Review of Research on Stockpiled Fescue for Beef Cattle

M. H. Poore[*], G. A. Benson[†], M. E. Scott[‡] and J. T. Green[‡].
Departments of [*]Animal Science, [†]Agricultural and Resource Economics,
and [‡]Crop Science
North Carolina State University, Raleigh, 27695

Summary

Tall Fescue is the predominant cool season forage in the Eastern USA. Because of its relatively high autumn growth rate, propensity to accumulate non-structural carbohydrates, and ability to resist deterioration due to freezing/thawing, it is ideal for stockpiled winter grazing. Fescue does inevitably lose some quality as winter progresses, but stockpiling potentially allows a year-round grazing program. To accumulate significant forage, it is essential that nitrogen is available in late summer and autumn. Applying 50-100 kg/ha N to pastures in late summer has resulted in a yield response of 7 to 33 kg DM/kg N, but a range of 10-20 kg DM/kg N can be expected in most situations. This response will be economical with current N prices. Date to initiate stockpiling has been researched widely, and most studies show that accumulation starting in late summer (Aug 1 to Sept 1) is important, especially when precipitation is short in autumn. Nutrient concentrations of stockpiled fescue reported in the literature are variable, but generally are at or above the requirement of beef cows or calves growing at moderate rates of gain. Cattle performance, however, is often lower than expected if endophyte is present, and supplementation is often necessary to achieve growing animal performance goals. Research has shown that highly digestible fiber supplements such as soybean hulls will result in more cost effective gains than high starch supplements like corn. While research evidence is limited, it appears that quality and utilization are improved by controlled grazing, and are maximized by the use of daily strip-grazing. Economic simulation for a cow wintering system showed that strip-grazing stockpiled fescue could reduce feeding costs by about 40% compared to harvesting and feeding autumn growth as hay. Use of stockpiled fescue could be expanded, and with controlled grazing management and efficient supplementation, could lead to improved economics of winter feeding in the fescue belt.

Introduction

Tall fescue is widely distributed across the middle eastern half of the United States, totaling over 14 million ha (Burns and Chamblee, 1979). Much of the fescue is infected with an endophyte, *Acremonium coenophialum*, that reduces cattle performance, but enhances agronomic aspects of the plant (Hoveland et al., 1975). Several advantages of using fescue for stockpiling are that it responds to late summer N fertilization and maintains forage nutrient concentration better than other cool season foages. This maks it possible to extend the grazing season well into the winter (Van Keuren, 1972; Reynolds, 1975).

Traditionally, on many farms autumn growth has been harvested as hay or grazed before winter, but stockpiling growth for winter grazing has potential to reduce beef cattle production costs. This paper will review information on; 1) agronomic aspects of stockpiling fescue including optimal initiation dates, timing and level of nitrogen fertilization, and nutrient concentrations of stockpiled fescue especially in late winter, and 2) animal performance and supplementation responses while grazing stockpiled fescue. In addition a case simulation will be used to examine the economic benefits of late summer N fertilization, and feed costs in a cow wintering system with stockpiled fescue compared with hay.

Review of Agronomic Aspects of Producing Stockpiled Fescue

Fescue produces more autumn forage growth than other cool season forages, and has great potential as accumulated winter grazing, a practice known as stockpiling (Mays and Wasko, 1960). In Kentucky (Taylor and Templeton, 1976) tall fescue yielded about twice as much as bluegrass and had similar quality in winter. In Tennessee it was shown that fescue provided about 30% more autumn yield than did orchardgrass (Reynolds, 1975), and in Ohio, Van Keuren (1972) showed that fescue had similar quality, but yielded about 50% more than bluegrass. In Maryland (Archer and Decker, 1977) autumn growth of orchardgrass was about 75% that of tall fescue. In Iowa, tall fescue yielded about 33% more than reed canarygrass, orchardgrass, smooth bromegrass and meadow foxtail (Wedin et al., 1967). Another positive aspect of tall fescue for winter grazing is that it accumulates high levels of non-structural carbohydrates improving pallatability (Bagley et al., 1983) and is more digestible due to a lower and more digestible fiber content when grown in cool rather than warm weather (Fales, 1986).

Date to initiate stockpiling. To develop high quality stockpiled fescue, it is important to remove lower quality growth that accumulates during the summer (Fales, 1986), but not to overgraze the sward during hot weather, reducing carbohydrate reserves, which could reduce potential autumn yield (Brown and Blaser, 1965). Berry and Hoveland (1969) showed reduced autumn yields when fescue was clipped in mid-July, but not when clipped in early June. In contrast Ocumpaugh and Matches (1977) reported that defoliating fescue frequently throughout the summer did not reduce stockpile yields. These apparently conflicting observations may be due to different summer environments between Alabama and Missouri.

Work has been conducted to evaluate the best time to initiate stockpiling of fescue, however there has been significant confounding of when the rest period begins and when N is applied. In some studies, N was applied at the time the rest period began, and in others N was added at a specific date (i.e. Sept 1) despite differing initiation dates for stockpile accumulation.

