Nitrogen Utilization in Tall Fescue (*Festuca arundinacea* Schreb.) Pastures Fertilized with Nitrogen or Grown with Alfalfa (*Medicago sativa* L.) or Red Clover (*Trifolium pratense* L.)

by

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(ABSTRACT)

Use of legumes as an alternative to nitrogen (N) fertilization in pasture management improves forage quality and animal performance and has been suggested to reduce the potential for environmental pollution. 'Kentucky 31' tall fescue fertilized with 160 kg N ha^{-1} yr^{-1} (split application) was compared to tall fescue grown with alfalfa or red clover in a 5-yr pasture experiment on a mixed Typic Hapludult. During yr 6, effects of N fertilization or the legume on soil N, forage N concentration, yield, botanical composition, N intake by esophageally fistulated steers grazing the pastures and N utilization by wethers fed the harvested forages were investigated. Soil ammonium was higher ($P \leq .01$) in the A and B horizons in the tall fescue-red clover pastures compared to the other treatments and nitrate was lower ($P \leq .05$) in the A horizon, but concentrations differed ($P \leq .01$) by date. Nitrate in the A horizon averaged 2.65, 1.38 and 2.21 ppm for tall fescue-N, tall fescue-red clover and tall fescue-alfalfa, respectively. In the B horizon, average soil NO_3^- was .43, .23 and .53 ppm for tall fescue-N, tall fescue-red clover and tall fescue-alfalfa, respectively. Tall fescue-alfalfa pastures were higher ($P \leq .01$) in percentage legume than tall fescue-red clover, overall, but differed by date ($P \leq .01$). Alfalfa was generally higher ($P \leq .05$) in N concentration than red clover. Total kg N accumulated ha^{-1} in above-ground herbage was higher ($P \leq .05$) for the grass-legume mixtures than N-fertilized tall fescue. Esophageally fistulated steers grazing stockpiled tall fescue-alfalfa selected forage higher ($P \leq .05$) in N concentration than steers grazing the other pastures. Stockpiled tall fescue-alfalfa fed to wethers in a metabolism trial was higher ($P \leq .01$) in N concentration, dry matter digestibility (DMD), apparent N absorption, and N retention than the other treatments. All treatments differed, with wethers fed tall fescue-red clover having the lowest DMD, apparent N absorption and N retention. Wethers fed tall fescue-alfalfa and tall fescue-red clover had higher blood urea N then those fed tall fescue-N. Results of this research demonstrate that soil NO_3^- concentrations were low for all three forage treatments and would not contribute to ground water contamination. Legumes supplied adequate N to achieve yields similar to tall fescue fertilized with N and increased N production ha^{-1} in the above ground biomass. Digestibility and utilization of the N in stockpiled tall fescue were improved by inclusion of alfalfa but not red clover.

Dedication

This thesis is dedicated
with love and appreciation
to my family

In honor of my parents,

my grandparents,

my aunt,

and my siblings,

and in memory of

Mr. and Mrs. Jones.

and in honor of my close friend,

Mr. Witt

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Chapter I

Introduction

'Kentucky 31' tall fescue was recognized as early as 1875 in Menifee County Kentucky. Seed collection and testing began in 1930, resulting in certification in 1945. Currently, tall fescue is abundant throughout the United States. Stockpiling tall fescue has been an accepted management procedure in the United States since late 1940. Digestibility of fall stockpiled tall fescue is high, but may be improved by increasing the N concentration of the forage by applying N fertilizers. In addition, N fertilization increases yield. Legumes are a natural source of N which fix atmosperic N through a symbiotic relationship with ***Rhizobia*** bacteria. Interest has developed in using legumes as an alternative to N fertilization due to concern over environmental contamination as a result of excessive N fertilization. Legumes have been observed to improve animal performance due to their high protein content. Alfalfa and red clover are two legumes with potential for utilization in tall fescue stockpiling systems. The present research was initiated to investigate the influence of stockpiling tall fescue with N fertilization vs stockpiling tall fescue grown with alfalfa or red clover as related to soil, plant and animal components.

Chapter II

Literature Review

Tall Fescue

The cultivar of tall fescue (***Festuca arundinacea*** Schreb.) known as 'Kentucky 31' was recognized as early as 1875 in Menifee County, Kentucky (Fergus and Buckner, 1972). In 1931, seed was collected for testing at the University of Kentucky. Seed was released in 1942 and certified in 1945 (Fergus and Buckner, 1972). Currently, tall fescue is grown on approximately 14 million ha in the United States (Steen et al., 1979b; Buckner et al., 1985).

Blaser et al. (1956) classified tall fescue as agressive in comparison with other cool season grasses, being rated below only perennial (***Lolium perrenne*** L.) and Italian ryegrass (***Lolium multiflorum*** L.). Tall fescue is considered medium in maturity as compared to other fescue species. Leaves of tall fescue are medium to narrow in width, have serate edges and tend to roll. A moderate amount of wax covers the leaf surface (Fergus and Buckner, 1972).

The adaptability of tall fescue to a wide range of environmental conditions is one of the reasons for the widespread use of this grass. Tall fescue is drought resistant, yet capable of maintaining production in wet soils (Mott et al., 1971; Steen et al., 1979b; Wilkinson and Mays, 1979). Tall fescue is also adapted to a wide range of pH and soil fertility conditions (Steen et al., 1979b) and is moderate in salt tolerance (Wilkinson and Mays, 1979). Overall, tall fescue is recognized for persistence in a wide range of locations, even under conditions of stress and poor management (Mott et al., 1971; Burns and Chamblee, 1979). Tall fescue is also highly recommended for use in prevention of erosion for soil and water conservation (Fergus and Buckner, 1972; Burns and Chamblee, 1979; Steen et al., 1979b).

'Kentucky 31' tall fescue has a wide range of uses. Used in turf, 'Kentucky 31', is capable of withstanding closer mowing than is the 'Alta' cultivar (Fergus and Buckner, 1972). 'Kentucky 31' tall fescue has been recognized as resistant to leaf and stem rust and more resisitant to crown rust than other fescue varieties (Fergus and Buckner, 1972). The persistence and potential for yield and quality of this forage under proper management result in the recognition of tall fescue as a valuable forage crop. 'Kentucky 31' tall fescue plays a large role in pastures utilized for livestock production throughout the north to south transition zone of the United States (Fergus and Buckner, 1972; Wilkinson and Mays, 1979).

The persistence and yield of tall fescue often exceeds that of other cool season grasses or grass-legume mixtures (Blaser et al., 1956; Seath et al., 1956; Reid et al. 1978; Wilkinson and Mays, 1979). Researchers have found tall fescue to have higher carrying capacity than perennial ryegrass, smooth bromegrass (***Bromus inermis*** L.), orchardgrass (***Dactylis glomerata*** L.) or mixtures of orchardgrass, Kentucky bluegrass (***Poa pratensis*** L.) or tall fescue with ladino clover (***Trifolium repens*** L.) (Seath et al., 1956; Reid et al., 1978). With proper fertilization, tall fescue is capable of producing high yields of total digestible nutrients (TDN) as well as dry matter per ha (Seath et al., 1956; Jacobson et al., 1970; Wilkinson and Mays, 1979).

However, tall fescue also has some disadvantages as a forage used in livestock production. Often, tall fescue has been classified as an unpalatable, low quality feed by livestock producers and researchers and has been associated with decreased animal performance (Wilkinson and Mays, 1979). Problems occur when tall fescue is infected with the endophytic fungus ***Acremonium coenophialum*** (Buckner et al., 1985; Boling et al., 1989). Symptoms include decreased feed intake

(Bryan et al., 1970; Jacobson et al., 1970; Buckner et al., 1985; Gay et al., 1988), decreased live wt gains and milk production (Seath et al., 1956; Jacobson et al., 1970; Mott et al., 1971; Buckner et al., 1985), elevated respiration rates, increased body temperature, rough haircoat, diarrhea, lameness, severe necrosis of the tail or rear legs (Bryan et al., 1970; Jacobson et al., 1970; Wilkinson and Mays, 1979; Buckner et al., 1985; Read and Camp, 1986; Gay et al., 1988), and decreased conception rates and increased embryonic mortality (Gay et al., 1988). Goetsch et al. (1989) found that the decrease in dry matter intake of steers fed endophyte infected tall fescue was associated with the decrease in live wt gain. Zylka (1989) observed similar apparent N absoption and retention for wethers fed tall fescue ensiled in the fall with endophyte infection levels ranging from 0 to 70 %. The reproductive problems recognized by Gay et al. (1988) are probably a result of the influence of elevated body temperatures on conception rates (Gwazdauskas, 1985).

In a ten-yr study by Jacobson et al. (1970) incidence of fescue toxicity varied annually. In some yrs cattle grazing tall fescue performed well while in other yrs performance was low. In yrs where performance was poor, other symptoms of toxicity were apparent. Fescue toxicity also varies by season. Generally symptoms are most evident in the summer and are generally considered to be related to elevated ambient temperatures (Boling et al., 1989).

Although detrimental to livestock, fungal infection appears to play a beneficial role in the plant by improving stress tolerance. Read and Camp (1986) found infected tall fescue to have a higher carrying capacity and greater stand maintenance than non-infected tall fescue. However, wt gain per ha as well as per animal were lower on the infected tall fescue.

Problems of animal performance on tall fescue in the summer have also been attributed to alkaloids. Perloline, one of many alkaloids in tall fescue is found to have its highest levels in mid-summer, late July to August (Bush et al., 1970; Boling et al., 1975; Steen et al., 1979a; Buckner et al., 1985). Inhibition of cellulose digestibility by perloline at levels found in tall fescue in the summer has been observed in ***in vitro*** studies (Bush et al., 1970; Steen et al., 1979a). Boling et al. (1975) isolated and fed similar levels of perloline as those observed in tall fescue in late summer to lambs. Lambs receiving perloline had decreased apparent digestibility of crude fiber, N-free extract, ether extract and ash. Nitrogen retention decreased as urine vol and N contencentration in urine increased. Plasma urea N was decreased and the relative levels of specific amino acids in the rumen were affected. Buckner et al. (1985) implicated the role of environment on perloline level.

Mott et al. (1971) reported that energy was the limiting factor of tall fescue forage. By feeding grain as well as fertilizing the pasture with N he managed to increase cattle gains. Smith et al. (1987) improved feed conversion by supplementing endophyte-infected tall fescue silage with corn silage. Added corn improved N retention and gains.

Rainfall, temperature, plant maturity and soil fertility influence the quality of tall fescue as a forage. Soil moisture is the factor most often associated with yield and quality (Nelson and Robins, 1957; Jung et al., 1976; Mott et al., 1971). Moisture is necessary for the plant to take up nutrients, such as N, which affect the quality of the forage.

Temperature is another factor which limits forage quality when soil moisture is adequate (Nelson and Robins, 1957; Jung et al., 1976). Cool temperatures restrict plant growth so total nonstructural carbohydrates (TNC) are higher at cooler temperatures (Jung et al., 1976). Van Soest et al. (1978) predicted that forage quality, in general, improved with fall cuttings since forage was produced at lower temperatures due to the negative association between temperature and forage quality.

As plants advance toward maturity, forage quality declines (Troelsen and Campbell, 1969; Van Soest, 1978). Nitrogen concentration decreased with the advancement of maturity and was greater in regrowth than in mature tissue (Van Eys and Reid, 1987). Brown et al. (1963) found digestible protein also decreased with age. They found that dry matter digestibility remained constant until 13 wks of age at which time digestibility began to decline.

Nirtrogen fertilization has been reported to have variable effects on forage quality. Nitrogen fertilization increases the N compounds in the plant and improves apparent digestibility in grasses (Blaser, 1964; Bryan et al., 1970). Van Soest (1978) disagreed with this in stating that the digestibility of grasses is not increased because the increases in N compounds as a result of fertilization are accompanied by reduced levels of soluble carbohydrates and increased lignification. Matches (1979) considered N to be the most limiting fertility component on the growth of tall fescue. Nitrogen fertilization generally increases yield, root mass and concentration of nonprotein

N (NPN) in tall fescue (Jung et al., 1976; Matches, 1979). High concentrations of NPN in the form of nitrates (NO_3^-) may result in NO_3^- toxicity to livestock, so excessive fertilization should be avoided (Farra and Satter, 1971; Kemp et al., 1977; Vertregt, 1977; Wilkinson and Mays, 1979; Burrows et al., 1987).

Nitrate toxicity occurs as a result of the transformation of NO_3^- to ammonium (NH_4^+) in the rumen. Nitrite (NO_2^-) is an intermediate in this reaction. When excessive NO_3^- is present in the feed, NO_2^- accumulates and may be taken into the blood system. In the blood, the NO_2^- oxidizes ferric hemoglobin to ferric methemoglobin which is incapable of oxygen transport, so the animal suffers anoxia which leads to death (Farra and Satter, 1971; Kemp et al., 1977; Vertregt, 1977; Burrows et al., 1987). This is most often recognized in ruminants on high roughage diets. Feeding of concentrates decreases the animals propensity to NO_3^- toxicity (Farra and Satter, 1971; Burrows et al., 1987).

Stockpiled Tall Fescue

Stockpiling of tall fescue has been an accepted management technique through east central United States since the late 1940's (Taylor and Templeton, 1976). In stockpiling, forage is accumulated during periods when environmental conditions favor forage growth to be grazed by livestock at a time when forage growth is reduced or has ceased. Tall fescue is considered by some to be the best cool season grass to be used for stockpiling (Matches, 1979). In comparison with bluegrass, stockpiled tall fescue produced higher yields (Taylor and Templeton, 1976). Tall fescue stockpiling takes advantage of cool temperatures which favor improved forage quality. Digestibility and crude protein content are generally higher in the fall than in the summer (Bryan et al., 1970; Pendlum et al., 1980). Bagley et al. (1983) observed greater N retention and digestible dry matter intake for tall fescue in November as compared to May, July and February. Utilizing stockpiled tall fescue allows producers to extend the grazing season through December, delaying or eliminating the need for supplemental feed until January in most cases (Ocumpaugh and Matches, 1977; Bradley et al., 1981b).

Matches (1979) accumulated tall fescue for a complete yr. He found that quality of the stockpiled product was improved by the removal of mature growth. Longer periods of accumulation increased forage yields but decreased forage quality. Generally, accumulation of forage begins in mid August (Taylor and Templeton, 1976; Smith et al., 1987). Frequent grazing or hay harvest in spring and summer appear to have no influence on the growth of fall stockpiled tall fescue (Ocumpaugh and Matches, 1977).

Stockpiled forage needs to be grazed by the end of December if maximum crude protein, dry matter and digestibility are to be utilized (Taylor and Templeton, 1976; Ocumpaugh and Matches, 1977). Ocumpaugh and Matches (1977) found that temperatures below freezing initiated a decrease in forage production. Taylor and Templeton (1976) observed that sward crude protein concentration began to decline after October, although living, green tissue within the sward maintained relatively high crude protein concentrations into the winter.

The date that grazing of stockpiled tall fescue begins should be planned so that the forage is removed prior to the decline of quality associated with the advanced maturity of the forage. Smith et al. (1987) compared stockpiled tall fescue harvested in September and November. They found that although dry matter intake for cattle was similar at both times, daily gains were considerably higher in November than in September. Brown et al. (1963) began stockpiling September 2 and harvested tall fescue forage at various time intervals up to 13 wks and found no significant difference in forage quality as related to the length of time prior to harvest. However, they recognized a tendency for dry matter digestibility to increase until the forage was 9 wks old. Protein concentration and digestibility began to decrease with age beyond this point. Nitrogen-free extract (NFE) increased until 9 wks of age, remained constant from 9 to 11 wks and began to decline by 13 weeks of age. Soluble carbohydrates increased from 25% at 2 wks to 50% at 11 wks and were probably associated with changes in NFE.

Favorable animal performance has been shown on stockpiled tall fescue. Bagley et al. (1983) found digestible dry matter intake and digestibility were higher in November than in July or February and were similar to in May. Nitrogen retention in livestock was greatest in November as compared with May, July and February. Only February had negative N retention (Bagley et al., 1983). Brown et al. (1963) also observed greater digestibility in tall fescue accumulated between mid-August to September. Bradley et al. (1981b) found similar animal performance of calves grazing stockpiled fescue to those on corn in finishing to slaughter wt and choice grade.

