2.529506
302	2	3	3	3	32.12253	43.08594	27.625	137.9105	2.475457
303	1	3	3	3	29.77194	40.81513	25.75	149.7567	2.480862
301	3	4	3	3	27.18548	36.86176	24.75	170.9026	2.826777
302	2	4	3	3	32.52786	43.14829	25.75	137.0305	2.605175
303	1	4	3	3	31.28119	40.93192	32.875	146.6575	2.410598
401	3	1	4	3	25.36825	37.75762	29.5625	170.3353	2.864612
402	2	1	4	3	31.47779	43.7633	23.25	136.8436	2.578151
403	1	1	4	3	30.05408	39.29275	27.375	155.0387	2.378168
401	3	2	4	3	25.2108	35.73002	29.25	180.3207	1.594454
402	2	2	4	3	32.55275	41.61578	25.3125	142.0334	2.626795
403	1	2	4	3	30.34155	40.81352	28.5	148.7513	1.978204
401	3	3	4	3	27.33238	36.76497	24.1875	171.0629	1.626883
402	2	3	4	3	34.26633	42.81586	28.0625	135.1521	2.178186
403	1	3	4	3	34.50468	41.77036	26.25	138.1214	2.026848
401	3	4	4	3	26.63835	36.65142	28.1875	172.9651	2.199806
402	2	4	4	3	33.67726	44.67483	26.125	130.4838	2.032253
403	1	4	4	3	29.23333	41.11657	26.75	149.6081	2.524101
101	1	1	1	4	31.33269	41.44605	26.3125	144.7482	4.491495
102	2	1	1	4	33.37117	43.93849	22.9375	133.1753	4.734717
103	3	1	1	4	24.013	37.30002	25.875	175.0579	5.015773
101	1	2	1	4	31.85485	40.62681	22.25	146.7357	4.340157
102	2	2	1	4	30.88399	43.33762	25.1875	139.1806	4.88065
103	3	2	1	4	28.85741	39.24405	22.6875	157.4407	2.275475

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
101	1	3	1	4	32.8011	39.36603	25.8125	149.6933	3.945598
102	2	3	1	4	32.01305	44.03501	25.375	135.1184	3.324031
103	3	3	1	4	27.03193	35.98781	24.25	175.3621	3.275387
101	1	4	1	4	31.52138	42.75085	25	140.0105	2.605175
102	2	4	1	4	33.13791	42.80848	26.125	137.0856	2.848397
103	3	4	1	4	27.18165	38.22596	22.375	164.8107	3.042975
201	1	1	2	4	32.94184	41.37056	0	142.1937	3.280791
202	2	1	2	4	31.5424	43.11363	0	138.797	3.194313
203	3	1	2	4	26.93182	35.94883	0	175.754	3.491584
201	1	2	2	4	31.9304	41.34906	0	144.0402	3.626707
202	2	2	2	4	32.80573	42.17432	0	139.7176	3.76183
203	3	2	2	4	25.40033	35.62482	0	180.4677	4.534735
201	1	3	2	4	29.26656	40.83732	0	150.5721	3.04838
202	2	3	2	4	35.57068	45.08939	0	126.2411	3.475369
203	3	3	2	4	27.1615	36.86755	0	170.9228	3.36727
201	1	4	2	4	29.52517	41.91722	0	146.2459	2.913256
202	2	4	2	4	34.48658	40.77187	0	141.5361	2.210616
203	3	4	2	4	29.53302	37.1006	0	165.2171	3.102429
301	3	1	3	4	26.34009	38.46894	26.25	165.355	3.972622
302	2	1	3	4	33.5766	43.84196	25.4375	133.129	3.151073
303	1	1	3	4	31.35421	41.34962	30.625	145.048	4.307728
301	3	2	3	4	28.16083	38.34127	28.75	162.4644	2.924066
302	2	2	3	4	34.09391	43.33928	25.0625	133.8082	4.723907
303	1	2	3	4	31.15283	43.11979	26.375	139.4319	3.259172
301	3	3	3	4	28.18103	38.02818	23.5	163.7635	3.626707
302	2	3	3	4	31.02885	43.80069	28.5625	137.4695	2.578151
303	1	3	3	4	31.30576	42.53729	27.1875	141.0807	2.399788
301	3	4	3	4	29.1029	39.21042	22.4375	157.1221	1.902535
302	2	4	3	4	32.16603	42.38054	26.625	140.1316	2.28088
303	1	4	3	4	34.27345	42.49375	22.75	136.1645	2.475457