Most studies show higher yields with earlier initiation dates, but nutrient concentrations in forage are lower for earlier initiation dates. Green (1974) showed that yield was higher when stockpiling was initiated in May (8804 kg/ha) or June (8119 kg/ha) than when it was initiated in August (5376 kg/ha). In Missouri (Matches et al., 1973) dry matter yields were 2616 , 1272 and

775 kg/ha for May, June and August initiation, respectively, and in NC (Burns and Chamblee, 2000a), yields were 4677, 3720, 3210 and 1660 kg/ha when stockpiling was initiated at the beginning of June, July, August or September, respectively. In the latter study, 90 kg N /ha was added to all plots on August 25, such that the yield effect is attributed both to the amount of "rest" the plants had between clipping the residual dry matter and the addition of the late summer N. The low yield of September initiated stockpile was associated with two years in which autumn rainfall was below average, resulting in very low yields (935 kg/ha, or 30% of the August innitiated stockpile) as compared to a year with normal precipitation in autumn, when the September initiated stockpile yielded a comparable amount as the August initiated stockpile (3110 vs 3210 kg/ha).

It is also important to note that as winter progresses, yield of fescue will decline. Most studies reviewed showed a decline in both yield and forage nutrient concentrations as winter progressed which is a compromise that must be made if it is desirable to extend grazing into late winter. For example, in Virginia (Green, 1974) yield declined 19 to 29% when harvest was delayed from December to February, and this was associated with a 47% decline in the yield of total non-structural carbohydrate and a 23% reduction in yield of green herbage. Taylor and Templeton (1976) showed that in Kentucky DM yield declined from December to February by 21, 26 and 5% for 0, 50 and 100 kg N/ha, respectively. That was associated with an increase from 40 to 55% dead tissue in December to 78 to 82% dead tissue in February, and a 50% decline in total non-structural carbohydrates.

Nitrogen Responses. Forage yield, stockpiling initiation dates, N rates and timing, and N use efficiency are summarized in Table 1. Nitrogen application to tall fescue in autumn generally shows significant, but highly variable responses in forage yields. Rayburn et al. (1979) investigated initiation date and fertilization (112 kg N/ha) date and showed a DM yield response of 1500 and 636 kg/ha in yr 1 and 2, respectively, when accumulating from mid-September, and 747 and 988 kg/ha in yr 1 and 2 respectively when accumulating from mid-August. Nitrogen use efficiency was 8 to 10 kg DM/kg N. Taylor and Templeton (1976) reported that when stockpiling in Kentucky was initiated during August and harvested in December or February, average yield response was 994 and 1815 kg/ha from 50 and 100 kg N/ha resulting in an N use efficiency of 15 to 24 kg DM/kg N.

Accumulated growth in Virginia (Green, 1974) gave yield responses by January 2 of 440, 1220, 2080 and 1970 kg/ha when topdressed on September 1 with 28, 84, 140 and 280 kg N/ha, respectively. Incremental N use efficiency using 28 kg/ha as a baseline was 7 to16 kg DM/kg N. In a second experiment yields on December 4 were 3561, 4876 and 5741 kg/ha when topdressed with 28, 84 or 140 kg N/ha. Incremental N use efficiency was 23 kg DM/kg N between 28 and 84 kg N/ha, and 19 kg DM/kg N between 84 and 140 kg N/ha. In the second experiment, delaying harvest until Feb 4 resulted in a 65 to 78% reduction in yield.

Gerrish et al. (1994) reported a detailed study of N rates (0, 45, 90 or 135 kg/ha) and timing of application to swards that had rested for 0, 14 or 28 days following summer hay cutting. The most efficient response to nitrogen occurred during one of the three years when 45 kg/ha was applied August 1, resulting in an increased yield of approximately 1131 kg/ha. Nitrogen use efficiency that year was 14 to 25 kg DM/kg N when N was applied on August 1, but it dropped to 6 to 9 kg DM/kg N when applied August 29. Based on this work they recommended that N be added in early August, but that the timing and amount of N added be based on the cost of N and the soil moisture conditions at the time stockpiling is initiated. Workers in West Virginia (Balasko, 1977; Collins and Balasko, 1981a) have reported the best N efficiency responses (18 to 33 kg DM/kg N) when 30 to 90 kg N/ha were applied in mid-August.

Several studies have evaluated the effects of stockpiling fescue on yields in subsequent years. Burns and Chamblee (2000a) showed that there was no effect of the date stockpiling started during summer on subsequent spring/summer growth. Rayburn et al. (1979) and Gerrish et al. (1994) looked at carry over effects from N addition. Late summer application of N, to stimulate autumn growth, also resulted in slightly higher spring growth, especially for high rates of application (Gerrish et al., 1994). This is probably attributed to residual N in the soil.

Current N management recommendations for stockpiling fescue vary depending on the latitude and elevation of the farm. In general, the farther north in the fescue belt, and the higher the elevation, the earlier the nitrogen should be applied. Response will be highly variable due to environmental conditions, however a response of about 10 to 20 kg forage/kg N applied is a practical expectation with late summer (August) application of 50 to100 kg N/ha. In the Piedmont of North Carolina, we recommend that producers clip or graze fescue by early August and then add N at a rate of 50 to 100 kg/ha when soil moisture is present, preferably on or before September 1. If N application is too early, and late summer weather is hot with moisture stress, much of the N may be taken up by warm season forages in the sward such as foxtail (Gerrish et al, 1994) or bermudagrass (Scott, 2000). If soil moisture status is low, applying N in late summer may not result in high yields, and in those years producers should plan on other feed alternatives to satisfy winter feed requirements.