Environmental factors play a role in the quality and accumulation of stockpiled forage. Accumulated precipitation is highly related to stockpiled forage production (Jung et al., 1976; Taylor and Templeton, 1976; Ocumpaugh and Matches, 1977). Ocumpaugh and Matches (1977) found correlation coefficients of 0.99 in 1971 and 0.93 in 1972 for fall growth of tall fescue and accumulated precipitation. Temperature is another major environmental factor involved. Total non-structural carbohydrates are higher in plants grown in cool temperatures (Jung et al., 1976). Freezing temperatures initiate a decline in forage production. Further action of freezing and thawing contributes to dry matter loss through desication, leaching and decay. Winter precipitation in the form of snow or sleet presents a physical barrier which limits grazing of forage (Taylor and Templeton, 1976).

Digestibility of stockpiled tall fescue is highest in the fall. In addition, N digestibility generally increases with higher N concentration of forage (Blaser, 1964; Bryan et al., 1970). To improve dry matter production and N concentration, application of fertilizer to stockpiled tall fescue is generally recommended. Taylor and Templeton (1976) stockpiled tall fescue with 0, 50 and 100 kg N/ha. They found that tall fescue that was not fertilized did not accumulate dry matter from October to November. Only the tall fescue fertilized with 100 kg N had increased yield during November, at which time maximum accumulation occurred. Tall fescue with 0 or 50 kg N ha^{-1} did not achieve maximum yield until December. This study also found that crude protein concentration of the forage increased with N fertilization.

The Nitrogen Cycle

Nitrogen makes up approximately 79% of the earth's atmosphere (Delwiche, 1970). However, atmospheric N is unavailable for plant use. High levels of energy are ordinarily required to break the strong triple bond which links the two molecules of atmospheric N (Havelka et al., 1982; Stevenson, 1982). This is accomplished in the Haber-Bosch process used in industrial fixation of N for the production of fertilizers (Delwiche, 1970). In nature, high levels of energy associated with cosmic radiation, meteorite trails and lightning fix small amounts of atmospheric N (Delwiche, 1970).

Legume species are considered to be the greatest natural source of N fixation (Delwiche, 1970; Stevenson, 1982). Legumes participate in symbiotic relationships with N-fixing bacteria (***Rhizobia***). Phillips (1980) estimated that 16 moles of ATP and a minimum of 0.75 mole of glucose were required by ***Rhizobia*** to reduce one mole of N_2. The legume provided approximately 2.57 g of carbon contained in photosynthetically derived carbohydrates, to the ***Rhizobia*** per g of fixed N returned. The amount of C required may vary from 0.3 to 20 g depending on the legume species. By this process, legumes may be responsible for the fixation of up to 600 kg of N per ha annually (Phillips, 1980; Stevenson, 1982). The amount of N fixed is dependent on factors including the legume species (Phillips and Bennett, 1978; Phillips, 1980; Labandera, 1988), soil temperature (Stevenson, 1982), amount of sunlight (Vaughn and Jones, 1976; Havelka et al., 1982), soil moisture (Havelka et al., 1982; Stevenson, 1982), other plant species present and plant density (Phillips and Bennett, 1978; Phillips, 1980). In general, factors which influence photosynthesis determine the relative amount of N fixation which may occur (Phillips, 1980; Havelka et al., 1982). Legumes demand higher levels of phosphorus and potassium relative to requirements for grassses. In addition, small amounts of molybdenum and cobalt are necessary. These elements are directly involved in the N fixation process (Delwiche, 1970; Havelka et al., 1982). Nitrogen fixation also occurs in association with some trees (Havelka et al., 1982) and has been reported in some grasses (Vaughn and Jones, 1976) although only to a limited extent. Other natural sources of N include fixation by marine organisms and algea (Delwiche, 1970), the decomposition of plant or animal tissue (Phillips, 1980) and the breakdown of mammalian waste (Delwiche, 1970; Phillips, 1980; Stevenson, 1982).

Ammonium and NO_3^- are the N forms which are taken into plant roots to be used in the formation of plant proteins (Mills et al., 1974; Vaughn and Jones, 1976). However, all of the N in the soil is not utilized by plants. Interest in preserving the environment has resulted in studies to determine the effects of high rates of N applied in agricultural production. Excessive levels of fertilization, followed by rainfall can result in runoff and erosion of high levels of N into surface water. The presence of these N-containing compounds in the lakes and streams enhances algea growth and with algae decomposition decreases oxygen levels, killing fish and other oxygen (O_2) dependent species (Delwiche, 1970; Riggan et al., 1985). Nitrogen losses from the soil may also occur through volatilization of ammonia (Elliott et al., 1971; Denmead et al., 1974; Stevenson, 1982). Elliott et al. (1971) stated that release of ammonia and other forms of N into the atmoshpere contributed to pollution of ground and surface water by undergoing distillation. Mills et al. (1974) found N loss as a result of volatilization was higher in bare soil than in soil on which plants were present. The potential for leaching of NO_3^- into the ground waters has received considerable attention in recent yrs (Stewart et al., 1967; Delwiche, 1970; Nielsen et al., 1982; Stevenson, 1982; Riggan et al., 1985).

Atmoshperic N pollutants as a result of burning of organic compounds (Riggan et al., 1985) use of fertilizers on agricultural cropland (Stewart et al., 1967; Nielsen et al., 1982) and application of manure (Stewart et al., 1967; Stevenson, 1982) are considered to be threats to ground water contamination as a result of the leaching of NO_3^-. Ammonium not absorbed by the plant is generally held in close association with soil particles in soils having small particle size or in soils containing high levels of organic matter (Stevenson, 1982; Riggan et al., 1985). However, in sandy soils (Stevenson, 1982), or where NH_4^+ levels are high such as under feedlots NH_4^+ leaching may also occur (Stewart et al., 1967). Soil N may also be lost to the atmosphere through denitrification. In the rooting zone, this represents loss of plant nutrients. However, occurrence below the rooting zone is beneficial as NO_3^- is reduced prior to entering the ground water.

Soil NO_3^- and NH_4^+ which are taken up by the root system into the plant are utilized in amino acids for use in proteins (Vaughn and Jones, 1976). The N in the plant may be returned to the soil when the plant completes the life cycle, senesces and decays. Decomposition of plant parts will also return N compounds to the soil (Phillips, 1980). Burning of vegetation, which occurs accidentally or as a management tool in some cases, also returns N to the soil (Riggan et al., 1985). An alternative route of plant N occurs when the plant is ingested by mammals. Some of the proteins in the plant will be broken down, formed into new amino acids and used in the protein of muscles or organs. This N may be returned to the soil by the death and subsequent decay of the animal or through the constant sloughing of dead cells.

Some of the plant N ingested by the animal will not be digested and will pass through the gastro-intestinal tract to be excreted along with other metabolic waste in the feces (Delwiche, 1970; Elliott et al., 1971; Stevenson, 1982). Johnstone-Wallace and Kennedy (1944) observed that cattle excreted approximately 21 kg of manure per d covering an area of approximately 3 m^2. The decay of the fecal matter allows some of the N to be returned to the soil although some may be lost through denitrification and volatilization to the atmosphere (Stewart et al., 1967; Stevenson, 1982). Nitrogen also leaves the body through the urine (Elliott et al., 1971; Denmead et al., 1974). Johnstone-Wallace and Kennedy (1944) also found that the cattle in their study urinated approximately 9 times per d. Urine was more evenly distributed than manure, but some scalding of plants occurred in dry weather. Urine may enter the soil or be volatilized due to the high ammonia concentration. The ammonia released in urine and gaseous exchanges of livestock plays a major role in the N cycling in pastures (Elliott et al., 1971; Denmead et al., 1974).

Nitrogen is constantly being recycled in a grazing system. Nitrogen from the atmosphere is applied to the soil through fixation by legumes, in products of industrial fixation, through decay of organic matter, or other means. In the soil, the N is either taken up by the plants, or may take the route of volatilization or denitrification to return to the atmosphere. Nitrogen may enter the surface and ground waters as a result of runoff, erosion or leaching and present a threat to humans, animals and aquatic life. Nitrogen entering the plant and ingested by grazing livestock may be used for development of protein and remain in the body until death and decay return the N to the cycle, or the N may be returned to the soil through the excretion of waste.

Tall Fescue Stockpiled with Legumes

Interest in cutting costs (Jackobs, 1963; Wilkinson and Mays 1979), controlling ground water contamination and avoiding NO_3^- toxicity to livestock (Wilkinson and Mays, 1979) are reasons cited for considering sources of N other than application of N fertilizers. Forage legumes serve as an excellent source of N while improving forage quality and improving animal performance. In many cases, legumes, through the fixation of atmospheric N, have been able sufficient soil N for plant production as compared with N fertilizatin (McCloud and Mott, 1953; Fribourg and Johnson, 1955; Nelson and Robins, 1957; Chamblee, 1958a; Coffindaffer and Burger, 1958; Peterson and Bendixen, 1961; Jackobs, 1963; Smith et al., 1975; Matches, 1979; Spooner and McGuire, 1979; Wilkinson and Mays, 1979; Barnes et al., 1988). Legumes are capable of meeting their requirements for N through N fixation while also supplying N to grasses (Phillips and Bennett, 1978; Labandera et al., 1988). Red clover has been reported to provide 16 to 224 kg N ha^{-1} yr^{-1} (Fribourg and Johnson, 1955; Nelson and Robins, 1957; Wilkinson and Mays, 1979) while alfalfa provides 27 to 54 kg N ha^{-1}.

In terms of quality, legumes are generally higher in protein and calcium than grasses (Burroughs et al., 1950; Richards et al., 1962; Hill and Guss, 1976; Reid et al., 1959). Legumes may contain excess calcium relative to animal requirements, which may result in a mineral imbalance associated with the ratio of calcium to P (Hill and Guss, 1976). Legumes, particularly alfalfa (*Medicago sativa* L.), are also associated with the occurrence of bloat in grazing ruminants (Woods, 1953; Jackobs, 1963; Matches, 1979; Walgenbach and Marten, 1981).

Jackobs (1963) suggested that the goal of pasture mixtures containing both grasses and legumes is to have enough grass to control bloat, but enough legume to supply N for satisfactory yields. Wilkinson and Mays (1979) suggest that a grass-legume mixture containing 40% or more clover will produce dry matter equivalent to that produced by fertilized grass alone. Woods et al. (1953) found no significant difference in hay yield for grass-legume mixtures compared to straight grass when as little as 35 % of the total sward consisted of grass.

Characteristics which influence the establishment of legumes are determined primarily by forage species and cultivar (Kalton and Wilsie, 1953). However, other factors affect botanical composition of the stand, once established. Attention to these factors and their management determine the persistence of the individual species used in the mixture (Van Keuren and Heinemann, 1958; Matches, 1979; Wilkinson, 1979; Casler, 1988). Mixtures need to contain species which are morphologically compatible to allow establishment of both species (Chamblee and Lovoorn, 1953; Jackobs, 1963; Burns and Chamblee, 1979). Blaser et al. (1956) found that alfalfa seedlings grew more rapidly than other legumes. Therefore, alfalfa would be expected to be more competitive with grasses than some other legumes. Consideration should also be given to the lifespan of the legume. Legumes, such as red clover (***Trifolium pratense*** L.), which act as bienniels require frequent reseeding (Jackobs, 1963; Graffis, 1982).

Alfalfa is generally favored in mixtures during periods of drought and high temperature (Kalton and Wilsie, 1953). This is attributed to the ability of the alfalfa to remove soil moisture at greater depths than the grasses (Chamblee, 1958b). However, high temperature with excessive water may be detrimental to alfalfa (Christian, 1977) due to reduced O_2 in the root zone. Nitrogen fertilization nearly always results in an increase in the grass component of the mixture with a subsequent decline in the legume portion (McCloud and Mott, 1953; Peterson and Bendixen, 1961). Grazing management also plays a role in determination of the botanical composition of a grass-legume forage mixture. Alfalfa is susceptible to loss of stand as a result of continuous grazing. Therefore, in mixtures containing alfalfa, rotational grazing is recommended so that the alfalfa has a chance to recover (Counce et al., 1984; Van Keuren and Matches, 1988).

There are benefits above as well as below the ground to both grasses and legumes when grown in mixtures. Mixtures have been reported to produce similar (Peterson and Bendixen, 1961; Burns and Chamblee, 1979; Wilkinson and Mays, 1979) or greater yields (Graffis, 1982) than that produced by grass alone. Chamblee (1958a) reported increased growth of orchardgrass grown between two rows of alfalfa with or without partitions to separate the roots, indicating benefits above as well as below ground. Van Riper (1960) observed more protein produced per unit land area in a grass-legume mixture than in a straight grass and found that the grasses which were grown with alfalfa were higher in percentage protein than grasses grown with or without N fertilization. Dawson (1970) also reported higher levels of crude protein in grasses grown in association with legumes. Chamblee (1958a) concluded that alfalfa improved orchardgrass production by shading which reduced the air temperature of the canopy or by reducing soil temperature and soil moisture evaporation. Coffindaffer and Burger (1958) found an increased leaf to stem ratio in alfalfa grown with orchardgrass as compared to alfalfa grown alone. Van Keuren and Heinemann (1958) observed more avg animal d per unit land area and heavier carrying capacity on tall fescue-alfalfa and tall fescue-ladino clover mixtures than on tall fescue alone.

Grass-legume mixtures containing alfalfa are excellent in moisture utilization. Grasses generally have a fairly shallow root system while legumes tend to have deeper roots (Jones et al., 1988). Alfalfa roots have the ability to grow where water is available. Roots may spread laterally up to 16 feet to locate water (Christian, 1977). Chamblee (1958b) found that when soil moisture was more than adequate, alfalfa and orchardgrass removed soil moisture at the same rate. However, the alfalfa was able to remove moisture at greater depths in the soil when water became more limiting. Legumes are also recognized for their higher water use efficiency compared to C_3 grasses (Jones et al., 1988). Greater root production was observed in grass-legume mixtures as compared to pure stands (Woods et al., 1953). These root characteristics make mixtures useful for soil and water conservation.

Except when energy is considered limiting (Reid et al., 1959), use of grass-legume mixtures generally results in improved animal performance as compared with pure grass pastures (Van Keuren and Heinemann, 1958; Blaser, 1964; Smith et al., 1975; Matches, 1979; Spooner and

McGuire, 1979; Bradley et al., 1981a). This is reflected by higher wt gains, weaning wts, conception rates and total beef production per unit land than livestock on straight grass pastures. Bradley et al. (1981b) found similar calf gains for calves grazing stockpiled fescue-clover as for those fed corn as a finishing diet. Allen et al. (1988) reported higher daily gains in calves on stockpiled tall fescue grown with alfalfa, as compared to tall fescue fertilized with N or grown with red clover. Gains were similar in calves grazing the N fertilized tall fescue and that grown with red clover.

In addition to improved gains, mixture of grass and legumes may eliminate some of the problems associated with pure stands. Use of a grass-alfalfa mixture as opposed to straight alfalfa forage reduces the incidence of bloat (Woods et al., 1953; Jackobs, 1963). A mixture will also dilute the excess of calcium available in legumes to avoid mineral imbalances (Hill and Guss, 1976). There is some indication that inclusion of a legume with tall fescue helps to alleviate the effects of fescue toxicity. Gay et al. (1988) used 15 to 30% ladino and white dutch clover with highly infected (98%) tall fescue and compared this with low endophyte and high endophyte tall fescues without legumes. Cattle on the high endophyte tall fescue pasture had the lowest gains for both cows and calves, and the lowest pregnancy rates in the cows. The high endophyte-legume tall fescue pastures produced similar results as the low endophyte pasture. Smith et al. (1975) reported similar results in comparing straight orchardgrass and tall fescue pastures to a tall fescue-legume pasture. Average daily gains for both cows and calves, conception rates and udder scores were similar for livestock grazing the orchardgrass and the tall fescue-legume pastures. Endophyte infection was not indicated for the tall fescue, although the results were similar to those of Gay et al. (1988) with the orchardgrass representing the endophyte-free tall fescue.