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
401	3	1	4	4	26.13273	35.12669	28.5	181.516	2.864612
402	2	1	4	4	33.47286	41.80728	26.9375	139.7879	2.756513
403	1	1	4	4	30.41077	41.33463	29.3125	146.7546	3.453749
401	3	2	4	4	25.17067	35.29257	29.6875	182.6382	3.134858
402	2	2	4	4	33.95562	46.42115	26.375	125.1406	3.091619
403	1	2	4	4	31.2649	40.2818	26.0625	149.0537	2.507887
401	3	3	4	4	29.91951	38.63315	21.3125	157.9381	2.583556
402	2	3	4	4	34.87079	44.6282	22.1875	128.6821	2.826777
403	1	3	4	4	35.16255	41.62162	22.4375	137.4696	2.216021
401	3	4	4	4	29.39136	40.27621	27.0625	152.4453	2.707869
402	2	4	4	4	36.62371	45.6487	20.375	123.0227	3.124049
403	1	4	4	4	32.3194	42.33978	26.9375	140.004	2.686249
101	1	1	1	5	26.18993	36.07775	34.6875	176.6161	2.032253
102	2	1	1	5	26.14578	37.62538	34.125	169.4364	0.999912
103	3	1	1	5	23.18814	34.93387	35.375	188.626	1.026936
101	1	2	1	5	26.24798	36.66045	27.5625	173.6941	1.956584
102	2	2	1	5	29.97602	37.73906	25.375	161.5714	2.659225
103	3	2	1	5	23.99243	35.08669	27.375	186.1433	2.172781
101	1	3	1	5	27.82066	38.19826	25.6875	163.718	2.221425
102	2	3	1	5	30.09217	40.52432	23.625	150.2588	2.697059
103	3	3	1	5	24.70586	35.87782	26.5625	180.5978	1.356637
101	1	4	1	5	28.73988	36.82005	24.125	168.0369	1.394471
102	2	4	1	5	32.27288	40.88513	21.5	145.0677	1.707957
103	3	4	1	5	25.35877	36.08911	23.375	178.2294	1.616074
201	1	1	2	5	27.4237	36.97842	0	169.8966	1.394471
202	2	1	2	5	27.63924	37.74661	0	166.0252	1.086391
203	3	1	2	5	20.80255	34.98414	0	193.2964	1.010722
201	1	2	2	5	28.50291	37.25617	0	166.5308	2.097112
202	2	2	2	5	29.04911	37.88023	0	162.7424	1.540405
203	3	2	2	5	22.60905	35.88063	0	184.8184	1.89713

Plot	Variety	Fall cut	Block	Cut	ADF (%)	NDF (%)	CP (%)	RFV	Yield (Mg/ha)
201	1	3	2	5	29.02815	39.42072	0	156.4213	1.389067
202	2	3	2	5	29.8812	40.15784	0	152.0108	1.626883
203	3	3	2	5	24.8743	40.16025	0	161.0361	2.048468
201	1	4	2	5	29.05659	39.05962	0	157.8146	1.816056
202	2	4	2	5	31.51507	44.88139	0	133.3743	2.026848
203	3	4	2	5	25.7286	35.96977	0	178.0757	1.951179
301	3	1	3	5	25.10004	34.97807	34.0625	184.4267	0.891813
302	2	1	3	5	29.38565	38.33924	33.125	160.1579	1.372852
303	1	1	3	5	26.54615	36.79274	35.875	172.4823	0.805334
301	3	2	3	5	23.71379	35.20145	28.125	186.1101	1.880915
302	2	2	3	5	28.25433	38.54027	31.6875	161.4497	1.945774
303	1	2	3	5	25.43642	39.80865	31.1875	161.4351	2.243045
301	3	3	3	5	24.66542	37.49297	27.375	172.896	1.934964
302	2	3	3	5	28.59976	38.88383	25.125	159.3794	1.91875
303	1	3	3	5	26.96787	39.77953	26.375	158.7635	1.837676
301	3	4	3	5	26.39928	36.45194	22.5625	174.3869	1.880915
302	2	4	3	5	30.94323	42.69577	25.1875	141.1724	1.610669
303	1	4	3	5	30.87083	37.69545	24.4375	160.0381	1.626883
401	3	1	4	5	24.97076	34.1093	37.0625	189.3987	1.043151
402	2	1	4	5	26.25729	37.87565	37.375	168.1035	1.10801
403	1	1	4	5	26.54237	35.70809	34.5	177.7293	1.318802
401	3	2	4	5	25.32441	34.61587	31.25	185.8868	1.756602
402	2	2	4	5	27.57739	38.54691	28.5	162.6945	1.648503
403	1	2	4	5	27.1111	35.72581	27.9375	176.4875	1.929559
401	3	3	4	5	25.89495	37.34562	31.0625	171.1924	1.307993
402	2	3	4	5	28.37424	39.01086	26.9375	159.2794	1.91875
403	1	3	4	5	28.06966	39.04241	28.125	159.716	1.248538
401	3	4	4	5	26.5263	36.55869	23.1875	173.6259	1.48095
402	2	4	4	5	33.77829	42.92876	23.125	135.6205	1.410686
403	1	4	4	5	30.94356	39.74622	23.875	151.6481	1.670123