Forage nutrient concentrations. Several studies have reported the nutrient concentrations of stockpiled fescue throughout the winter, and several have provided detailed analysis of both green and brown fescue tissue. There is a great disparity of quality estimates, with some studies showing quality at a level requiring significant supplementation to reach animal production goals, and others showing values which should support satisfactory performance even with growing animals.

Several workers have shown that the later stockpile initiation dates (August-September) resulted in higher forage nutrient concentrations during the winter than earlier dates (June-July). This is due partially to a higher percentage of green tissue associated with the later stockpile initiation dates (Collins and Balasko, 1981; Fribourg and Bell, 1984; Burns and Chamblee, 2000b).

Ross and Reynolds (1979) evaluated nutrient concentrations of stockpiled fescue through the winter in Tennessee and found CP levels were high initially, especially in the first year (29%), but declined to near 8% by January of both years. Fribourg and Bell (1984) reported 14% CP in fescue growth accumulated starting in September, but by January, the concentrations had dropped to 12% at the Tennessee location, and to 3% in the Delaware location. Burns and Chamblee (2000b) reported no difference in forage CP content for differing stockpile initiation dates during a 3 yr study in North Carolina, but in that study N was applied near August 25 on all treatments. Crude protein content on Feb 5 was 9.9, 10.2 and 15.9% for the three years.

Observations we have made over five years on a commercial farm in south central Virginia where 76 kg/ha N were applied during early to late September (Poore, unpublished) showed consistently higher nutrient concentrations than reported in most literature citations. Samples taken during late winter (Jan 2-March 1) showed 13.5 to19.1% CP (mean 15.6%), 30.1 to 36.4% ADF (mean 33.5%), .66 to1.81% K (mean 1.18%) and .17 to .25% P (mean .21%). These observations stimulated the initiation of a three year grazing study in Raleigh starting in the winter of 1996-1997 to determine the forage quality of fescue managed by stripgrazing, and animal performance responses to supplementation (Poore and Green, 1999; Scott, 2000). During these three years, forage nutrient concentrations were high relative to most observations in the literature. Samples taken in early February in 1997, 1998 and 1999 showed CP and ADF levels of 14.8 and 30.5%; 15.2 and 28.5%; and 12.9 and 33.3 %, respectively.

Green and brown fractions. Several studies have separated green and brown fractions of the sward, and in part, forage quality is related to the proportions of green and brown tissue present (Taylor and Templeton, 1976; Archer and Decker, 1977; Scott, 2000; Burns and Chamblee, 2000b). In the study by Taylor and Templeton (1976), fescue was composed of 76% green tissue in November and this declined to 20% on February 8. Archer and Decker (1977) also initially had 75% green tissue, but this declined to 60% by December 24. Burns and Chamblee (2000b) reported 76% green tissue in November, but that declined to 36% by early January.

In contrast to these reports, Scott (2000) found that over a two year period, fescue was initially 75% green tissue, but that the fescue swards were still 57% green in early February. That observation was consistent with higher nutrient concentrations of that forage compared to the three previous studies. The reason for the disparity in these data is not apparent. It has been speculated that the farther south, and the lower the elevation, in the fescue belt, the quicker the sward will decline in quality because freezing and thawing conditions occur more frequently (Burns and Chamblee, 2000a). That does not seem to be the case, as studies from the Piedmont of North Carolina (Burns and Chamblee, 2000b; Poore et al., 1999; Scott, 2000) show some of the highest late winter nutrient concentrations in the literature.

Nitrogen fertilization also increases the CP content of fescue (Rayburn et al. 1979; Archer and Decker, 1977; Green, 1974), especially of the green tissue (Gerrish et al., 1994) and decreases the rate of senescence (Balasko, 1977). Green tissue in the various reports has ranged from 12.0 to 20.4% CP , while brown tissue ranged from 8.4 to 10.3% CP. The difference between the nutritive value of green and brown tissue can be used as a practical indicator when estimating the quality of a stockpiled fescue sward as winter progresses.

Mineral composition. There are several reports in the literature of the mineral composition of stockpiled fescue. Balasko (1977) reported that in West Virginia mineral content of fescue fertilized with N, P and K and harvested in January averaged .21% P, 1.18% K, .24% Ca, .12% Mg, .06% Na, 123 ppm Mn, 228 ppm Fe, 5.6 ppm Cu and 25.6 ppm Zn. In work from Kentucky (Taylor and Templeton, 1976), stockpiled fescue declined from .35% P on December 1 to .19% P on February 8. This was related to the fact that green tissue was .4% P and brown tissue was .16% P, and a large increase in brown tissue in late winter.

Ross and Reynolds (1979) reported Ca, P, K and Mg levels in stockpiled fescue in Tennessee during two winters. Levels of those minerals were adequate early in the winter in both years, but P declined to deficient levels by late winter. February samples showed an average of .40, .13, .78 and .17% for Ca, P, K and Mg, respectively. Reported P status of soil was relatively low in their study. Fribourg and Bell (1984) reported that both P (.15%) and K (.29%) dropped to levels below the requirement of most cattle during late winter and recommended significant supplementation with those minerals.

Collins and Balasko (1981) reported Ca, P, K and Mg levels in stockpiled fescue receiving 4 levels of N fertilization at different rates during December, January and February. Levels of K declined from 1.27 in December to .74% in February and Mg declined from .24 to .17% as winter progressed, while Ca and P were more stable. At the mid-February sampling date, Ca, P, K and Mg averaged, .49, .19, .73 and .17%, respectively.