The major disadvantage of using a grass-legume mixture is the emphasis on management of the forage system required (Matches, 1979). Management must consider the characteristics of each component of the mixture as well as the mixture as a whole, in making decisions to meet the goals of the production system.

Tall Fescue Stockpiled with Alfalfa and Red Clover

Alfalfa and red clover are two legumes with potential for utilization in stockpiling with tall fescue. Both are considered aggressive in production and stand maintenance when compared with a large selection of other legumes (Blaser et al., 1956). Alfalfa has greater stand longevity than red clover which is limited by its biennial growth habit. However, both are capable of providing adequate N to tall fescue for appropriate yields and quality (Jackobs, 1963; Graffis, 1982). Crude protein production per unit land on an annual basis is similar for both legumes (Van Riper, 1960).

Chamblee and Collins (1988) concluded that both alfalfa and red clover have potential for fall use following a late August harvest. Yields of both legumes increased 16 to 22 percent from October 7 to 17 in 1979 and 1980. After mid October, yields began to decline. Alfalfa had higher yields than red clover and produced more of its dry matter later in the fall than the red clover. Although yields were adequate to consider use of these legumes for stockpiling there was a greater decline in yield than in forage quality as reflected by N concentration and in vitro dry matter digestibility (IVDMD). Nitrogen concentration declined to a point and then remained steady through the fall. Sulfur, P and K all declined throughout the fall while calcium increased. Alfalfa contained a higher level of S (0.32 %) than red clover (0.21 %). In vitro dry matter digestibility remained constant, around 65%, until mid-November and then began to decline. Neutral detergent fiber began to increase slightly after November 8.

Tomlin et al. (1965) determined that the increase in lignin associated with advancing maturity did not affect cellulose digestibility in alfalfa and red clover as much as in grasses. Edmisten et al. (1988) compared the effect of September and October harvests on the winter survival of alfalfa and found that the length of time allowed for growth preceding the harvest was more important than the harvest date in determining spring yield. In a related study, Edmisten and Wolf (1988) measured photosynthesis in alfalfa regrowth until mid-December. They concluded that in the fall, respiration rates were lower and accumulation occurred at a slower rate as a result of decreased temperatures so that the plant was able to derive the carbohydrates needed for regrowth from photosynthesis and not deplete root supplies. These findings further indicate the adaptivity of alfalfa to a stockpiling system. Forage accumulations beginning in early September allows regrowth to occur while photosynthesis is active and there is time for accumulation of carbohydrates. By early November, when grazing of the stockpiled forage begins, cooler temperatures should have slowed down the plant respiration and growth. When plants begin regrowth the following spring, photosynthesis can once again supply carbohydrates.

Summary

The abundance, persistence and reliability of tall fescue make this forage a valuable resource for livestock production. Fall stockpiling takes advantage of the cool season growth pattern of this forage, making use of improved yield and quality, while extending the grazing season. The presence of adequate levels of N in the soil is essential for maximum yield and quality in a stockpiling system. Legumes may serve as a source of N, reducing costs and the potential for ground water contamination and NO_3^- toxicity associated with application of N fertilizers. Alfalfa and red clover are two specific legumes which are recognized for their influence on forage yield and quality yr round, as well as maintenance of these characteristics during the fall.

In the present study, the soil and plant characteristics of tall fescue fertilized with N or grown with the legumes, alfalfa and red clover, were investigated. Levels of soil N, in the form of NH_4^+ and NO_3^- were determined in the A and B horizons to compare soil N concentration and potential for NO_3^- leaching. Plant yield, botanical composition and N concentration were determined at various harvest dates throughout the yr. In addition, the influence of the three stockpiling treatments on livestock selectivity and digestibility of the forage was determined.

Chapter III

Soil Nitrogen as Influenced by Alfalfa, Red Clover or Nitrogen Fertilization in Tall Fescue Pastures

Abstract

Legumes have great potential, as a result of N-fixation, to supply N to forage-livestock systems. The purpose of this study was to compare soil ammonium and nitrate levels in tall fescue grazing systems utilizing either alfalfa, red clover or N fertilization as the source of N. Four replications of tall fescue, tall fescue-alfalfa, and tall fescue-red clover pastures were established in 1981 and 1982 for use in a 5-yr grazing study. Tall fescue pastures were fertilized at 160 kg N $ha^{-1}yr^{-1}$ using a split application of a urea-ammonium nitrate solution. In 1987, 10 plots in each of the 3 replicates used for the present study were located on mixed Typic Hapludult soils. Soil samples were taken from the A and B horizons to a depth of approximately 76 cm and composited by horizon for a total of 2 samples $horizon^{-1}$ rep^{-1} and analyzed for ammonium (NH_4^+) and nitrate (NO_3^-). For both horizons, soil NH_4^+ in tall fescue-red clover pastures was higher ($P \leq .05$) than in tall fescue-alfalfa or tall fescue-N. In the A horizon, tall fescue-red clover contained less ($P \leq .01$) NO_3^- than tall fescue-alfalfa or tall fescue-N with 1.38, 2.21 and 2.65 ppm, respectively. Nitrate-N at 1.66 kg ha^{-1} for both horizons was lower ($P \leq .01$) for tall fescue-red clover than for tall fescue-alfalfa or tall fescue-N which contained 2.75 and 2.85 kg ha^{-1}, respectively. In the B horizon, tall fescue-red clover had lower ($P \leq .01$) soil NO_3^- than tall fescue-alfalfa, with tall fescue-N similar to both treatments. Soil NH_4^+ concentrations were higher ($P \leq .01$) and NO_3^- concentrations were lower ($P \leq .01$) in May compared to November. Nitrate concentration in the B horizon of N-fertilized soils was higher in May compared to legumes but not in November (treatment by date interaction; $P \leq .01$). Alfalfa and red clover produced soil N concentrations equivalent to or greater than that achieved by N fertilization. Soil NO_3^- levels for all treatments in this study were low and would not pose a threat to ground water contamination as a result of leaching.

Introduction

Tall fescue is grown on approximately 14 million ha in the United States (Steen et al., 1979b; Buckner et al., 1985). This cool season grass is adapted to a wide range of environmental conditions, including extremes in soil moisture (Mott et al., 1971; Wilkinson and Mays, 1979; Steen et al., 1979a), soil pH and fertility (Steen et al., 1979a), moderate salt tolerance (Wilkinson and Mays, 1979), resistance to leaf and stem rust (Fergus and Buckner, 1972) and other conditions of stress or poor management (Mott et al., 1971; Burns and Chamblee, 1979).

Fall stockpiling of tall fescue has been an accepted management technique thoughout the east central United States since the late 1940's (Taylor and Templeton, 1976). This practice takes advantage of the improved quality of tall fescue in the fall (Bryan et al., 1970; Jung et al., 1976; Taylor and Templeton, 1976; Matches, 1979; Bagley et al., 1983) while allowing livestock producers to extend the grazing season through December (Ocumpaugh and Matches, 1977; Bradley et al., 1981).

Nitrogen fertilization of tall fescue used for stockpiling is recommended to obtain maximum yield (Taylor and Templeton, 1976) and forage quality (Blaser, 1964; Bryan et al., 1970) for grazing livestock.

One source of N is fertilizer application. Nitrogen fertilizers are readily available for agricultural use in the United States. However, use of N containing fertilizers has been related to NO_3^- toxicity in grazing livestock (Farra and Satter, 1971; Kemp et al., 1977; Vertregt, 1977; Wilkinson and Mays, 1979 Burrows et al., 1987), pollution of streams and lakes as a result of runoff and erosion (Delwiche, 1970) and NO_3^- leaching, with possible contamination of the ground water (Stewart et al., 1967; Delwiche, 1970; Wilkinson and Mays, 1979; Nielson et al., 1982; Stevenson, 1982; Riggan et al., 1985).

Nitrate leaching occurs most easily on sandy soils or soils low in organic matter which have low cation exchange capacity. If NO_3^- has accumulated in the soil, leaching is greatly influenced by the occurrence of precipitation (Mills et al., 1974; Stevenson, 1982; Riggan et al., 1985). Stewart et al. (1967) looked at levels of NO_3^--N in the soil at depths of 76 cm below the soil surface under alfalfa, native grass, cultivated dryland, irrigated crops excluding alfalfa, and feedlots. Soil on which alfalfa was grown had the lowest NO_3^--N levels with an average of 70 kg of NO_3^--N ha $^{-1}$. They concluded that this occurred because alfalfa had no N applied and the deep rooting of alfalfa made it capable of removing NO_3^- at a greater depth in the soil profile. A maximum of 175 kg of N yr^{-1} was applied to the native grass. These soils contained only 81 kg of NO_3^--N ha^{-1}. The irrigated crops excluding alfalfa had much higher levels of soil NO_3^--N with an average of 452 kg ha^{-1} and were considered similar to soils under feedlots with 1282 kg ha^{-1} in terms of threat to water contamination.

Legumes are recognized as an alternative source of N when grown in mixtures with grasses such as tall fescue (McCloud and Mott, 1953; Fribourg and Johnson, 1955; Nelson and Robins, 1957; Chamblee, 1958; Coffindaffer and Burger, 1958; Peterson and Bendixen, 1961; Jackobs, 1963; Delwiche, 1970; Smith et al., 1975; Vaughn and Jones, 1976; Matches, 1979; Spooner and McGuire, 1979; Wilkinson and Mays, 1979; Stevenson, 1982; Barnes et al., 1988). Stevenson (1982) suggested that legumes are the main source of fixed N in most of the world's soils and the only source in some countries. Properly innoculated legumes are capable of producing large quantities of atmospheric N through their symbiotic relationship with N-fixing ***Rhizobium*** bacteria (Delwiche, 1970; Vaughn and Jones, 1976; Phillips and Bennett, 1978; Phillips, 1980; Havelka et al., 1982; Stevenson, 1982; Labandera et al., 1988). Red clover has been estimated to provide 16 to 224 kg of N ha^{-1} annually (Fribourg and Johnson, 1955; Nelson and Robins, 1957; Wilkinson and Mays, 1979; Phillips, 1980; Stevenson, 1982) while alfalfa may produce up to 600 kg N ha^{-1} yr^{-1} (Phillips, 1980; Stevenson, 1982). Phillips and Bennett (1978) observed that N fixation of red clover increased both when grown in a mixture with a grass and when plant density was increased.

The objective of this study was to investigate the influence of annual N fertilization of tall fescue over a 6-yr period, on soil N form and distribution in the A and B horizon, as compared to tall fescue grown with either alfalfa or red clover.

Materials and Methods

'Kentucky 31' tall fescue and tall fescue grown in mixture with either 'Arc' alfalfa or 'Kenland' red clover were established in 1981 and 1982 for use in a 5-yr grazing study at the Virginia Forage Research Station[1] of Virginia Polytechnic Institute and State University in Middleburg, Virginia (Allen et al., 1988). Red clover was overseeded annually, each February. Lime, phosphorus and potassium were applied to pastures according to soil test recommendations. Nitrogen was applied in a split application at 160 kg ha^{-1} annually to the pure stand of tall fescue in a urea-ammonium nitrate solution containing 30 % N. Times of application were early spring and early August. Endophyte concentration for the pastures was determined in May, 1986. Endophyte infection ranged from 15 to 53 % in the tall fescue-N pastures, and 8 to 48 % in the tall fescue-red clover

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[1] Currently known as the Middleburg Agricultural Experiment Station

pastures. Tall fescue-alfalfa pastures were endophyte free. Tall fescue-N and tall fescue-red clover pastures were stockpiled each fall with accumulation of forage beginning in early August, while accumulation for stockpiled tall fescue-alfalfa was delayed until early September. This delay was based on earlier work at the Middleburg station which indicated that forage yield was unaffected by this delay, while the stockpiled forage could be utilized at a more immature stage of growth (R. Barlow, unpublished data). Tall fescue-alfalfa pastures were grazed by Angus steers and heifers at a stocking rate of 4 calves ha^{-1} from early November until late December or early January. Steers and heifers were grazed at the same stocking rate on tall fescue-N and tall fescue-red clover pastures from November until early March. Spring and summer hay cuttings were taken when either alfalfa or red clover were in the early bloom stage.

In the fall of 1987, the present study was initiated to investigate the influence of the three forage systems on yield, botanical composition and N accumulation in the forage produced. Three replications of each treatment were used in the present experiment. Ten plots were selected in each field to provide uniform soil types for plots on all treatments. The soil was described as fine-loamy to clayey mixed mesic Typic Hapludult. Plots were .5 m^2 and were located randomly within the area selected as having similar soil type. Plots were permanately identified for the duration of the experiment by driving two wooden stakes in opposite corners. One stake was covered with a metal cap on which the plot number was imprinted.

Soil samples were collected on three dates, November 20, 1987, May 19, 1988 and December 20,1988. Samples were taken from the A and B horizons, to a depth of approximately 76 cm. The change from the A to the B horizon was recognized by the color change and approximately 5 cm of soil in the transition zone surrounding the horizon change was discarded. Samples were composited for plots 1 through 5 and 6 through 10 by horizon and were mixed together at the time of sampling. Samples were placed in a freezer immediately. Soil classification and uniformity within sampling areas was determined after the first sampling date. As a result, plots in one of the tall fescue-N and two of the tall fescue-red clover pastures had to be relocated so soil types would be similar for all plots. Samples from the first sampling of these pastures were discarded.

Prior to analysis, soil samples were thawed, large clumps were gently separated and samples were thoroughly mixed. Soil NH_4^+ and NO_3^- were extracted following the procedure of Keeney and Nelson (1982) using 6 g of wet soil and 50 ml of 1 *M* KCl. The solution was analyzed colorimetrically for NO_3^- and NH_4^+ using a Quick Chem automated ion analyzer[2]. Soil NO_3^- and NH_4^+ were converted to an oven-dry basis.

This experiment consisted of a completely randomized design with three replications per treatment. Data were analyzed using a general linear model (SAS, 1985). A probability level of .05 was considered for significance. Where differences in treatment or date were observed, the Tukey (HSD) studentized range test was used for mean separation.

Results and Discussion

Ammonium: Soil collected from both A and B horizons contained higher ($P \leq .01$) levels of NH_4^+ on May 19, 1988 than on the winter sampling dates (Table 1). Tall fescue-red clover soils in both the A and B horizons had higher ($P \leq .05$) levels of NH_4^+ than the other treatments. When separated by sampling dates, NH_4^+ in the A horizon was similar among all soils on November 20, 1987 and May 19, 1988. However, on December 20, 1988, all treatments differed ($P \leq .05$) with tall fescue-red clover being the highest and tall fescue-N the lowest of the three treatments.

