Summer Accumulation of Tall Fescue at Low Elevations in the Humid Piedmont: II. Fall and Winter Changes in Nutritive Value

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ABSTRACT

The mild but variable temperatures and predominant rainfall during the winter could reduce the nutritive value in the winter of summer-accumulated tall fescue (*Festuca arundinacea* Schreb.). The objective of our 3-yr study was to determine the nutritive value of tall fescue accumulated from 1 June, 1 July, 1 July + N (67 kg N ha^{-1}), 1 August, and 1 September and sampled from October to March. The treatments were arranged in a randomized complete block design with four replicates. Delaying accumulation from 1 June to 1 September increased in vitro dry matter disappearance (IVDMD) linearly ($P \leq 0.05$) at each monthly sampling from October to March. Highest IVDMD (717 g kg^{-1}) was obtained from the 1 September accumulation sampled in October and declined to 623 g kg^{-1} in March. Forage accumulated from 1 June and 1 July was lowest in IVDMD and averaged 590 g kg^{-1} in October and declined to 539 g kg^{-1} in March. Crude protein (CP) concentrations showed little change from November to March (mean = 121 g kg^{-1}). Green tissue in accumulated forage retained high IVDMD (mean = 714 g kg^{-1}) throughout the winter, but the proportion shifted from about 73% green in November to 36% in January. Dead tissue, consistently low in IVDMD (mean = 393 g kg^{-1}), reduced canopy IVDMD from 26 to 55 g kg^{-1} for each 10 percentage unit increase. Tall fescue can be accumulated during the summer in the Piedmont and can provide forage of high nutritive value until January or until dead tissue dominates in the forage.

THE value of tall fescue as a fall–winter feed has been documented in the western (Ocumpaugh and Matches, 1977) and the northern portions of the tall fescue transition zone (Burns and Chamblee, 1979) at the higher (>280 m) elevations (Taylor and Templeton, 1976; Fribourg and Loveland, 1978; Rayburn et al., 1979; Collins and Balasko, 1981a). A major consideration for summer-accumulated tall fescue is its nutritive value relative to the daily ruminant response desired during fall and winter grazing.

Although limited, some estimates of dry matter digestibility of accumulated tall fescue are available, but only from the more northern and higher elevations of the transition zone. The IVDMD of tall fescue accumulated from mid- to late-August averaged >640 g kg^{-1} until late November in Missouri (Ocumpaugh and Matches, 1977). In Tennessee, IVDMD averaged 700 g kg^{-1} by January and declined by February (Ross and Reynolds, 1979). Accumulating tall fescue from mid-July in West Virginia produced forage that averaged only 481 g kg^{-1} IVDMD by mid-December, declined to 450 g kg^{-1} by mid-January, and declined further to 425 g kg^{-1} by mid-February (Collins and Balasko, 1981b). Crude protein in the forages accumulated from mid- to late-August averaged 150 to 160 g kg^{-1} in November and declined to 100 to 130 g kg^{-1} by January (Ocumpaugh and Matches, 1977; Ross and Reynolds, 1979).

To the north of the tall fescue transition zone, but at lower elevations along the Atlantic coast, tall fescue accumulated in Maryland from mid-September averaged 755 g kg^{-1} IVDMD in early October, 770 g kg^{-1} by mid-November, and 741 g kg^{-1} by late December in one year but averaged only 528, 541, and 553 g kg^{-1} for the same sampling dates in a second year (Archer and Decker, 1977b). Concentration of CP averaged 167 g kg^{-1} in the accumulated forage in early October and declined to 137 g kg^{-1} by late December.