In recent work in North Carolina (Poore and Green, 1999; Scott, 2000) mineral levels were much more stable over the winter, and were above animal requirements (National Research Council, 1996) with the exception of Na which was clearly deficient, and trace minerals which were marginal. Samples from near February 1 averaged .45% Ca, .22% P, .01% Na, .24% Mg, 1.97 % K, 9.7 ppm Cu, 22.7 ppm Zn, 43 ppm Mn and .19% S over the three years. At this site, soil P and K status were high, and soil analysis recommendations called for no application of these elements, which may explain the higher P and K levels than seen in some of the previous studies.

Nutrient concentrations in stockpiled fescue are at or above the requirement of most beef animals, especially mature beef cows. The quality is quite variable by year, and appears to be influenced by the time stockpiling is initiated, the time N is applied, and the amount of brown tissue present as the winter progresses. Mineral content will be adequate for most animals, but in swards with much dead and little green tissue, supplementation with P and K may be required, especially if soils are deficient in P and K.

Review of Animal Performance and Supplementation Responses

Relatively few published studies evaluating performance of cattle grazing stockpiled fescue are found in the literature. Most studies that have been reported show lower performance than would be expected based on forage nutrient content. Studies that evaluated supplementation of cattle grazing stockpiled fescue are summarized in Table 2. It is interesting that most studies found were conducted with growing calves rather than brood cows which are the primary class of animals grazed on stockpiled fescue.

McClure et al. (1977) fed light steer calves on stockpiled fescue for 112 d starting January 8, with or without 1% body weight corn. Unsupplemented calves gained .51 kg/d and supplemented calves gained .66 kg/d. In another study under similar conditions (Gerken and McClure, 1979), calves were grazed from Jan 4 through April 26 on stockpiled fescue with no supplement or with 2 lb of a 12% CP concentrate with or without 200 mg monensin. Calves gained .30, .53 and .59 kg/d on the respective treatments.

In Georgia steers were grazed on stockpiled fescue as compared to several other forage treatments for 140 days (Stuedemann et al., 1981). Calves on stockpiled fescue gained .38 kg/d as compared to .69 kg/d for calves grazing rye overseeded on a bermudagrass sod. In a study comparing stockering systems in Virginia (Allen et al., 1992), calves were grazed on stockpiled fescue as opposed to other forage systems including stockpiled fescue/alfalfa and orchardgrass/alfalfa hay for 151 days starting November 1. When calves had utilized all the stockpiled forages, they were fed hay produced earlier on the same pastures. Calves on stockpiled fescue required fewer days of supplemental hay than the other treatments, but gained less (.34 kg/d) than calves that grazed either fescue/alfalfa or that were wintered on orchardgrass/alfalfa hay (.50 kg/d).

Several recent studies have compared starchy and digestible fiber supplements for calves grazing stockpiled fescue. Larson et al. (2000), grazed steers for 84-d on infected KY-31 fescue starting on December 18. Calves were supplemented with .6% of body weight of either cracked corn (C) or soybean hulls (SH) and there were no unsupplemented cattle. Forage contained 10.4% CP and 38.6% ADF initially, and 10.5% CP and 42.4% ADF in the last month of grazing. Calves supplemented with corn gained .10 kg/d as compared to those fed soybean hulls which gained .34 kg/d. The difference in gain was attributed to the carbohydrate source, but could also have resulted from a difference in protein content of the supplements (9 vs 14% CP for C and SH, respectively).

Burris et al. (2000) reported two trials from Kentucky in which weaned calves were preconditioned on stockpiled fescue with various supplements. In the first trial, calves (312 kg) were supplemented with 3.2 kg corn/soybean meal or SH for 60 days starting November 17. Calves fed corn and soybean meal gained .64 kg/d as compared to .82 kg/d for soybean hull supplemented cattle. Protein content of the supplements and the forage were not reported. In the second trial, calves (278 kg) were fed 4.1 kg of C, SH or corn gluten feed (CGF) for 62 days starting November 16. Unsupplemented cattle gained .30 kg/d, as compared to .66, .72, and .83 kg/d for C, SH and CGF, respectively. The greater response to CGF than C or SH may have been due to its much higher CP content (10, 13 and 25% CP for C, SH and CGF, respectively).

In North Carolina replacement heifers were grazed on stockpiled KY-31 for 56 d starting on November 24 (Poore and Green, 1999) . Forage quality declined slightly during the trial, but contained 16.1% CP and 27.3% ADF at the start, and 13.4% CP and 30.5% ADF at the end of the trial. Heifers were either unsupplemented or supplemented with a free-choice experimental block containing 25% cottonseed, 10% cottonseed meal, 28% wheat midds, 11.2% rice mill feed, 10% molasses, 8% salt and other mineral components (17.1% CP). Unsupplemented heifers gained .47 kg/d and body condition score (BCS) was not altered. Supplemented heifers consumed 3.4 kg DM/d of the supplement, and ADG and change in BCS were .77 kg/d and +.53, respectively.