Nitrate: Although significant differences among treatments were observed in both the A and B horizons, all levels of soil NO_3^- were extremely low (Table 2). Soil NO_3^- in the A horizon differed ($P \leq .05$) for all dates with November 20, 1987 having the highest levels followed by December 20, 1988 and May 19, 1988. Soil nitrate was lower ($P \leq .05$) on May 19, 1988 then on the

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[2] LaChat Instruments

Table 1. Ammonium content of A and B horizons of a Typic Hapludult soil as influenced by N fertilization and legumes

Horizon	Date	Stockpiling treatment			SE
		Nitrogen	Red clover	Alfalfa	
		- - - - - - - - - - - - - - ppm	- - - - - - - - - - - - - -		
A[a]	11/20/87	9.2	11.6	11.1	3.4
	5/19/88	12.9	18.6	15.6	1.8
	12/20/88	9.27[c]	12.60[d]	6.62[e]	.65
	Average	10.5[c]	14.3[d]	11.1[c]	1.06
B[b]	11/20/87	1.26	1.47	.93	.14
	5/19/88	3.75	4.94	3.47	.55
	12/20/88	1.74	2.04	2.08	.13
	Average	2.25[c]	2.82[d]	2.16[c]	.22

[a] 5/19/88 differs from other dates ($P \leq .01$; SE = 1.12).
[b] 5/19/88 differs from other dates ($P \leq .01$; SE = .23).
[cde] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

Table 2. Nitrate content of a Typic Hapludult soil as influenced by N fertilization and legumes

Horizon	Date	Stockpiling treatment Nitrogen	 Red clover	 Alfalfa	SE
		ppm			
A^{abc}	11/20/87	3.83^{f}	1.21^{g}	3.07^{fg}	.41
	5/19/88	1.81^{h}	$.69^{i}$	$.94^{i}$	.12
	12/20/88	2.32	2.24	2.61	.29
	Average	2.65^{h}	1.38^{i}	2.21^{h}	.18
B^{cde}	11/20/87	$.46^{fg}$	$.10^{f}$	$.80^{g}$	.12
	5/19/88	$.45^{f}$	$.17^{g}$	$.17^{g}$	.07
	12/20/88	.39	.42	.61	.10
	Average	$.43^{hi}$	$.23^{h}$	$.53^{i}$	.07

[a] All dates differ ($P \le .05$; SE = .16).
[b] 5/19/88 differed from other dates ($P \le .01$; SE = .16).
[c] Treatment by date interaction ($P \le .01$).
[d] 5/19/88 differs from other dates ($P \le .05$; SE = .06).
[e] 11/20/87 differs from 5/19/88 ($P \le .01$).
[fg] Means with superscripts that do not have a common superscript letter differ ($P \le .05$).
[hi] Means with superscripts that do not have a common superscript letter differ ($P \le .01$).

fall sampling dates. Treatment by date interaction was significant ($P \leq .01$). On November 20, 1987, soil NO_3^- in the A horizon of tall fescue-red clover was significantly lower ($P \leq .05$) than for tall fescue-N while tall fescue-alfalfa levels were intermediate. On December 20, 1988, soil NO_3^- levels in the A horizon were similar for all treatments. On May 19, 1988, tall fescue-N soils contained higher levels ($P \leq .01$) of NO_3^- than the other treatments. Nitrates in the A horizon do not raise as great a concern as at lower horizons. This is particularly true in pastures where there is minimal bare soil and the sod minimizes runoff and erosion. In addition, a high proportion of the plant roots are located in the A horizon, so the NO_3^- is easily removed by the plants.

In the B horizon, NO_3^- in soil samples collected on May 19, 1988 differed ($P \leq .05$) from samples obtained of the two winter dates. Date by treatment interactions were significant ($P \leq .01$). On November 20, 1988, tall fescue-red clover soils contained a lower ($P \leq .05$) concentration of NO_3^- than soils in tall fescue-alfalfa. All treatments had similar soil NO_3^- levels on December 20, 1988. On May 19, 1988, tall fescue-N had higher ($P \leq .05$) soil NO_3^- than the other treatments.

Estimated total soil N: Estimated soil NH_4^+-N levels for the A and B horizons were higher ($P \leq .01$) for tall fescue-red clover than for the other treatments, which were similar (Table 3). In other studies, (Fribourg and Johnson, 1955; Nelson and Robins, 1957; Wilkinson and Mays, 1979; Phillips, 1980; Stevenson, 1982) alfalfa supplied more N than red clover, although in the present study, NH_4^+ concentrations were higher in the tall fescue-red clover as compared to the tall fescue-alfalfa soils. However, this study only considered the N present in the soil and not the N removed by the plants and N-fixing capability of the individual legumes in these forage systems. In agreement with the results of Stewart et al. (1967), NO_3^- levels were low for all pastures with tall fescue-N having the highest level of NO_3^--N. (Table 3). Stewart et al. (1967) considered levels of 81 and 74 kg NO_3^--N ha^{-1} for fertilized native grass and alfalfa, respectively, as safe regarding possibility of groundwater contamination due to nitrate leaching. The amount of NO_3^--N in the tall fescue pastures in the present study was considerably lower than this level. Nitrate accumulation under pastures is slight, even with periodic N fertilization, due to a large extent, to the fibrous root systems of grasses which are capable of quickly removing soil N.

Table 3. Estimated NH_4^+-N and NO_3^--N of Typic Hapludult soils as influenced by N fertilization or legumes

Nitrogen form[a]	Stockpiling treatment Nitrogen	 Red clover	 Alfalfa	SE
	kg ha^{-1}			
NH_4^+-N[b]	44.6^d	62.2^e	44.8^d	3.7
NO_3^--N[c]	2.9^d	1.7^e	2.8^d	.2
Total mineral N[b]	47.4^d	63.9^e	47.5^d	3.7

[a] Calculated to a depth of 76.2 cm, based 2.2 x 10^6 kg soil per ha furrow slice (16.9 cm).
[b] 5/19/88 differs from other dates ($P \leq .01$; SE = 3.6).
[c] 5/19/88 differs from other dates ($P \leq .01$; SE = 3.6).
[de] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).

Summary: Based on these results, red clover and alfalfa supplied soil NH_4^+ in levels higher than or equal to that provided by N fertilization. Overall, NH_4^+ content of the soils on which the tall fescue-red clover were grown was higher ($P \leq .01$) than for the other treatments. Values for the soil in tall fescue-alfalfa and tall fescue-N were similar. This may have been the result of greater N fixation by the red clover, or sloughing of nodules, and decay of the red clover plants as they began to senesce as a result of their short life span. One advantage that use of legumes may have over N fertilization is the constant presence of the N source. With N fertilization, soil N levels are increased immediately following application. However, as the N is utilized by the plant or lost through other channels, the soil N levels decline.

Tall fescue-red clover soils also contained lower average concentrations of NO_3^- than the other treatments, although treatment by date interactions were significant ($P \leq .05$). Tall fescue-N soils contained a higher ($P \leq .05$) concentration of NO_3^- than both legumes in the A horizon at the spring sampling which was probably a reflection of fertilizer application. In the B horizon, tall fescue-N soil NO_3^- was higher ($P \leq .01$) than tall fescue-red clover but similar to tall fescue-alfalfa on this date. On November 20, 1987, tall fescue-alfalfa had more ($P \leq .05$) soil NO_3^- in the B horizon than tall fescue-red clover. Soil NO_3^- was similar for tall fescue-alfalfa and tall fescue-N in both horizons on the fall sampling dates. Because of the low nitrate levels in these pastures, none of these systems serve as a threat to ground water contamination.

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Chapter IV

Botanical Composition and Nitrogen Concentration in Tall Fescue Stockpiled with Nitrogen Fertilization or Grown With Legumes

Abstract

The use of legumes as an alternative to N fertilization of pastures improves animal performance and has been suggested to reduce environmental contamination. Yield, botanical composition and N accumulation by forages in 6-yr old stands of 'Kentucky 31' tall fescue pastures either fertilized with N or grown with alfalfa or red clover were compared. Pure tall fescue pastures were fertilized using a split applicaiton of a urea-ammonium nitrate solution, annually at 160 kg N ha^{-1}

yr $^{-1}$. In 1987, 10 .5-m^2 quadrats in each of three pasture replications used for the present study were located on mixed Typic Hapludult soils. Forage samples were taken in November, 1987, and May, June, August and November of 1988. Total forage yield was unaffected by treatment. The tall fescue-N sward contained 88.7 % grass and 0 % legume while tall fescue-red clover and tall fescue-alfalfa contained 40.1 and 32.7 % grass and 53.1 and 58.9 % legume, respectively. Grass yield was similar for both legume treatments. Tall fescue-alfalfa produced more ($P \leq .05$) legume (7640 kg ha^{-1}) than tall fescue-red clover (5490 kg ha^{-1}), although legume yield as a percentage of total yield was similar for both treatments (58.9 and 53.1 %, respectively). The percentage of grass was higher ($P \leq .01$) in tall fescue-red clover than tall fescue-alfalfa in the late summer and fall, while the reverse occurred in the spring. In June, the percentage of grass was similar for these forage mixtures (40.9 and 47.1 %). Weed production was similar for all treatments, ranging from 570 to 1160 kg ha^{-1} and 5.3 to 11.1 % of total yield. Nitrogen concentration of the tall fescue differed by date but was influenced by treatment only on the first fall harvest when the N concentration in tall fescue grown with alfalfa was 2.93 %, and higher ($P \leq .01$) than in tall fescue-N or tall fescue-red clover at 2.09 and 2.00 %, respectively. Percentage N in alfalfa was higher ($P \leq .01$) than red clover only in November, 1987 at 4.43 vs 3.31 % and June, 1988 ($P \leq .05$) at 2.81 vs 2.19 % sampling dates. Tall fescue-alfalfa and tall fescue-red clover produced more ($P \leq .01$) total kg N ha^{-1} in above-ground forage than tall fescue-N with 328, 285 and 172 kg N ha^{-1}, respectively.

Introduction

Tall fescue is grown on approximately fourteen million ha in the United States (Steen et al., 1979b; Buckner et al., 1985). This cool season grass is adapted to a wide range of environmental conditions including extremes in soil moisture, (Mott et al., 1971; Wilkinson and Mays, 1979; Steen et al., 1979a), soil pH and fertility (Steen et al., 1979a), moderate salt tolerance (Wilkinson and Mays, 1979), resistance to leaf and stem rust (Fergus and Buckner, 1972) and other conditions of stress or poor management (Mott et al., 1971; Burns and Chamblee, 1979).

Fall stockpiling of tall fescue has been an accepted management technique throughout east central United States since the late 1940's (Taylor and Templeton, 1976) Tall fescue is often considered to be one of the best cool season grasses for use in stockpiling (Matches, 1979). Fall stockpiling takes advantage of the improved quality of tall fescue in the fall (Bryan et al., 1970; Jung et al., 1976; Taylor and Templeton, 1976; Matches, 1979; Bagley et al., 1983) while allowing the livestock producer to extend the grazing season through December (Ocumpaugh and Matches, 1977; Bradley et al., 1981). Nitrogen fertilization of tall fescue used for stockpiling is recommended to obtain maximum yield (Taylor and Templeton, 1976) and forage quality (Blaser, 1964; Bryan et al., 1970) for grazing livestock.

Nitrogen fertilization has been related to nitrate toxicity in grazing livestock (Farra and Satter, 1971; Kemp et al., 1977; Vertregt, 1977; Wilkinson and Mays, 1979; Burrows et al., 1987), pollution of streams and lakes as a result of runoff and erosion (Delwiche, 1970) and NO_3^- leaching resulting in potential contamination of the ground water (Stewart et al., 1967; Delwiche, 1970; Wilkinson and Mays, 1979; Nielson et al., 1982; Stevenson, 1982; Riggan et al., 1985). An alternative source of N for pastures is inclusion of legumes (McCloud and Mott, 1953; Fribourg and Johnson, 1955; Nelson and Robins, 1957; Chamblee, 1958a; Coffindaffer and Burger, 1958; Peterson and Bendixen, 1961; Jackobs, 1963; Delwiche, 1970; Smith et al., 1975; Vaughn and Jones, 1976; Matches, 1979; Spooner and McGuire, 1979; Wilkinson and Mays, 1979; Stevenson, 1982; Barnes et al., 1988).

Properly innoculated legumes are capable of reducing large quantities of atmospheric N through their symbiotic relationship with N-fixing ***Rhizobium*** bacteria (Delwiche, 1970; Vaughn and Jones, 1976; Phillips and Bennett, 1978; Phillips, 1980; Havelka et al., 1982; Stevenson, 1982; Labandera et al., 1988).

Characteristics which influence the establishment of legumes are determined primarily by forage species and variety (Kalton and Wilsie, 1953). However, other factors affect botanical composition of the stand once established. Attention to these factors and their management determine the persistence of the individual species used in the mixture (Van Keuren and Heinemann, 1958; Matches, 1979; Wilkinson and Mays, 1979; Casler, 1988). Mixtures need to contain species which are compatible based on morphological characteristics alone, so that one species does not shade the other prior to or following establishment (Chamblee and Lovoorn, 1953; Jackobs, 1963; Burns and Chamblee, 1979). Blaser et al. (1956) found that alfalfa seedlings grew more rapidly than other legumes. Therefore, alfalfa would be expected to be more competitive with grasses than some other legumes. Consideration should also be given to the lifespan of the legume. Legumes, such as red clover which act as bienniels require frequent reseeding (Jackobs, 1963; Graffis, 1982).

In mixtures containing alfalfa, alfalfa is generally favored during periods of drought and high temperature (Kalton and Wilsie, 1953). This is attributed to alfalfa's ability to remove soil moisture at greater depths than grasses (Chamblee, 1958b). However, high temperature with excessive water may be detrimental to alfalfa (Christian, 1977). Nitrogen fertilization nearly always results in an increase in the grass component of the mixture with a subsequent decline in the legume portion (McCloud and Mott, 1953; Peterson and Bendixen, 1961). Grazing management also plays a role in determination of the botanical composition of a grass-legume forage mixture. Alfalfa is susceptible to loss of stand as a result of continuous grazing. Therefore, in mixtures containing alfalfa, rotational grazing is recommended so that the alfalfa has a chance to recover (Counce et al., 1984; Van Keuren and Matches, 1988).

Grass-legume mixtures have been reported to produce similar (Peterson and Bendixen, 1961; Burns and Chamblee, 1979; Wilkinson and Mays, 1979) or greater yields (Graffis, 1982) than that produced by grass alone. Chamblee (1958a) reported increased growth of orchardgrass grown between two rows of alfalfa with or without partitions to separate the roots, indicating benefits above as well as below ground. He concluded that alfalfa improved orchardgrass production by shading which reduced the air temperature of the canopy or by reducing soil temperature and soil moisture evaporation. Van Riper (1960) observed higher protein production per ha in a grass-legume mixture than in a straight grass and found that the grasses themselves which were grown with alfalfa were higher in protein concentration than grasses grown with or without N fertilization. Dawson (1970) also reported higher levels of protein in grasses grown in association with legumes. Coffindaffer and Burger (1958) found an increased leaf to stem ratio in alfalfa grown with orchardgrass as compared to alfalfa grown alone.

In a preliminary sampling at the Virginia Forage Research Station[3], Middleburg, Virginia, tall fescue grown with alfalfa contained 14.5 percent crude protein and 29.8 percent fiber while tall fescue grown with red clover contained 10.6 percent crude protein and 31.8 percent fiber. These indications of potential differences in the crude protein and fiber concentration of the tall fescue led to the present study. The objectives of the present study were to determine the influence of alfalfa or red clover on the yield, botanical composition and quality of stockpiled tall fescue as compared with tall fescue stockpiled using N fertilization.

Materials and Methods

In 1987, three replications of 'Kentucky 31' tall fescue and tall fescue grown in mixture with either 'Arc' alfalfa or 'Kenland' red clover, established in 1981 and 1982 for use in a 5-yr grazing study (Allen et al., 1988) as described in Chapter 2, were used in the present study. Plant material was harvested from previously located quadrats for all treatments November 7, 1987, May 18 and

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[3] Currently the Middleburg Agricultural Research Station

19, 1988, June 29, 1988, August 8, 1988 and November 2, 1988. Additionally, forage was harvested from the tall fescue-alfalfa pastures on September 9, 1988 to correspond with the beginning of accumulation of forage for this treatment. Spring and summer sampling dates corresponded with the time at which forages were cut for hay based on the growth stage of the forage. The November sampling coincided with the time cattle began grazing the stockpiled forage. Following the November 1987 sampling date, soil types were defined. Plots in one tall fescue-N and two tall fescue-red clover pastures had to be relocated to match soil types. Samples taken from these pastures on the first sampling date were discarded.

At the time of sampling, wooden stakes were relocated and .5 m^2 quadrats made from pvc pipe were placed with staked corners identifying opposite corners of the quadrat. Plants within the quadrat were cut to approximately 2 cm from the soil surface. Plant samples were separated by hand for determination of botanical composition and samples of each species present were taken for N analysis. These samples were immediately frozen in liquid N and kept frozen until freeze-dried. Remaining samples were oven dried and weighed to determine dry matter production. Samples for N determination were weighed after freeze-drying for inclusion in yield computation and then ground to pass through a 1-mm screen on a stainless steel Wiley[4] mill. Grasses and legumes were composited by species into two samples per replication for quality analysis. Sample 1 consisted of plant tissue from plots 1 through 5 while sample 2 was plots 6 through 10. Weeds were composited for a total weight of no less than .5 g for plots 1 through 10. Plant samples were analyzed for total N by the micro-Kjeldahl procedure of Nelson and Sommers (1973). Dry matter was determined and results are presented on a dry matter basis.