In a two-year trial in North Carolina, Scott (2000) strip-grazed heifers (initial body weight 260 kg and body condition score 5.0) on highly infected (98%) stockpiled KY-31 for 83 d starting near December 1. Unsupplemented cattle were compared to those supplemented with .33% of bodyweight whole cottonseed and a small amount (.2 kg per animal) of grain to insure complete supplement consumption (1.1 kg DM total supplement). Average forage quality in year 1 (16.8% CP and 25.9% ADF) was higher than year 2 (12.6% CP and 30.7% ADF) and declined only slightly during the trial. Unsupplemented and supplemented heifers had an ADG of .46 vs .56 kg/d and had a BCS change of -.028 vs +.33 in year 1. In year 2, heifers had an ADG of .22 vs .44 kg/d and had a BCS change of .13 vs .50 on the respective treatments. Low blood urea N levels, and substantial performance response with supplementation suggested that part of the response in year 2 may have been due to protein status of unsupplemented heifers, despite apparently adequate CP levels in forage. Intake measurements were made by determining pasture mass before and after grazing discrete strips, and showed that cattle only consumed 3.3 and 3.7 kg/d of forage organic matter in year 1 and 2, respectively (average 1.25% of body weight), with no effect of supplementation. This low level of intake helps explain the low performance despite relatively high forage quality.

Endophyte effects. Despite the general concept that endophyte toxicity is less severe in cool weather (Chestnut et al., 1991), endophyte infection apparently reduces the performance of calves grazing stockpiled fescue. Workers in Oklahoma (Smith et al,1989) reported that ADG was .60 kg/d for infected fescue (76% infection rate) as compared to .72 kg/d for endophyte free fescue when grazed from November through mid-March.

Chestnut et al. (1991) showed that performance of calves was reduced in all seasons as endophyte infection rate increased. In the winter grazing period, fescue with a 60% or higher infection rate resulted in gains of .40 kg/d as compared to .55 kg/d for endophyte free fescue.

Beconi et al. (1995) compared performance of implanted or non-implanted steers grazing stockpiled endophyte infected Ky-31 fescue (KY31+, 65% infection), endophyte free Ky-31

(KY31-), Johnstone (J) or Kenhy (K). Grazing was initiated October 24 and continued for 53 days. Forage quality of the Ky31+ and J were similar and were highest at the start of the trial (16.9 and 14.8% CP, and 32.2 and 32.6% ADF, respectively) and declined slightly by mid-December (15 and 13.1% CP, and 34.9 and 33.9% ADF for the respective treatments). Steers gained .68, .92, .95 and 1.1 kg/day on KY31+, KY31-, J and K, respectively. Implants improved gain by 14%, but did not interact with fescue cultivar.

Grazing Management. Most studies utilized continuous grazing, which presumably results in more rapid decline in forage quality as winter progresses, and less efficient forage utilization. The studies from NC (Poore and Green, 1999; Scott, 2000) utilized daily stripgrazing, sometimes also known as "frontal grazing." Gerrish (1996) suggested that a three day stripgrazing system increased animal grazing days 40% as compared to 2 week grazing periods. It appears that providing fresh forage every 1 to 4 days greatly improves utilization, but additional studies are needed to provide quantitative estimates on amount of forage wasted, and to document the performance of cattle when grazing selectivity is largely eliminated as it is in stripgrazing.

Summary. Studies that reported cattle performance on stockpiled fescue showed that performance was better when cattle were grazed for shorter grazing periods, starting earlier in autumn. Performance is generally not as high as expected based on forage nutrient concentrations, and this appears to be due to the use of endophyte infected fescue in most studies. Supplementation with highly digestible fiber supplements results in better animal performance than corn, but due to frequent confounding with protein levels, this is an area that needs additional research. Grazing management techniques for optimal utilization of stockpiled fescue is of obvious importance and is widely discussed by producers, but has not been researched to any extent.

A Case Simmulation on the Economic Benefit of Grazing Stockpiled Fescue

Two aspects of stockpiled fescue were addressed in an economic analysis. The first question addressed was whether it is economical to apply N in late summer to stimulate autumn growth, and the second, whether it is more economical to harvest the autumn growth as hay for winter feeding, or to graze it.

Because response of dry matter yield to N application is most efficient at low to moderate rates , we evaluated applications of 50 to 100 kg/ha. Nitrogen efficiency reported in the literature varies widely, but a practical expectation would be from 10 to 20 kg DM/kg N. Based on current market prices a kg of N might vary from $.44-.88. Therefore, cost of additional forage dry matter would range from .022 to .088 $/kg. Using intermediate values for both variables (15 kg forage DM/kg N and $.66/kg applied N) results in a cost of .044 $/kg of standing forage.

When making the decision whether or not to apply late summer nitrogen, one should be aware that forage growth responses are variable, and that if N response is low, a producer could probably purchase hay or alternative feeds more economically. Very dry autumn conditions and/or late autumn applications appear to lead to poor responses, and may be uneconomical (Gerrish et al., 1994; Burns and Chamblee, 2000a). However, if N is applied early and rainfall is adequate, then the forage is very inexpensive. Producers should use judgement to guide their applications based on date, current soil moisture, precipitation forecast, N prices and price of alternative feeds. Recovery of late summer N application in growth in the subsequent spring has not been seen in most studies at moderate application levels and the value of this carry over N is assumed to be negligible.

Hay it or Graze it? After the decision has been made to grow autumn forage, one must decide whether to harvest the resulting forage as hay, or to stockpile the forage for winter grazing. If the decision is to graze, there should be some consideration about whether to intensively manage the grazing (strip or frontal grazing) with frequent allocation of fresh pasture, or less frequent allocation of a larger area of pasture. To evaluate these factors, a partial budgeting approach has been utilized with a case study simulation.