This experiment consisted of a completely randomized design with three replicates per treatment. There were 10 observations per replicate for yield data. Plots 1 through 5 and 6 through 10 were composited for N analysis of grass and legumes. Plots 1 through 10 were composited for N analysis of weeds. Data were analyzed using GLM (SAS, 1985). Probability level of .05 was considered for significance. Where differences in treatment or date were observed, the Tukey (HSD)

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[4] Thomas-Wiley Mill. Model ED-5. Arthur H. Thomas Company, Philadelphia, PA.

studentized range test was used for mean separations. When significant differences indicated by GLM and the standard error were not observed by Tukey, the Duncan mean separation procedure was used as mentioned in the discussion.

Results and Discussion

Total annual forage yield was similar for all treatments (Table 4). More ($P \leq .01$) grass was produced by tall fescue-N than tall fescue-red clover or tall fescue-alfalfa as would be expected. Tall fescue-alfalfa had higher ($P \leq .05$) legume yield than tall fescue-red clover. Total annual forage production of both tall fescue-legume mixtures were similar. However, yield components as a percentage of total yield followed the same trend. Weed production was similar for all treatments. Yield of all components differed by date ($P \leq .01$) with treatment by date interactions ($P \leq .01$).

Changes in botanical composition were observed for individual harvest dates (Table 5). When comparing botanical composition of the three forages, grass was consistently higher ($P \leq .01$) and legume was lower ($P \leq .01$) for tall fescue-N as compared to the other treatments. On the November, 1987, August and November, 1988 sampling dates, tall fescue-red clover contained more grass and less legume than tall fescue-alfalfa ($P \leq .01$). In May, 1988, tall fescue-alfalfa contained more grass ($P \leq .05$) and less legume ($P \leq .01$) than tall fescue-red clover. Grass content was similar for both legume treatments on the June harvest date while red clover contained more legume ($P \leq .05$). Tall fescue-N contained more weeds ($P \leq .01$) than the other treatments in November, 1987 and 1988. Tall fescue-alfalfa contained a higher percentage of weed in May, 1988 compared to the other treatments. Weed yields were statistically similar for all treatments on the June and August, 1988 sampling dates.

Nitrogen concentration of the tall fescue differed by date only for the November, 1987 sampling when tall fescue found in the tall fescue-alfalfa plots was higher ($P \leq .01$) in N than the other

Table 4. Total annual yield and botanical compositon of forages produced by tall fescue stockpiling during 1988

Item[a]	Tall fescue stockpiling treatment Nitrogen	 Red clover	 Alfalfa	SE
Total forage yield[bc], kg ha^{-1}	10,590	10,540	12,990	656
Grass[cd]				
Total, kg ha^{-1}	9410[g]	4310[h]	4260[h]	557
Percentage	88.7[g]	40.1[h]	32.7[h]	2.7
Legume[ce]				
Total, kg ha^{-1}	3[i]	5490[j]	7640[k]	275
Percentage	.0[g]	53.1[h]	58.9[h]	3.5
Broadleaf weeds[cf]				
Total, kg ha^{-1}	1160	570	1160	279
Percentage	11.1	5.3	8.9	2.6

[a] Yield reported on a dry matter basis.
[b] Differ by dates ($P \leq .01$; SE = 106).
[c] Treatment by date interaction ($P \leq .01$).
[d] Differ by dates ($P \leq .01$; SE = 83).
[e] Differ by dates ($P \leq .01$; SE = 70).
[f] Differ by dates ($P \leq .01$; SE = 44).
[gh] Means with superscripts that do not have a common superscript letter differ ($p \leq .01$).
[ijk] Means with superscripts that do not have a common superscript letter differ ($p \leq .05$).

Table 5. Botanical composition and total yield by date of harvest as influenced by N fertilization and legumes

		Tall fescue stockpiling treatment			
Date[a]	Forage type	Nitrogen	Red clover	Alfalfa	SE
11/7/87	Grass, percent	99.6^{b}	73.2^{c}	28.0^{d}	3.7
	Legumes, percent	$.0^{b}$	26.6^{c}	67.2^{d}	3.8
	Weeds, percent	$.4^{b}$	$.2^{b}$	4.7^{c}	1.1
	Total, kg ha^{-1}	4410^{b}	2920^{c}	1940^{d}	180
5/18,19/88	Grass, percent	90.3^{e}	35.0^{f}	46.1^{g}	3.1
	Legumes, percent	$.0^{b}$	55.4^{c}	36.3^{d}	2.4
	Weeds, percent	9.7^{e}	9.6^{e}	17.5^{f}	2.3
	Total, kg ha^{-1}	6250^{e}	4990^{f}	5350^{f}	240
6/29/88	Grass, percent	97.8^{b}	40.9^{c}	47.1^{c}	3.3
	Legumes, percent	$.0^{e}$	58.0^{f}	47.8^{g}	3.0
	Weeds, percent	2.2	1.0	5.1	1.7
	Total, kg ha^{-1}	1520	2260	2040	250
8/8/88	Grass, percent	93.8^{b}	32.7^{c}	10.1^{d}	2.4
	Legumes, percent	$.3^{b}$	64.9^{c}	87.0^{d}	2.3
	Weeds, percent	5.9	2.4	2.8	1.1
	Total, kg ha^{-1}	560^{e}	950^{f}	2670^{g}	100
9/9/88	Grass, percent			30.5	2.7
	Legumes, percent			65.4	2.8
	Weeds, percent			4.10	.68
	Total, kg ha^{-1}			1185	70
11/2/88	Grass, percent	82.3^{b}	61.0^{c}	6.1^{d}	3.1
	Legumes, percent	$.0^{b}$	36.3^{c}	91.3^{d}	2.4
	Weeds, percent	17.7^{b}	2.7^{c}	2.6^{c}	2.1
	Total, kg ha^{-1}	2250^{be}	2070^{bce}	1680^{cf}	107

[a] Dry matter basis.
[bcd] Means with superscripts that do not have a common superscript letter differ ($p \leq .01$).
[efg] Means with superscripts that do not have a common superscript letter differ ($p \leq .05$).

treatments (Table 6). Alfalfa was higher in percentage N at the November, 1987 ($P \leq .01$) and June, 1988 ($P \leq .05$) harvests, compared to red clover. Using Duncan's procedure, weed N concentration was higher ($P \leq .05$) for tall fescue-alfalfa than tall fescue-N in November, 1988 and similar for all treatments at all other dates.

When total N ha^{-1} in the above ground portion of the pasture (Table 7) was calculated, tall fescue-N produced less ($P \leq .01$) N ha^{-1} than the other treatments. Both forages containing legumes were similar in total N production. Total N ha^{-1} in the grass component was similar for both grass-legume mixtures, but was greater ($P \leq .05$) in the alfalfa than the red clover. As would be expected, essentially all of the N produced in the tall fescue-N was contained in the grass since the sward consisted primarily of grass. Nitrogen ha^{-1} in weeds was similar for all treatments. Nitrogen ha^{-1} in the above ground biomass of the tall fescue-N sward was approximately equal to the amount of N applied as fertilizer-N.

Summary: Similar total annual forage yield was achieved with the tall fescue-legume mixtures as for the tall fescue receiving N fertilization. Botanical composition varied by date. Tall fescue-alfalfa contained more legume and less grass than tall fescue-red clover on the November and August harvests. In May and June this was reversed, when tall fescue-red clover contained more legume and less grass. Weed content was similar for all treatments for individual harvest dates with the exception of the two November harvests. Tall fescue-alfalfa contained more ($P \leq .01$) weeds than the other treatments in November, 1987 while tall fescue-N contained more ($P \leq .01$) weeds than the legume treatments in November, 1988.

Nitrogen concentration of the tall fescue varied by date. Differences by treatment occurred only in November, 1987 when tall fescue-alfalfa contained a higher percentage of N than the other treatments. This followed the indication of the preliminary study but occurred only on the single date. Precipitation levels were extremely low in 1988, so perhaps the lack of available soil moisture limited grass uptake of N which was utilized in 1987. Alfalfa had higher N concentrations than the red clover only in November, 1987 and June 1988. On the other dates, N concentration was similar for the two legumes. Total N ha^{-1} in above ground biomass was higher ($P \leq .01$) for tall fescue grown with legumes than tall fescue-N. Therefore, growing tall fescue with alfalfa and red clover

Table 6. Nitrogen composition of fescue, legumes and weeds as influenced by N fertilization or legume treatments

Item[a]	Date	Tall fescue stockpiling treatment: Nitrogen	Red clover	Alfalfa	SE
		%			
Tall fescue[bc]					
	11/7/87	2.09[e]	2.00[e]	2.93[f]	.12
	5/18,19/88	1.76	2.73	1.98	.34
	6/29/88	1.97	2.23	2.10	.14
	8/8/88	2.63	3.45	2.38	.37
	9/9/88[i]			2.39	.21
	11/2/88	1.84	2.19	1.60	.21
Legume[bd]					
	11/7/87		3.31[e]	4.43[f]	.04
	5/18,19/88		3.27	2.83	.36
	6/29/88		2.19[f]	2.81[g]	.18
	8/8/88	.80[e]	3.34[f]	3.45[f]	.24
	9/9/88[i]			2.55	.07
	11/2/88		2.64	2.39	.22
Weeds					
	11/7/87			1.14	
	5/18,19/88				
	6/29/88	2.42	1.22	2.42	.70
	8/8/88	1.24	1.81	2.13	.43
	9/9/88[i]			2.28	.39
	11/2/88	1.23	1.32	1.87	.19

[a] Dry matter basis.
[b] Differ by date ($P \leq .01$)
[c] Treatment by date interaction ($P \leq .05$).
[d] Treatment by date interaction ($P \leq .01$).
[ef] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).
[gh] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).
[i] Tall fescue-alfalfa only harvested on this date.

Table 7. Nitrogen production of forage as influenced by N fertilization or legume treatments

Item[ab]	Tall fescue stockpiling treatment			SE
	Nitrogen	Red clover	Alfalfa	
	kg/ha			
Total[cd]	172[i]	285[j]	328[j]	14
Grass[de]	157[i]	103[ij]	85[j]	12
Legume[df]	0[i]	165[j]	225[k]	27
Weeds[gh]	14.7	12.4	19.1	3.8

[a] Dry matter basis.
[b] May, June, August, September, November, 1988 harvests included.
[c] Differs by date ($P \leq .01$; SE = 6.4).
[d] Treatment by date interaction ($P \leq .01$).
[e] Differs by date ($P \leq .01$; SE = 4.2).
[f] Differs by date ($P \leq .01$; SE = 5.2).
[g] Differs by date ($P \leq .01$; SE = 1.7).
[h] Treatment by date interaction ($P \leq .05$).
[ijk] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

provided similar forage yield as that achieved with N fertilization, while increasing N produced ha^{-1} in the above-ground forage. Most of the N applied as fertilizer N appeared to be contained within the tall fescue-N plant canopy.

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Chapter V

Nitrogen and Cell Wall Composition of Esophageal Extrusa of Steers Grazing Tall Fescue Stockpiled with N Fertilizer or Legumes

Abstract

Environmental concerns and emphasis on improved animal performance suggest use of legumes as an alternative to N fertilization of pastures. Six esophageally fistulated and canulated Angus steers were randomly assigned to three pasture treatments for a 15-d grazing study to determine the influence of N fertilization or legumes on N and cell wall (NDF) concentration of ingested forage. 'Kentucky 31' tall fescue was established alone and in mixture with alfalfa or red clover on predominantly Typic Hapludult soils in 1981 and 1982 for use in a 5-yr grazing study. Pure tall fescue pastures were fertilized using a split application of a urea-ammonium nitrate solution, at 160

kg N ha^{-1} yr^{-1}. Pasture treatments were replicated twice with one esophageally cannulated steer per pasture. A sample of esophageal extrusa was collected immediately following introduction to the pastures in mid-afternoon on November 3 (d 1) with subsequent samples taken daily from each steer at approximately 0600 for a total of 15 d. Nitrogen concentration in esophageal samples was determined for each d and NDF was determined for d 1, 2 and 15. Separate grass and legume samples were hand-clipped from the pastures on November 4, 8, 11 and 17 (d 2, 6, 9, 15) and analyzed for N. Hand-clipped samples for November 4 and 17 (d 2, 15) were analyzed for NDF. Non-cannulated steers grazing with the cannulated steers were weighed initially and at 28-d intervals. Available forage at the time grazing began was lower ($P \leq .01$) for tall fescue-alfalfa pastures than tall fescue-N or tall fescue-red clover, being 1680, 2250 and 2070 kg ha^{-1}, respectively. Tall fescue-alfalfa contained a higher ($P \leq .01$) percentage of legume than tall fescue-red clover. Nitrogen concentration in esophageal extrusa of steers grazing tall fescue-alfalfa contained a higher ($P \leq .05$) percentage of N, compared to the other treatments, only on November 3 (d 1). Averaged over 3-d intervals, N concentrations in tall fescue-alfalfa were higher ($P \leq .01$) compared to the other forages, on November 3 to 8 (d 1 to 6). Percentage N in esophageal extrusa declined linearly ($P \leq .01$) for tall fescue-alfalfa and tall fescue-red clover during the grazing period. Selective grazing was implicated for steers grazing all three forages by higher concentrations of N in the extrusa as compared to the hand-clipped grass, alone, on November 4, 8 and 11 (d 2, 6 and 9). In addition, on November 4 and 8 (d 2 and 6) N percentage in extrusa exceeded N in the hand-clipped legume. Cell wall increased ($P \leq .01$) between November 3 to 17 (d 1 and 15). Percent NDF in legume was lower ($P \leq .01$) than in grass. Red clover, with 40 percent, was higher ($P \leq .05$) in NDF than alfalfa which contained 28 percent. Steers grazing grass-legume mixtures had higher ($P \leq .05$) average daily gains for the first 28-d interval of grazing the stockpiled pastures. These results indicate the increased N and decreased NDF intake, compared to hand-clipped samples, of steers grazing tall fescue stockpiled with legumes, implicating the occurrence of selective grazing. Forage quality, as selected by the grazing animal, can be improved by the inclusion of legumes in a stockpiling system, as an alternative to N fertilization, providing the potential for improved animal performance.

Introduction

Selective grazing by livestock was recognized as early as 1927 by Stapledon. Johnstone-Wallace and Kennedy (1944) estimated that a cow would walk approximately 3.1 km per d. With such great mobility, livestock have ample opportunity to cover a wide range of forage situations. Livestock selectively graze according to plant species (Johnstone-Wallace, 1937; Edlefsen et al., 1960; Cook, 1964; Van Dyne and Heady, 1965; Jeffries and Rice, 1969; Obioha et al., 1970), maturity (Cook, 1964) and plant part (Stapledon, 1927; Johnstone-Wallace and Kennedy, 1944; Blaser et al., 1960; Edlefsen et al., 1960; Cook, 1964).

Generally, grazing livestock select legumes rather than grasses (Blaser et al., 1960; Bredon and Torell, 1967). Peiper et al. (1959) found that on rangeland where only grass and shrubs were available, sheep preferred plants in a more immature growth stage to older or dead herbage (Johnstone-Wallace, 1937; Johnstone-Wallace and Kennedy, 1944; Grimes et al., 1965). In addition, leaves are chosen in preference to stems (Stapledon, 1927; Johnstone-Wallace, 1937; Johnstone-Wallace and Kennedy, 1944; Meyer et al., 1957).

Other factors affecting selective grazing include livestock species, grazing intensity, time of d and weather conditions (Cook, 1964). Sheep are considerably more adept at selective grazing than cattle (Meyer et al., 1957; Cook et al., 1963; Van Dyne and Heady, 1965). Although Meyer et al. (1957) recognized this with alfalfa, they found little difference between selectivity of sheep and cattle grazing a birdsfoot trefoil-orchardgrass mixture. They concluded that selective grazing was not as effective in a low, dense forage as in a tall, dense forage. Meyer et al. (1957) also found that on forage with lower palatability, forage intake by sheep was decreased by their selectivity while steers were able to increase intake, and therefore, their performance, since they were less selective. Van Dyne and Heady (1964) also found more variation due to individual animal variability in sheep than in cattle. As grazing intensity increases, the amount of forage available for selective grazing declines followed by decreased digestibility, forage intake and individual animal performance (Pieper et al., 1959; Weir and Torell, 1959; Blaser et al., 1960; Jeffries and Rice, 1969). Van Dyne and Heady (1965) reported that sheep and cattle grazed slower and more selectively in the afternoon as compared to morning, but significant differences did not exist for botanical composition of forage chosen as related to time.

Many methods have been developed in an attempt to quantify the influence of selective grazing. Some methods include hand clipping of samples believed to be similar to those ingested by the grazing animal (Torell, 1954; Weir and Torell, 1959; Edlefsen et al., 1960; Cook, 1964; Bredon and Torell, 1967; Jeffries and Rice, 1969; Kiesling et al., 1969; Barth and Kazzall, 1971; Langlands, 1974), harvest prior to and immediately following grazing (Cook, 1964), the bite count method (Free et al., 1971), analysis of fecal samples (Vavra et al., 1978; McInnis et al., 1983), collection of samples via rumen fistulation (Rice et al., 1971; Mayland and Lesperance, 1977; McInnis et al., 1983), and collection of samples via esophageal fistulation (Torell, 1954; Cook et al., 1958; Edlefsen et al., 1960; Galt et al., 1968; Laycock et al., 1972; Langlands, 1974; Vavra et al., 1978; McInnis et al., 1983). The use of esophageally fistulated livestock is generally considered to be the most effective of these methods since the sample is actually chosen by the animal and is gathered prior to digestion as occurs in rumen samples. (Cook et al., 1958; Laycock et al., 1972; Langlands, 1974; Vavra et al., 1978).

Selectivity of animals, as measured using esophageally fistulated animals, results in increased crude protein (Weir and Torell, 1959; Edlefsen et al., 1960; Cook et al., 1963; Bredon and Torell, 1967; Jeffries and Rice, 1969; Kiesling et al., 1969) and decreased fiber (Weir and Torell, 1959; Kiesling et al., 1969; Bredon and Torell, 1967) in the diet as compared to hand clipped samples. Weir and Torell (1959) concluded that with high forage availability, sheep were able to select a diet with 4.1percent more crude protein and 3.5 percent less crude fiber as compared to clipped samples. On previously grazed pasture, the sheep selected 3.0 percent more crude protein and .90 percent less crude fiber. Bredon and Torell (1967) found that steers grazing tropical pastures consisting of numerous plant species increased crude protein consumption 66.4 percent and decreased crude fiber by 7.71 percent due to selective grazing.

In the present study, esophageal extrusa collected from esophageally fistulated, cannulated steers was used to investigate the influence of N fertilization, red clover, or alfalfa with tall fescue on N and NDF composition of ingested forage. Esophageal and hand-clipped samples were used to indicate the trend of forage quality as related to time and decreased availability of forage. Non-cannulated steers were also used to indicate related animal performance on the stockpiled pastures.

Materials and Methods

In the fall of 1988, three replications of 'Kentucky 31' tall fescue and tall fescue grown in mixture with either 'Arc' alfalfa or 'Kenland' red clover, established in 1981 and 1982 for use in a 5-yr grazing study (Allen et al., 1988) as described in Chapter 2, were used in the present study. Six, 2-yr old Angus steers were esophageally fistulated by the procedure of Torell (1954) and fitted with cannulas as developed by Ellis et al. (1984) to study the influence of the three forage treatments on N and NDF composition of esophageal extrusa as influenced by selective grazing. Steers were randomly assigned to the three forage treatments with one steer per pasture and two replications per treatment. Prior to the trial, steers were grouped together on orchardgrass pasture. During the grazing study, fistulated steers were grouped with three non-cannulated steers of similar breed and weight. Non-cannulated steers were blocked by weight and randomly assigned to pastures. Full and shrunk weights were obtained initially and at 28-d intervals for a concurrent study.

Esophageal extrusa was collected for a total of 15 consecutive d beginning November 3, 1988, which corresponds with the time that grazing of stockpiled forage traditionally begins. The first collection was made in mid-afternoon, at the time steers were placed on the stockpiled forage. The remaining collections were made at approximately 0600 each d, to correspond with sunrise.

Esophageal extrusa was collected in plastic bags with the lower corners removed to allow drainage of exess saliva. Samples early in the study were oven-dried immediately at 60 C. Later samples were frozen and oven-dried at a later date. Samples were ground to pass through a 1-mm screen on a stainless steel Wiley[5] mill for chemical analysis.

Pastures were sampled on November 4, November 8, November 11 and November 17, 1988 (d 2, 6, 9 and 15). Two samples each of grass and legume were clipped at random throughout the pasture in an attempt to mimic the selection of the steer for particular plant parts. Clipping height varied as the available forage decreased, but ranged from within 5 to 10 cm of the soil surface. Samples were frozen, freeze-dried and ground to pass through a 1-mm screen in a stainless steel Wiley mill for later analysis.

All esophageal extrusa and forage samples were analyzed for total N using the micro-Kjeldhal procedure of Nelson and Sommers (1973). Esophageal and forage samples for the first, second and final d of collection were analyzed for neutral detergent fiber (NDF; Van Soest and Wine, 1967; Goering and Van Soest, 1970).

This experiment was a randomized design with two replicates per treatment. Data were analyzed using GLM (SAS, 1985). A probability level of .05 was considered for significance. Where differences were observed the Tukey (HSD) studentized range test was used as a means separation procedure.

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[5] Thomas-Wiley Mill. Model ED-5. Arthur H. Thomas Company, Philadelphia, PA.

Results and Discussion

Available forage at the beginning of the grazing study was estimated using the small plots described in chapter IV (Table 4) to be 2250, 2070 and 1680 kg ha^{-1} for tall fescue-N, tall fescue-red clover and tall fescue-alfalfa, respectively, with tall fescue-alfalfa having lower ($P \leq .01$) available forage than the other treatments. However, percent legume was higher ($P \leq .01$) for tall fescue-alfalfa at 91.3 % than for tall fescue-red clover which contained 36.3 %. There was no legume in tall fescue-N pastures. Weeds comprised 17.7 % of the total yield in tall fescue-N, being higher ($P \leq .01$) than tall fescue-red clover or tall fescue-alfalfa which contained 2.7 and 2.6 percent weeds, respectively.

Nitrogen: Percentage N in esophageal extrusa (Table 8) of steers grazing stockpiled tall fescue-alfalfa was higher ($P \leq .05$) than for the other treatments only on November 3, when the dates where considered individually. When averaging over 3-d intervals (Figure 1), esophageal extrusa of steers grazing tall fescue-alfalfa was higher ($P \leq .01$) in concentration of N through November 8, 1988. The N concentration of the esophageal extrusa declined linearly ($P \leq .01$) for tall fescue-alfalfa and tall fescue-red clover. The magnitude of the decrease was most evident with tall fescue-alfalfa, since initial N concentration was higher for this treatment.

On November 4, 8, and 11 (d 2, 6, and 9) esophageal extrusa contained more N than was measured in the grass alone for all treatments (Table 9). On November 4 and 8, esophageal extrusa from the tall fescue-legume mixtures exceeded the N concentration of the hand-clipped legume. These values may indicate the steers were successful in selectively grazing plant parts as well as legumes to increase their N intake. This is also in agreement with other researchers that hand-clipping is not an accurate method of determining quality of forage ingested by the grazing animal (Torrell, 1954; Weir and Torell, 1959; Edlefsen et al., 1960; Cook, 1964; Bredon and Torell, 1967; Jeffries and Rice, 1969; Kiesling et al., 1969; Barth and Kazzall, 1971; Langlands, 1975 Pigurina, 1986).

Table 8. Percentage N in esophageal extrusa of steers grazing tall fescue stockpiled with N fertilization or legumes

Date[abc]	Tall fescue stockpiling treatment			SE
	Nitrogen	Red Clover	Alfalfa	
		%		
11/3/88	2.14[d]	2.50[d]	4.05[e]	.26
11/4/88	2.37	2.89	3.94	.45
11/5/88	2.50	2.88	3.38	.21
11/6/88	2.55	2.75	3.84	.25
11/7/88	2.08	2.51	3.95	.24
11/8/88	2.71	2.67	3.63	.42
11/9/88	2.71	2.75	2.89	.43
11/10/88	2.97	2.38	3.36	.26
11/11/88	2.16	2.09	2.96	.35
11/12/88	2.24	2.40	3.02	.24
11/13/88	2.25	1.93	2.85	.40
11/14/88	2.36	2.27	1.97	.44
11/15/88	1.92	1.75	3.05	.39
11/16/88	2.05	2.59	2.30	.33
11/17/89	1.95	1.85	1.51	.24

[a] Dry matter basis.

[b] Percent N differs by date ($P \leq .01$; SE = .20).

[c] Treatment by date interaction ($p \leq .01$).

[de] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

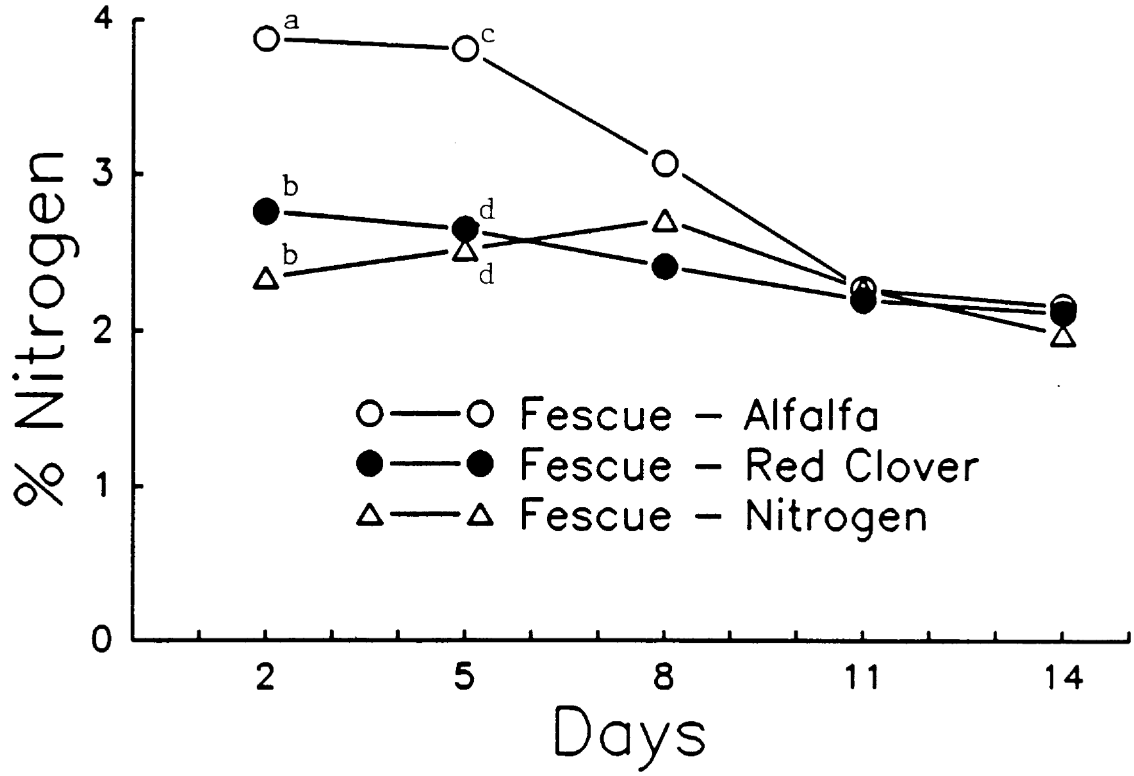

Figure 1. **Concentration of N in esophageal extrusa of steers grazing stockpiled tall fescue using N fertilization or legumes (3-d avg)** ^{ab}Means with superscripts that do not have a superscript letter in common differ ($P \leq .01$; SE = .17). ^{cd}Means with superscripts that do not have a superscript letter in common differ ($P \leq .01$; SE = .16).

Table 9. Nitrogen composition of individual species in tall fescue stockpiled with N fertilization or legumes

Forage type[a]	Date	Tall fescue stockpiling treatment			SE
		Nitrogen	Red Clover	Alfalfa	
		%			
Fescue					
	11/4/88	1.88	1.73	2.20	.16
	11/8/88	1.94	1.78	1.96	.15
	11/11/88	2.10	1.92	2.20	.11
	11/17/88	1.99^c	1.41^d	1.53^{cd}	.13
Legume[b]					
	11/4/88		2.79^c	3.79^d	.08
	11/8/88		3.41^e	3.89^f	.12
	11/11/88		3.36^c	3.95^d	.09
	11/17/88		2.63	3.25	.16

[a] Reported on a dry matter basis.

[b] 11/8/88 and 11/11/88 differ from 11/4/88 and 11/17/88 ($P \leq .01$; SE = .08).

[cd] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).

[ef] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

Many researchers have studied the influence of saliva contamination on the composition of esophageal extrusa. Numerous reports indicate that the high ash content of saliva does increase the ash concentration of the esophageal samples (Bath et al., 1956; Lesperance et al., 1960a; Hoehne et al., 1967; Campbell et al., 1968; Barth et al., 1970; Wallace et al., 1972; Mayland and Lesperance, 1977; Cohen, 1979; Hart, 1983). Cohen (1979) found a loss of N in esophageal extrusa only when the N concentration was high, being in excess of 2.74 percent. The hand-clipped legumes in this study were in this range and may have been affected. Lesperance et al. (1960b) reported that salivary contamination had no effect on crude protein content of the sample. Hart (1983) observed that crude protein concentration was decreased when samples were rinsed to remove saliva, but that squeezing of the samples had no effect on percentage crude protein. Samples in the present study were not rinsed and should not have lost N in this manner.

Using a simple arithmetic equation, the relative levels of legumes needed to increase the N concentration of the extrusa above that of the grass can be suggested. Two assumptions which must be made include: 1) no weeds were grazed, 2) N concentration of ingested forage was similar to clipped grass and legume samples. Using these assumptions, on the November 8 (d 6) sampling date, 87 % of the forage ingested on the fescue-alfalfa treatment would need to be alfalfa with the remaining 13 percent grass for the esophageal extrusa to contain 3.63 % N while fescue contained 1.96 % and alfalfa contained 3.89 % N. For tall fescue-red clover steers, 55 percent red clover would need to be ingested to achieve 2.67 percent N in the extrusa with fescue and red clover concentrations being 1.78 and 3.41 percent N, respectively. These numbers give indications of the degree of selectivity for legumes required, but are not absolute since weeds were present in the pastures and would have varied the N levels. Steers may have selectively chosen weeds high or low in N which are not considered in this study. Also, selectivity may have been practiced for plant parts, such as more immature grass leaves, or leaves versus stems in the legumes or for younger, more immature growth as opposed to older or dead material. As a result of the ability of livestock to selectively graze, clipped forages are generally not equivalent to forages ingested by livestock.

Cell wall: Cell wall concentration tended to increase over time in the esophageal extusa as indicated by the lower ($P \leq .01$) percentage of NDF on November 3 as compared to November

17 (Table 10). Several factors may contribute to this difference. On the initial sampling date, November 3 (d 1), sampling occured in the afternoon as compared to early morning for the subsequent samples. In addition, these samples were taken from the cattle as they first grazed without prior adjustment to these pastures. Concentration of NDF in the clipped forage components also increased ($P \leq .01$) from November 4 to 17 (d 2, 15; Table 11).

In analysis of individual forage components, legumes contained less ($P \leq .01$) NDF than grass. Grass NDF was similar for all treatments. Red clover had a higher ($P \leq .05$) percentage of NDF than alfalfa on both November 4 and 17 (d 2 and 15). This may be attributed to species variation as well as differences in maturity.

Pigurina (1986) indicated that mastication and mixture with saliva of ingested forage collected via esophageal fistulation did not affect NDF concentration in studies where known percentages of grass and legume were fed. This indicates the potential for using NDF to determine the botanical composition of esophgeal extrusa. Using the NDF concentration of the esophageal extrusa, tall fescue and legumes indicates that on November 4 (d 2), steers grazing tall fescue-alfalfa ingested 99 % grass while those grazing tall fescue-red clover consumed 82 % grass. This varies considerably from the estimates based on N concentration, and would be impossible to achieve given the N concentration of the components. Pigurina (1986) also recognized difficulty in calculating botanical composition of esophageal extrusa of steers grazing forage, since higher NDF concentrations were observed in the esophageal extrusa than in the pasture components. The findings of the present study support his recommendation that other methods be used for this determination.