In this case study, it is assumed that a producer has a 10 ha pasture with late summer/autumn harvestable growth amounting to 2227 kg/ha. We assume that 32 yearling heifers require 6.8 kg DMI per head from autumn forage to meet nutrient needs, with a wintering period of 120 days. The quality of the stockpiled forage is assumed to meet the needs of the cattle (with the exception of a mineral supplement).

Three optional systems for using autumn growth are considered; 1) cut the forage as hay (using an assumption of 90% harvest efficiency), 2) use a less intensive grazing program with a 2 week graze period and a 50% harvest efficiency (2wk), or 3) use an intensive daily stripgrazing allocation of forage with an 85% harvest efficiency (daily). Assume that the pasture has electric fence on the perimeter, water located at one end, and close proximity to the producer's residence (<1 km). Additional hay needed other than that produced on the pasture in question is assumed to be of high quality, requiring the same 6.8 kg/d DMI, and it has a market value of 0.088 $/kg. To compare these systems, equipment costs, forage production costs and hay harvest costs were taken from NCSU Department of Agricultural and Resource Economics budgets ***(http://www.ag-econ.ncsu.edu/faculty/sampson/budgets/Forage_Budgets_99/frgbud99.html)***. Waste factors including hay storage and feeding losses were taken from the Sustainable Dairy Farming Systems Manual (Cross et al., 1997).

Costs for each system and assumptions regarding waste factors, forage harvest efficiency, labor cost, supplemental feed costs, etc. are shown in Table 3. All three systems have the same cost for the standing forage, and for mineral supplementation of the cattle. The hay system accrues labor and equipment costs for hay cutting, while the grazing systems accrue costs for labor and equipment required to check and allocate grazing to the cattle. All three systems accrue labor and equipment costs for hay feeding, but it is much lower for the grazing systems, especially the daily system. The daily grazing system acrues more labor and equipment costs for allocating grazing than the 2 wk system. This is not as great as perceived, however, because the cattle must still be checked periodically whether provided with fresh forage or not. In this case, we assumed that cattle in the 2 wk system would be checked every 3 days.

The average daily feeding cost for an animal in each system is 1.25, 0.95, and 0.74 $ for the hay, 2 wk and daily systems, respectively. Total costs for 32 head for 120 days are 4797, 3660 and 2835 $ for the respective systems. Similar relative costs have been demonstrated by over 100 producers using their costs and this same simulation.

The grazing system with daily moves is much lower in cost than the other two systems, primarily because of the high cost of cutting hay in the hay system, and the greater amount of wasted forage that occurs in the 2wk grazing system. It is important to remember that the forage utilization efficiencies are based on observations of the authors and others (Gerrish, 1996), and need to be verified by additional research. It is also important to note that in many areas autumn harvest of hay is difficult at best, and this analysis does not take into account any harvest and curing losses associated with rain damage which may further favor the grazing systems.

Based on the economic analysis outlined above, it appears that applying N to fescue swards in late summer, allowing them to stockpile until early winter and then stripgrazing the forage will prove to be an economical system for many producers. However, it should be understood that these considerations will be very site specific and producers need to evaluate their own situation using a partial budgeting process. Cost of purchased hay will vary considerably from area to area, as will the availability of alternative winter feeds such as broiler litter, which would appreciably impact the economics of stockpiling fescue.

Conclusions

Stockpiling fescue for winter grazing has the potential to decrease winter feed costs as compared to traditional hay-based wintering programs. Fescue responds to late summer application of moderate amounts of N to produce economical forage yields, and relatively high forage nutrient concentrations. Performance of growing cattle grazing endophyte infected stockpiled fescue is low, so this forage may be best utilized for brood cows or other animals with low nutritional requirements. Daily stripgrazing appears to be economically beneficial, but research is needed to establish optimal grazing management strategies for intensive utilization of stockpiled fescue.

Literature Cited

Allen, V. G., J. P. Fontenot, and D. R. Notter. Forage Systems for Beef Production from Conception to Slaughter: II. Stocker Systems. J. Anim. Sci. 70:588-596.

Archer, K.A. and A.M. Decker. 1977. Autumn-accumulated tall fescue and orchardgrass. II. Effect of leaf death on fiber components and qualtiy parameters. Agron. J. 69:605-609.

Bagley, C.P., J.P. Fontenot, R.E. Blazer and K.E. Webb, Jr. 1983. Nutritional value and voluntary intake of tall fescue (festuca arundinacea Solseb.) fed to sheep. J. Anim. Sci. 57:1383-1391.

Balasko, J.A. 1977. Effects of N, P, and K fertilization on yield and quality of tall fescue forage in winter. Agron. J. 69: 425-428.

Beconi, M. G., M. D. Howard, T. D. A. Forbes, R. B. Muntifering, N. W. Bradley, and M. J. Ford. 1995. Growth and subsequent feedlot performance of estradiol-implanted vs nonimplanted steers grazing fall-accumulated endophyte-infested or low-endophyte tall fescue. J. Anim. Sci. 73:1576-1584.

Berry, R. F. and C.S. Hoveland. 1969. Summer defoliation and autumn-winter production of *phalaris* species and tall fescue varieties. Agron. J. 61: 493-497.

Brown, R.H. and R.E. Blaser. 1965. Relationships between reserve carbohydrate and accumulation and growth rate in orchardgrass and tall fescue. Crop Sci. 5:577-582.

Burns, Joseph C. and Douglas S. Chamblee. 1979. Adaptation. In Robert C. Buckner And Lowell P. Bush (ed.). Tall Fescue. Agronomy 20: 9-30.

Burns, J. C. and D. S. Chamblee. 2000a. Summer accumulation of tall fescue at low elevations in the humid piedmont. I. Fall yield and nutritive value. Agron. J. 92:(in press).

Burns, J. C. and D. S. Chamblee. 2000b. Summer accumulation of tall fescue at low elevations in the humid piedmont. II. Fall and winter changes in nutritive value. Agron. J. 92:(in press).

Burris, W.R., J.H. Randolph, K.M. Laurent, G.D. Lacefield, M. Rasnake, D.E. Wolfe and D. Anderson. 2000. Byproduct feeds for the postweaning feeding of calves. 2000 Kentucky Beef Cattle Research Report Pg. 86-87. University of Kentucky, Lexington

Chestnut, A.B., H.A. Fribourg, J.B. McLaren, R.W. Thompson, R.J. Carlsile, K.D. Gwinn, M.C. Dixon, and M.C. Smith. 1991. Effects of endophyte infestation level and endophyte-free tall fescue cultivar on steer productivity. p. 38-44.
In Tennessee Farm and Home Science. no. 160.

Collins, M. and J.A. Balasko. 1981. Effects of n fertilization and cutting schedules on stockpiled tall fescue. Ii. Forage quality. Agron. J. 73: 821-826.

Cross, T., G. Bates, R. Bowling and J. Henning. 1997. Forage Production. Chapter 7 in: Training Manual for Sustainable Dairy Systems, University of Tennessee. Part of final report for

SARE/ACE Southern Region Subaward # RE353-091/8553373.

Fales, S.L. 1986. Effects of temperature on fiber concentration, composition, and in vitro digestion kinetics of tall fescue. Agron. J. 78: 963-966.

Fribourg, H.A., and K.W. Bell. 1984. Yield and composition of tall fescue stockpiled for different periods. Agron. J. 76: 929-934.

Gerken, H. J. and W.H. McClure. 1979. Value of supplemental concentrate with and without monensin for wintering light calves on stockpiled fescue. Research Division Report 175 pg 127-129. Virginia Polytechnic Institute and State University, Blacksburg.

Gerrish, J.R., P.R. Peterson, C.A. Roberts, and J.R. Brown. 1994. Nitrogen fertilization of stockpiled tall fescue in the midwestern USA. J. Prod. Agric., Vol. 7, no. 1: 98-104.

Gerrish, J.R.. 1996. Extending the grazing season. Chapter 13 in the 1996 Missouri Grazing Manual. University of Missouri Extension Publication M157, pg 113-118.

Green, James Terrill, Jr. 1974. Accumulating canopies of tall fescue (*festuca arundinacea schreb.)* as influenced by nitrogen and cutting management. Ph.D. Thesis. Virginia Polytechnic Institute and State Univ. (Libr. Congr. Card No. Mic. 75-15874).

Hoveland, C.S., S.P. Schmidt, C.C. King, Jr., J.W. Odom, E.M. Clark, J.A. McGuire, L.A. Smith, H.W. Grimes, and J.L. Holliman. 1975. Steer performance and association of *Acremonium coenophialum* fungal endophyte on tall fescue pasture. Agron. J. 75:821-824.

Larson, B.T., R.B. Hightshoe, and D.L. Harmon. 2000. Supplementing steers grazing stockpiled tall fescue with cracked corn or soyhulls. 2000 Kentucky Beef Cattle Research Report Pg.11-13. University of Kentucky, Lexington.

Mays, D.A., and J.B. Wasko. 1960. The feasibility of stockpiling legume-grass pasturage. Agon. J. 52:190-192.

Matches, A.G., J.B. Tevis, and F.A. Martz. 1973. Yield and quality of tall fescue stockpiled for winter grazing. Pp. 54-57. In Research in Agronomy 1973. Univ of Missouri-Columbia Misc.Pub 73-5.

McClure, W.H., J.P. Fontenot and H.J. Gerken, Jr. 1977. Stockpiled fescue for wintering beef calves. Research Division Report 172 pg 79-81. Virginia Polytechnic Institute and State University, Blacksburg.

National Research Council. 1996. Growth and Body Reserves. Chapter 3, pg 24 in “Nutrient Requirements of Beef Cattle” National Acadamy Press, Washington DC.

Ocumpaugh, W.R., A.G. Matches. 1977. Autumn-winter yield and quality of tall fescue. Agron. J. 69: 639-643.

Poore, M.H. and J.T. Green. 1999. Influence of supplementing growing heifers grazing stockpiled fescue with a pressed block containing whole cottonseed. Department of Animal Science Report No. 248 pg 24-26, North Carolina State University, Raleigh.

Rayburn, E.B., R.E. Blaser, and D.D. Wolf. 1979. Winter tall fescue yield and quality with different accumulation periods and N rates. Agron. J. 71:959-963.

Reynolds, J.H. 1975. Yield and chemical composition of stockpiled tall fescue and orchardgrass. Tenn. Farm Home Sci. 94:27-29.

Ross J.P. and Reynolds, J. H. 1979. Nutritive value of fall-stockpiled tall fescue. Tenn. Farm Home Sci. 112:44-48.

Scott, M.E. 2000. Forage composition and utilization of stockpiled fescue by beef heifers. Masters Thesis, North Carolina State University, Raleigh.