Animal performance: Steers grazing the grass-legume mixtures had higher ($P \leq .05$) total and average daily gains than steers grazing tall fescue-N over the 28-d interval immediately following the beginning of grazing of stockpiled forage (Table 12). This was due to the improvement in forage quality recognized as a result of the inclusion of a legume. These results may change as grazing continued and amount of available pasture declined.

Summary: Throughout the trial, N concentration tended to decrease while NDF concentration increased for both esophageal extrusa and plant samples. A portion of this could be attributed to the advancing maturity of the forage as indicated further by the increase in NDF

Table 10. Cell wall concentration of esophageal extrusa of steers grazing tall fescue stockpiled with N fertilization or legumes

	Tall fescue stockpiling treatment			
Date[ab]	Nitrogen	Red Clover	Alfalfa	SE
		%		
11/3/88	37.5	36.2	27.0	2.5
11/4/88	49.5	44.1	34.9	7.6
11/17/88	56.0	47.4	56.6	4.2

[a] Dry matter basis.
[b] 11/3/89 differed from 11/17/88 ($P \leq .01$; SE = 3.02).

Table 11. **Cell wall composition of individual species in stockpiled forage at beginning and end of sampling.**

Forage type[a,b]	Date	Tall fescue stockpiling treatment			
		Nitrogen	Red Clover	Alfalfa	SE
		%			
Fescue[c]					
	11/4/88	38.9	47.0	35.0	3.6
	11/17/88	50.1	56.6	58.4	1.4
Legume[d]					
	11/4/88		30.82[e]	21.60[f]	.98
	11/17/88		48.9[e]	35.1[f]	1.9

[a] Dry matter basis.

[b] Tall fescue differs from legumes ($P \le .01$; SE = 3.3).

[c] 11/4/88 differs from 11/17/88 ($P \le .01$; SE = 1.5).

[d] 11/4/88 differs from 11/17/88 ($P \le .01$; SE = 1.1).

[ef] Means with superscripts that do not have a common superscript letter differ ($P \le .05$).

Table 12. Performance (28-d) of steers grazing with esophageally fistulated steers on stockpiled forages.

Item	Tall fescue stockpiling treatment			SE
	Nitrogen	Red Clover	Alfalfa	
		kg		
Initial weight	221.9	218.1	219.5	3.4
Total gain	18.9^a	23.7^b	23.5^b	1.3
Average daily gain	.674^a	.847^b	.839^b	.05

^{ab}Treatments with superscripts that do not have a common superscript letter differ ($P \leq .05$).

concentration of fescue and legumes on November 17 (d 15) as compared to November 4 (d 2). In addition, by grazing, the steers were decreasing the forage available for selection. This was most easily observed in tall fescue-alfalfa. As the alfalfa was removed from the pasture, the percentage N in the esophageal extrusa approached that of the extrusa of steers on the other treatments.

Tall fescue-alfalfa allowed for ingestion of higher quality forage than in tall fescue-N or tall fescue-red clover using the management practices employed in this case. Tall fescue-alfalfa was higher quality forage compared with tall fescue-red clover, containing more N and less NDF associated primarily with the differences in the legume components, alfalfa and red clover. Selectivity was practiced in all of the stockpiled tall fescue forages as evidenced by the higher N levels of the extrusa as compared to the hand-clipped grass samples. Selection was probably practiced in all cases according to plant species, plant part and maturity. The decline in available forage associated with time and grazing decreased the effectiveness of selective grazing. Animal performance was higher ($P \leq .05$) for steers grazing the tall fescue containing legumes as compared to N fertilization. This may be due to the higher N concentration of both the alfalfa and red clover as compared to the tall fescue. These findings indicate benefits of using legumes in tall fescue stockpiling systems as an alternative to N fertilization.

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Chapter VI

Digestibility and Nitrogen Utilization of Stockpiled Tall Fescue as Influenced by N Fertilization and Legumes

Abstract

Environmental concerns and emphasis on high animal performance support the use of legumes in pastures as an alternative to N fertilization. A metabolism trial was conducted to investigate the influence of stockpiled tall fescue fertilized with N, or grown with alfalfa or red clover on N utilization and digestibility by wethers. 'Kentucky 31' tall fescue, tall fescue-alfalfa, and tall fescue-red clover pastures were established in 1981 and 1982 for use in a 5-yr grazing study. Pure tall fescue pastures were fertilized using a split application of a urea-ammonium nitrate solution, at 160 kg N ha^{-1} yr^{-1}. In 1988, forage from these pastures was used in a metabolism trial to compare the influence of N fertilization vs the inclusion of alfalfa or red clover on N utilization and DM digestibility of the stockpiled forages. Forages were harvested daily and 800 g of fresh forage were fed to wether lambs twice daily during a 7-d collection period preceded by a 10-d preliminary period. Tall fescue-alfalfa was higher in N ($P \leq .01$) and lower in cell wall (NDF; $P \leq .05$) concentration than the other forages. Wethers fed tall fescue-alfalfa had higher ($P \leq .01$) N intake, apparent N absorption ($P \leq .01$), N retention ($P \leq .01$) and dry matter digestibility (DMD; $P \leq .01$) than wethers fed tall fescue-N or tall fescue-red clover. Serum sodium (Na) concentration was higher for wethers fed tall fescue-alfalfa ($P \leq .05$) as compared to wethers fed the other forages. Tall fescue-red clover was similar to tall fescue-N in N and NDF concentration. Wethers fed tall fescue-red clover had lower N intake ($P \leq .01$), apparent N absorption ($P \leq .01$), N retention ($P \leq .01$), DMD ($P \leq .01$) and NDF digestibility ($P \leq .01$). Blood urea N (BUN) was higher ($P \leq .05$) in wethers fed tall fescue-alfalfa and tall fescue-red clover than tall fescue-N. Results indicate that growing tall fescue with alfalfa improves N intake, N utilization and DMD of the stockpiled forage as compared with N fertilization. Stockpiled tall fescue grown with red clover decreased N utilization and dry matter digestibility and would not be a recommended procedure for a stockpiling system in which animal performance is a major concern.

Introduction

Tall fescue is established on an estimated 14 million ha in the United States (Steen et al., 1979b; Buckner et al., 1985). Stockpiling of tall fescue allows livestock producers to take advantage of the cool season growth pattern while extending the growing season. By stockpiling, winter use of hay or other supplemental feeds may be avoided until January (Ocumpaugh and Matches, 1977; Bradley et al., 1981b). Rainfall (Jung et al., 1976; Taylor and Templeton, 1976; Ocumpaugh and Matches, 1977), temperature(Jung et al., 1976), forage maturity (Taylor and Templeton, 1976;

Ocumpaugh and Matches, 1977; Matches, 1979; Van Soest et al., 1978) and soil fertility (Blaser, 1964; Bryan et al., 1970; Taylor and Templeton, 1976) all influence yields and quality of stockpiled tall fescue. While rainfall and temperature are beyond the control of the producer, forage maturity and soil fertility can be influenced by management to improve the production of tall fescue stockpiling systems. Forage maturity in stockpiled forage at the time of grazing may be influenced by the time forage accumulation begins and the time at which the accumulated forage is grazed. Traditionally, stockpiling begins from mid-August to early September (Taylor and Templeton, 1976; Smith et al, 1987). Grazing of stockpiled tall fescue is recommended to begin in early November with the main concern being that grazing be complete before quality and productivity of the forage declines due to adverse environmental conditions by the end of December (Brown et al., 1963; Taylor and Templeton, 1976; Ocumpaugh and Matches, 1977; Smith et al, 1987).

Application of N fertilizers improves the yield and quality of stockpiled tall fescue (Blaser, 1964; Bryan et al., 1970; Taylor and Templeton, 1976). However, potential hazards including contamination of ground water as a result of leaching of nitrates (NO_3^-), NO_3^- toxicity in livestock as a result of fertilizer accumulation (Wilkinson and Mays, 1979), as well as interest in improving farm economics (Wilkinson and Mays, 1979; Jackobs, 1963) have led to interest in alternative sources of soil N. Legumes, through fixation of atmoshperic N, provide sufficient N to grasses when grown in mixtures, to equal or exceed yields of grasses grown alone or with N fertilization (McCloud and Mott, 1953; Fribourg and Johnson, 1955; Nelson and Robins, 1957; Chamblee, 1958a; Coffindaffer and Burger, 1958; Peterson and Bendixen, 1961; Jackobs, 1963; Smith et al., 1975; Matches, 1979; Spooner and McGuire, 1979; Wilkinson and Mays, 1979; Barnes et al., 1988). In addition, by using legumes with tall fescue, declines in animal performance attributed to fescue toxicity may be overcome (Gay et al., 1988).

The purpose of this research was to investigate the influence of N fertilization vs inclusion of alfalfa or red clover on N utilization, DMD and NDF digestibility of stockpiled tall fescue fed to wethers.

Materials and Methods

'Kentucky 31' tall fescue and tall fescue grown in mixture with either 'Arc' alfalfa or 'Kenland' red clover, established in 1981 and 1982 for use in a 5-yr grazing study (Allen et al., 1988) as described in Chapter 2. In 1988, forage from 3 replications of the 3 treatments was fed to 18 crossbred wethers with an average initial weight of 32.7 kg in a metabolism trial. Wethers were blocked by weight and breed and a total of six wethers were randomly assigned per treatment and housed in false bottom metabolism crates (Briggs and Gallup, 1949) in a barn. Wethers were adjusted to metabolism crates and diets during a 10-d preliminary period which preceded the collection period. During this time, wethers were fed the diets ad libitum to determine the intake level for the trial. The preliminary period was followed by a 7-d collection period. Weights were obtained on wethers prior to and at the conclusion of the metabolism trial. Blood samples were taken via jugular puncture at the conclusion of the trial.

Wethers were fed 800 g of forage on a fresh weight basis with 5 g NaCl sprinkled on top of the forage at 0900 and 1900 daily. Forage was harvested each afternoon using a Gravely[6] scythe mower. Forage from each harvest was used for the evening and following morning feedings. Forage samples were taken at random as the feed was being weighed, starting two d prior to the beginning and ending two d prior to the end of the collection period. Separate samples were taken for dry matter determination and for the other analyses. Samples for dry matter analysis were weighed and dried at 60 C in a forced air dryer. Samples were reweighed after drying and dry matter was calculated. Forage samples for the other analyses were immediately placed in a freezer. These samples were later freeze-dried and ground to pass through a 1-mm screen on a stainless steel Wiley mill[7]. There were refusals only on the first d of the trial.

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[6] [1]Gravely Corporation

[7] Thomas-Wiley Mill. Model ED-5. Arthur H. Thomas Company, Philadelphia, PA.

Feces and urine were collected daily at 0930, following the morning feeding (Chappell and Fontenot, 1968). Feces were dried at 60 C for 24 hours and composited for the entire trial in large plastic bags folded over loosely. Total fecal weight per lamb was recorded. Feces were then subsampled and ground to pass through a 1-mm screen for determination of dry matter, NDF (Van Soest and Wine, 1967; Goering and Van Soest, 1970) and N (Nelson and Sommers, 1973). Urine was collected in plastic 4 liter jars containing 50-ml of a 50:50 mixture of water and sulfuric acid diluted to approximately 500 ml with water. Urine was brought to a constant weight by the addition of water at collection. A 2 % aliquot was taken and refrigerated. At the conclusion of the trial, urine samples were frozen. Prior to analysis, urine was thawed and filtered.

Forage, refusal, fecal and urine samples were analyzed for total N concentration by the micro-Kjeldahl procedure of Nelson and Sommers (1973). Cell wall percentage was determined on forage and fecal samples (Van Soest and Wine, 1967; Goering and Van Soest, 1970). For NDF analysis, feed samples were composited by treatment and time of feeding. Blood urea N was determined on whole blood (Coulombe and Favreau, 1963). Serum was diluted (Buttrey, 1989) and analyzed for minerals using inductively-coupled plasma optical emission spectrophotometry.

The experimental design for this study was a randomized block design. Results were analyzed using the GLM analysis of variance procedure (SAS, 1985). A probability level of .05 was considered for significance. Tukey's (HSD) studentized standard range test was used where significant differences were indicated by GLM, to further identify sources of variation. When differences indicated by GLM and the standard error were not observed using the Tukey test, the Duncan procedure was used as noted in the discussion.

Results and Discussion

Dry matter percentage was similar among the stockpiled forages fed to wethers (Table 13). The concentration of N was greater ($P \leq .01$) and NDF (cell wall) was lower ($P \leq .05$) in tall fescue-alfalfa compared to other forages. Stockpiled tall fescue-N and tall fescue-red clover were similar in percentages of N and NDF.

Nitrogen intake varied ($P \leq .01$) among wethers fed the three forages with N intake being greatest for tall fescue-alfalfa and lowest for tall fescue-red clover (Table 14). Fecal N excretion differed ($P \leq .01$) for all treatments. Fecal N was greatest for wethers fed tall fescue-red clover and least for those fed tall fescue-N. This is in contrast to the conclusion of Stallcup et al. (1975) that there is a high positive correlation (.90) between fecal N and total N intake. Urinary N excretion was similar among all treatments.

All treatments differed in apparent N absorption ($P \leq .01$). Wethers fed tall fescue-alfalfa had higher apparent N absorption as reported in grams d^{-1} and as percent of intake, followed by wethers fed tall fescue-N and tall fescue-red clover. Using Duncan's procedure, N retention also differed ($P \leq .05$) among all treatments. Retention followed the same trend as absorption, with tall fescue-alfalfa having the highest ($P \leq .01$) N retention and tall fescue-red clover having the lowest. In addition, N retention was positive in wethers fed stockpiled tall fescue-alfalfa, and tall fescue-N but negative for wethers fed tall fescue-red clover.

Although all treatments were similar in dry matter content, apparent dry matter digestibility differed ($P \leq .01$) for all treatments (Table 15). Dry matter digestibility was greatest for wethers fed tall fescue-alfalfa and lowest for wethers fed tall fescue-red clover. Langlands et al. (1973) found DMD increased with increased N and sulfur (S) digestibility in the diet. The DMD in the present study supports these findings since N digestibility followed the same pattern as DMD. Apparent NDF digestibility was lower ($P \leq .01$) for stockpiled tall fescue-red clover than for tall fescue-N and tall fescue-alfalfa which were similar.

Table 13. Dry matter, N, and cell wall composition of stockpiled forage fed to wethers

	Tall fescue stockpiling treatment			
Component	Nitrogen	Red Clover	Alfalfa	SE
	- - - - - - - - - - -	%	- - - - - - - - - - -	
Dry matter	36.3	29.2	31.7	3.0
Nitrogen[a]	2.38[b]	2.19[b]	3.01[c]	.13
Cell wall[a]	48.47[d]	46.11[d]	36.55[e]	.09

[a] Dry matter basis.
[bc] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).
[de] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

Table 14. Apparent N utilization by wethers fed tall fescue stockpiled with N fertilization or legumes

	Tall fescue stockpiling treatment			
Item[a]	Nitrogen	Red clover	Alfalfa	SE
Intake, g/d	13.1^{b}	10.2^{b}	15.2^{c}	1.0
Excretion, g/d				
Fecal	5.91^{b}	7.76^{c}	6.63^{d}	.10
Urinary	6.46	6.13	6.56	.33
Apparent Absorption				
g/d	7.22^{b}	2.42^{c}	8.58^{d}	.10
% of intake	55.02^{b}	23.76^{c}	56.42^{d}	1.08
Retention				
g/d	$.76^{b}$	-3.71^{c}	2.02^{b}	.36
% of intake	5.8^{b}	-36.5^{c}	13.3^{b}	2.7

[a] Dry matter basis.

[bcd] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).