Smith, S.C, J.D. Enis, K.S. Lusby, W.E. McMurphy, J.C. Hobbs and C.A. Strasia. 1989. Improving pasture and feedlot profitability of fescue cattle. Oklahoma State University Circular E-884.

Stuedemann, J.A., S.R. Wilkinson, H.C. McCampbell, and R.L. Wilson, Jr. 1981. Winter stocking-summer finishing systems using rye, kentucky-31 tall fescue and coastal bermudagrass pastures. J. Anim. Sci. 52: 945-953.

Taylor, T.H. and W.C. Templeton, Jr. 1976. Stockpiling kentucky bluegrass and tall fescue forage for winter pasturage. Agron. J. 68: 235-239.

Van Keuren, R.W. 1972. All-season forage systems for beef cow herds. p. 39-44. In Twenty-seventh Annu. Meeting Soil Cons. Soc. Am. Portland, Oreg. 6-9 Aug 1. Soil Cons. Soc. Am., Ankeny, Iowa.

Wedin W.F., I.T. Carlson, and R. L. Vetter. 1967. Studies on nutritive value of fall-saved forage, using rumen fermentation and chemical analyses. In: Proc. Of 10th International Grassland Cong. Pg 424-428, Helsinki, Finland.

Table 1. Yield and N use efficiency response of tall fescue to Nitrogen rates, time of application and length of stockpile period.

Reference	Accumulation period, month	Autumn-Fall N application		Stockpiled growth			Management prior to start of accumulation	
		Date	Kg/ha	Dry Matter kg/ha		Kg DM/kg autumn N; based on avg yield	N, kg/ha	Harvest
				Avg	Range			
Taylor & Templeton, 1976 3 yrs	Aug 15 to Dec15	Aug 15	0	1887	-	-	50 in March and July	May, June and Mid August.
			50	3086		23.9		
			100	3374		14.8		
	Aug 15 - Feb 8		0	1474	-	-		
			50	2262		15.7		
			100	3204		17.3		
Rayburn et al., 1979 2 yrs.	Aug 10 to Dec 7	Aug 5-15	0	901	880-923	-	0 in spring	once June 3-14 pre start of stockpile
			112	1769	1627-1911	7.7		
	Sep 15 to Dec 7	Sep 15	0	484	447-521			
			112	1552	1083-2021	9.5		
Balasko, 1977 3 yrs.	Mid Aug to Mid Dec	Mid Aug	0	1206	550-1890	-	0	May, July, mid August

			60	3193	2020-4460	33	180		
Collins & Balasko, 1981 2 yrs	Mid Jly to Mid Dec	Mid Aug	0	1700	1100-2200	-	0 in March	Early June, mid July
			30	2500	1900-3000	27	30 in March	
			60	3200	2300-4000	25	60 in March	
			90	3300	2100-4200	18	90 in March	
Gerrish et al., 1994 reporting only 1989 data here.	Aug 1 to Late Dec	Aug 1	0	2189	-	-		
			45	3320	-	25		
			90	3510	-	14.6		
			135	4297	-	15.6		
Green, 1974 Experiment I 1 yr	Sep 1 - Jan 2	Sep 1	0	1110	-	-	84 in April	cut twice before treatmetns started
			28	1550	-	16		
			84	2330	-	14		
			140	3190	-	15		
			280	3080	-	7		

Green, 1974 Experiment II 1 yr.	Aug 6 - Dec 4	Aug 6	28	3561	2258[1]	-	84 in March and 84 in June	harvested in June and August 6
			84	4876	3831	24		
			140	5741	3887	20		
	Aug 6 - Feb 4		28	2257		-		
			84	3829		28		
			140	3885		14.5		
Woodhouse & Chamblee, annual reports, 3 years (Unpublished date, Soil Science Dept., NCSU, Raleigh, NC)	Sep 15- Dec 1	Sep 14	0	711	633-809	-	50 in March and April 15.	Harvests 4-6 times prior to September 14
			56	1448	1333-1534	13.1		
			112	1892	1656-2222	10.5		

Table 2. Average daily gain (kg/d) of cattle grazing stockpiled fescue with or without supplementation

Reference	Control	Suppl	Days	Supplement type/level
McClure et al., 1977	0.51[a]	0.66[b]	112	1% Body weight (BWT) corn
Gerken and McClure, 1979	0.30[a]	0.53[b]	112	0.5% BWT 12% CP pellet
		0.59[b]		same plus 200 mg monensin
Poore and Green, 1999	0.47[a]	0.77[b]	56	1.1 % BWT Pressed Cottonseed Block
Burris, 2000 Study 1	-	0.69[a]	60	1% BWT Corn/soybean meal
		0.83[b]		1% BWT Soybean hulls
Burris, 2000 Study 2	0.30[a]	0.66[b]	62	1.5% BWT corn
		0.72[b]		1.5% BWT soybean hulls
		0.84[c]		1.5% BWT corn gluten feed
Larson et al., 2000	-	0.10[a]	84	0.6% BWT corn
		0.34[b]		0.6% BWT soybean hulls
Scott, 2000 Year 1	0.46[a]	0.56[b]	83	0.33% BWT cottonseed
Scott, 2000 Year 2	0.22[a]	0.44[b]	83	0.33% BWT cottonseed

[a,b,c]Within study superscripts indicate treatments differ, $P<.05$.