Table 15. Apparent dry matter, crude protein and cell wall digestibility of tall fescue stockpiled with N fertilization or legumes

	Tall fescue stockpiling treatment			
Item	Nitrogen	Red clover	Alfalfa	SE
		%		
Dry matter	65.85^a	49.27^b	70.10^c	.63
Cell wall	60.86^a	41.73^b	56.98^a	.93
Crude protein	55.02^a	23.76^b	56.42^c	1.08

^{abc}Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).

Blood urea N was lower ($P \leq .05$) in wethers fed tall fescue-N than in either of the grass-legume mixtures (Table 16). Blood urea N was similar for tall fescue-alfalfa and tall fescue-red clover. This may indicate differences in solubility in the forms of N present in legumes vs non-legumes.

Serum calcium, copper, iron, magnesium, phosphorus, potassium and zinc levels were similar for wethers fed all three forages (Table 16). Wethers fed tall fescue-alfalfa had higher ($P \leq .05$) levels of serum Na than those fed tall fescue-N or tall fescue-red clover. Although diets were not analyzed for Na, none of the sheep should have been deficient in Na since 5 g of NaCl were added to the forage at each feeding. In spring and summer grazing, Steen et al. (1979a) found Na levels of tall fescue to decrease with time. In addition, Coffindaffer and Burger (1958) indicated that the Na concentration of alfalfa decreases with decreasing photoperiod length. However, Na is easily supplemented in livestock diets so deficiencies are rarely observed.

Wethers fed tall fescue-alfalfa had higher ($P \leq .05$) serum S levels than those fed tall fescue-red clover. Serum S levels of wethers fed tall fescue-N were not significantly different from those in wethers fed forages including both legumes. Pendlum et al. (1980) found S to be greatest in tall fescue in April and similar to concentrations in November. Powell et al. (1978) concluded that the concentration of S in tall fescue decreased with advancing maturity. Jurgens (1984) reported .37 % S for alfalfa as compared to .17% for red clover. This, in addition to the increased maturity of the red clover as compared to the alfalfa as a result of the delay in stockpiling of the tall fescue-alfalfa may be responsible for these differences. The S content of the tall fescue grown with the alfalfa could be slightly higher due to more immature growth present with this forage as a result of the delay in stockpiling tall fescue-alfalfa as compared with tall fescue-N and tall fescue-red clover.

Evidence of S requirements and its influence on animal performance is well documented for both sheep (Thomas et al., 1951; Starks et al., 1954; Rendig and Weir, 1957; Kahlon et al., 1975b) and cattle (Chalupa et al., 1971; Boling and Gay, 1981). Sulfur functions in protein synthesis (Kahlon et al., 1975a) and cellulose digestion (Martin et al., 1964; Bull and Vandersall, 1973). Sulfur serum levels are indicative of S intake (Weir and Rendig, 1954; Rendig and Weir, 1957; Chalupa et al., 1971). Nitrogen balance has been improved in ruminants receiving supplemental

Table 16. BUN and serum mineral levels of wethers fed tall fescue stockpiled with N fertilization, red clover or alfalfa

Item	Tall fescue stockpiling treatment			SE
	Nitrogen	Red clover	Alfalfa	
BUN, mg/dl	3.45^{c}	4.15^{d}	4.44^{d}	.18
Serum Mineral, mg/dl				
Calcium	9.06	8.89	9.13	.11
Copper	.067	.161	.067	.057
Iron	.351	.239	.290	.041
Magnesium	1.830	1.818	1.936	.043
Phosphorus	9.559	10.412	10.154	.555
Potassium	16.25	15.69	17.24	.49
Sodium	293.90^{c}	294.53^{c}	303.83^{d}	2.39
Sulfur	79.41^{cd}	78.78^{d}	82.57^{c}	.98
Zinc	.112	.098	.104	.006

[ab] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).
[cd] Means with superscripts that do not have a common superscript letter differ ($P \leq .05$).

S (Thomas et al., 1951; Bull and Vandersall, 1973; Langlands et al., 1973; Kahlon et al., 1975b; Buttrey et al., 1986). Sheep on diets devoid of S experience negative N balance (Thomas et al., 1951; Kahlon et al., 1975b). Langlands et al. (1973) also found a positive correlation between the intake of dietary N and S and DMD.

Although S concentrations of the forages in the present experiment were not determined, the higher serum S levels in the wethers fed tall fescue-alfalfa suggest that this forage may have contained higher concentrations of S than the other forages. Buttrey et al. (1986) observed increased N retention in wethers fed S fertilized corn (***Zea maize*** L.) silage versus S supplemented silage, indicating the value of S in the plant. Given the role of S in DMD and N utilization, S may be a key element influencing the digestibility and utilization of N by ruminants fed the stockpiled forages in the present experiment.

Another explanation for these results may be the result of the varying degrees of endophyte infection in the different forages. Tall fescue-alfalfa was endophyte-free while concentrations in the tall fescue-N and tall fescue-red clover were 15 to 53 % and 8 to 48 %, respectively. Buttrey (1989) found no differences in N concentration of tall fescue due to the presence of the endophyte. In addition, Zylka (1989) found no significant differences in apparent N absorption and N retention in wethers fed fall ensiled tall fescue with varying degrees of infection, even though she had higher infection rates than in the present study. Based on these findings, endophyte infection would not be expected to have influenced these results. However, the influence of endophyte infection on forage intake and animal performance is well documented.

In conclusion, stockpiling tall fescue with alfalfa instead of N fertilization resulted in higher quality forage and improved N utilization and DMD. Stockpiling tall fescue with red clover produced a forage similar in composition to tall fescue stockpiled with N fertilization, but N utilization and DMD were decreased. Similar results for both legumes, alfalfa and red clover, were observed only as increased BUN in wethers fed these forages as compared to those fed N fertilized tall fescue.

Overall, forage quality and digestibility should not be expected to improve as compared to N fertilization simply by the inclusion of a legume. Characteristics and performance of specific legumes in stockpiling situations must also be considered. Forage composition cannot be used as an indicator of expected animal performance since digestibility may differ as with the stockpiled tall fescue-N and tall fescue-red clover in this study. Mineral compostition may be involved in digestibility of stockpiled tall fescue as may time of stockpiling. Future work should take these factors into consideration in determining the quality and efficiency of utilizing various legumes in stockpiling systems.

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Chapter VII

General Discussion

The influence of N fertilization versus the inclusion of the legumes, alfalfa and red clover, on stockpiled tall fescue was examined in relationship to soil, plants and animals. Soil analysis indicated that legumes maintained soil N levels similar to or higher than those achieved with N fertilization. Of the legumes, red clover appeared to maintain higher soil ammonium and lower soil nitrate (NO_3^-) concentrations as compared with the alfalfa. However, soil NO_3^- levels in all treatments were low and should not pose a threat to the environment or grazing livestock.

Total forage yield was similar for all treatments, reinforcing the fact that the legumes supplied adequate N to the sward, compared with N fertilization. Total N produced ha^{-1} in the herbage was greater in the tall fescue grown with legumes, compared to N-fertilized tall fescue. Nitrogen concentration of the individual legumes differed only on two dates. The percentage legume present in the grass-legume mixtures varied by date, with the tall fescue-red clover pastures having more legume than the tall fescue-alfalfa pastures in the spring and summer, while the opposite was true in late summer and fall.

The higher percentage of legume present in tall fescue-alfalfa at the time of the grazing study and metabolism trial may have been a major factor influencing the results of these experiments.

Nitrogen concentration of the esophageal extrusa of steers grazing tall fescue-alfalfa was higher than that of the steers grazing tall fescue-red clover during the early part of the grazing trial. Given the differences in the botanical composition of the two forages, the steers grazing the tall fescue-alfalfa had more legume present to select compared to tall fescue-red clover. In addition, wethers fed tall fescue-red clover in the metabolism trial would have recieved a lower percentage of legume in the 800 g of fresh feed they received, than did wethers fed tall fescue-alfalfa and did not have the opportunity for selection of plant species as did the grazing steers. The percentage N in the alfalfa and red clover was similar for the plant harvest which corresponded with the beginning of stockpiling. However, N concentration was considerably higher in the legumes as compared with the grass. This, combined with the differences in botanical composition is exemplified in the metabolism and grazing study. Percent N in the feed and the N intake in the metabolism trial were higher for tall fescue-alfalfa than the other treatments. Also, the esophageal extrusa of steers grazing tall fescue-alfalfa tended to be higher than that of the other steers. The higher digestibility observed with the metabolism trial combined with the opportunity for selective grazing, may have resulted in higher average daily and total gains for steers grazing the tall fescue-alfalfa as compared with the tall fescue-N. Steers grazing tall fescue-red clover had similar gains to those grazing the tall fescue-alfalfa. This may be due to the higher forage yield of the tall fescue-red clover as compared to the tall fescue-alfalfa. Results of the 5-yr grazing trial conducted prior to the present experiment consistently indicated higher animal performance by cattle grazing tall fescue-alfalfa compared to tall fescue-red clover and tall fescue-N (Allen et al., 1988).

Another factor which may have played a role in these results was plant maturity. The tall fescue-red clover and tall fescue-N treatments were one month older than the tall fescue-alfalfa due to the delay in initiating forage accumulation when stockpiling this forage. One indicator of advanced maturity is cell wall composition (NDF). Neutral detergent fiber for the hand-clipped tall fescue samples used in the grazing study was similar for all treatments. In comparison of the legumes, alfalfa had significantly lower NDF than red clover both initially and at the conclusion of the grazing study. This could be attributed to differences between the two species or stage of maturity.

In the future, determination of the N fixation of the individual legumes in addition to the information collected by this project, would be beneficial in understanding the influence of the individual legumes on these forage systems. Attention should also be given to the performance and selectivity of livestock on these forages on a yr round basis. Perhaps the differences observed in this study in digestibility and selective grazing would be balanced if other times of the year were considered. Furthermore, the influence of plant maturity of stockpiled forage on digestibility should be investigated to determine whether delaying the stockpiling date would improve the use of stockpiled tall fescue-red clover.

Overall, the use of alfalfa and red clover is an acceptable alternative to N fertilization of pastures. In a stockpiling system, alfalfa would be preferred for use with tall fescue, for improved N utilization and forage digestibility. The lower N retention of the stockpiled forage produced when stockpiling tall fescue with red clover indicates need for further study to determine if other management decisions may improve this stockpiled forage. The results of this study may have been considerably different if these forages were compared at a different time of the year, due to the seasonal changes in botanical composition of the systems. The higher legume content of tall fescue-red clover in the spring may improve digestibility and animal performance, as well as dilute the effects of fescue toxicity.

In conclusion, these pastures presented little threat to the environment due to the low accumultation of N in NH_4^+ or NO_3^--form as a result of N fertilization or the presence of alfalfa or red clover. Legumes provided sufficient N to achieve similar annual yields and improve crude protein yield ha^{-1} as compared with N fertilization. Tall fescue stockpiled with alfalfa has potential for use in animal production systems where high animal performance is desired.

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Appendix A

Soil Descriptions

Table 17. Soil profile descriptions of plots from which plant and soil samples were taken in fertilized tall fescue pastures

Rep	Horizon	Depth	Color	Texture & Description
4	Ap	0-9″	7.5YR 4/4	Loam
	Bt1	9-24″	7.5YR 5/6	Clay loam
	Bt2	24-38″	5YR 5/8 & 7.5YR 5/6	Silty clay loam
	Bt3	38-49″	5YR 5/8	Light silty clay loam, common medium areas of 10YR 6/6
	C	49-60″	7.5YR 5/8 7.5YR 5/6	Silt loam, many blackish stains and streaks, common clay flows

General description: Profile is fine-loamy, mixed mesic Typic Hapludult; has thick Bt1 horizon; C horizon materials appear to be from basic rock; similar to profile. Ten core samples similar to profile description. Possibly identified as Morrisonville on old map

Rep	Horizon	Depth	Color	Texture & Description
5	Ap	0-8″	7.5YR 4/3	Loam
	Bt1	8-30″	2.5YR 4/6	Silty clay to clay, many fine 10YR 3/2 stains
	Bt2	30-40″	5YR 4/6	Clay loam
	C	40-60″	7.5YR 4/4	Loam

General description: Profile is clayey, mixed, mesic Typic Hapludult,
Possibly Morrisonville,
Profile is similar to profile 1 (FRC9). Ten core samples
similar to profile descriptions. 31B map unit.

6 Plot relocated to match other soil descriptions

Table 18. Soil profile descriptions of plots from which plant and soil samples were taken in tall fescue-red clover pastures

Rep	Horizon	Depth	Color	Texture & Description
2	Relocated to match other soil descriptions			
4	Relocated to match other soil descriptions			
9	Ap	0-10″	7.5YR 4/4	Loam, 2-10% gravel
	Bt1	10-25″	2.5YR 4/8	Clay
	Bt2	25-34″	2.5YR 4/6	Clay loam, many 5YR 6/6 mottles
	2Bt	34-41″	2.5YR 4/8	Silty clay loam
	C	41-60″	10YR 4/4	Loam, many 5YR 5/8 clay flows that are clay loam to silty clay loam, 10-15% weathered gravel size fragments that are greenish in color

General
description: Area mapped as Morrisonville-Philomont complex 2-7%
This profile is clayey, mixed, mesic, Typic Hapludult, appears to fit Morrisonville description. Upper 34 inches probably local colluvium; has 2-10% fine subr. quartzite gravel. The ten soil cores were same as profile description, though plot 9 core had some weathered rock/C material in Bt that was excluded from the sample

Table 19. Soil profile descriptions of plots from which plant and soil samples were taken in tall fescue-alfalfa pastures

Rep	Horizon	Depth	Color	Texture & Description
4	Ap	0-7″	7.5YR 4/4	Loam, 2-5% quartzite gravel
	Bt1	7-17″	5YR 4/6	Heavy clay loam
	Bt2	17-36″	5YR 5/8	Clay, many medium 10YR 3/2 stains, also 10YR 5/4 mottles
	Bt3	36-43″	5YR 5/8	Clay loam
	BCt	43-50″	5YR 5/8 & 10YR 6/8	Sandy clay loam
	C	50-60″	7.5YR 6/8 & 10YR 6/8	Sandy clay loam

General description: This profile is clayey, mixed, mesic Typic Hapludult. C horizon is weathered granite material and few clay flows. Mapped as 31B Philomont-Brandywine complex, though profile appears more like Morrisonville (or profile FRC9). Ten core samples similar to profile description.

2

General description: This soil profile similar to profile AF4, bored to 50 inches to confirm; profile is clayey, mixed, mesic Typic Hapludult; beginning about 41 inches is BC like horizon high in mica; 31B unit; all ten cores similar to profile description.

3

General description: Similar to profile (AF4), bored to 36 inches to confirm; clayey mixed mesic Typic Hapludult. 31B unit

Table 20. Summary of soil types in which plots were located for plant and soil portions of this research

Field	Classification
FN4	Fine-loamy mixed mesic Typic Hapludult
FN5	Clayey mixed mesic Typic Hapludult
FN6	Fine-loamy, mixed, mesic Typic Hapludult
FRC2	Fine-loamy, mixed, mesic Typic Hapludult
FRC4	Fine-loamy, mixed, mesic Typic Hapludult
FRC9	Clayey mixed mesic Typic Hapludult
AF2	Clayey mixed mesic Typic Hapludult
AF3	Clayey mixed mesic Typic Hapludult
AF4	Clayey mixed mesic Typic Hapludult

Appendix B

Weed Nitrogen Composition

Table 21. Percentage nitrogen in broadleaf weeds located in tall fescue stockpiling treatments

Weed[a]	Stockpiling treatment			SE
	Nitrogen	Red Clover	Alfalfa	
	- - - - - - - - - - % - - - - - - - - - -			
Dandelion	-	1.54 (4)	2.49 (8)	0.35
Lamb's Quarter	1.36^{b} (7)	0.83^{c} (3)	-	0.12
Plantain	-	1.20 (2)	1.64 (1)	0.12
Doc	-	-	1.41 (1)	-
Fall Panicum	-	-	1.56 (2)	-
Chickweed	-	-	1.12 (1)	-
Henbit	-	-	2.28 (1)	-
Mullen	-	-	2.38 (1)	-
Oxalis	1.49 (1)	-	-	-

[a] Number of observations is in parenthesis.
[bc] Means with superscripts that do not have a common superscript letter differ ($P \leq .01$).

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