Generally, declines in the nutritive value of the accumulated forage during the fall–winter period have been attributed to normal leaf aging and senescence in the canopy; leaf death and senescence associated with freezing, with subsequent soluble nutrients either translocated out or leached; and to the intensity of frosting. Frosting results in physical cell rupture and subsequent leaching of the solubles with the onset of rain and has been a perceived determent to the practice of accumulating tall fescue in the lower south. A shift from green to dead tissue in summer-accumulated tall fescue occurs with the progression of winter (Taylor and Templeton, 1976; Archer and Decker, 1977b). Forage averaged >80% green leaf in October and declined to about 60% by December. By late winter, green tissue composed only 20% (Taylor and Templeton, 1976) to essentially none (Archer and Decker, 1977b) of the summer-accumulated forage. This has implications about the nutritive value of the accumulated tall fescue as IVDMD declined 35 g kg^{-1} for each 10 percentage units increase in dead leaf (Archer and Decker, 1977b). Green leaf from a late-December sampling averaged 1.4 times higher in IVDMD than dead leaf.

Information is needed on the potential nutritive value of the tall fescue accumulated during the summer for fall–winter grazing at the lower elevations in the southern portion of the tall fescue transition zone. The objective of this study was to determine the changes in the nutritive value of tall fescue accumulated for different periods in the summer when sampled from October to March. The proportion and nutritive value of green and dead tissues also was determined.

MATERIALS AND METHODS

The experiment was conducted at the Reedy Creek Road Field Laboratory in Raleigh, NC. The site (123 m elevation)

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Abbreviations: ADF, acid detergent fiber; CP, crude protein; IVDMD, in vitro dry matter disappearance; NDF, neutral detergent fiber; TNC, total nonstructural carbohydrates.

was a Cecil clay loam (fine, kaolinitic, thermic Typic Kanhapludults) soil. The experiment was established and managed as described by Burns and Chamblee (2000). The experiment was designed to permit a previously unused land area for forage accumulation in the summer for each of the three years.

Five treatments were evaluated in a randomized complete block design with four replicates. The treatments consisted of four periods of forage accumulation starting 1 June, 1 July, 1 August, and 1 September. The fifth treatment was a N rate variable with 67 kg N ha^{-1} applied at the 1 July (J + N) starting date. Nitrogen was applied to all summer accumulation treatments at 112 kg N ha^{-1} 1 March and 90 kg N ha^{-1} 25 August as ammonium nitrate for a seasonal total of 202 kg N ha^{-1}. The J + N treatment received an additional 67 kg N ha^{-1} on 1 July, giving a seasonal total of 269 kg N ha^{-1} for this treatment. The general nitrogen application for summer accumulation was delayed until 25 August to avoid stand losses associated with high nitrogen application in June and July (Hallock et al., 1973). The experiment was topdressed annually with 35 and 201 kg ha^{-1} of P and K, respectively.

Each plot (1.9 × 4.6 m) was halved (0.95 m) and one-half was randomly assigned for yield estimates with a harvest made only in mid-November. These results and additional details of the experiment are presented elsewhere (Burns and Chamblee, 2000). The other one-half of each plot, designated for nutritive value estimates, was mapped into two rows of six subplots (total of 12 subplots), each 0.15 by 0.46 m. The six subplots within each row were randomly assigned to six monthly sampling dates beginning 15 October through 5 March. Each month, forage from the appropriate two subplots was hand-clipped to a 5-cm stubble, composited, and immediately quick frozen in liquid N (−195°C). Thereafter, samples were transferred to a freezer (−160°C) for storage, then freeze dried and ground in a Wiley mill to pass a 1-mm screen and returned to the freezer until analyzed. In Years 2 and 3, an adjacent 0.15 by 0.46-m subplot was harvested, the two fresh subsamples were combined, and were hand separated into tall fescue and weeds. The tall fescue portion was further hand separated into green and dead tissues, then oven-dried (750°C), ground in a Wiley mill to pass a 1-mm screen, and stored for analyses.

Samples of accumulated forage were analyzed for IVDMD (Burns and Cope, 1974) from all four replicates. The other analyses were conducted on three replicates and consisted of neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to Goering and Van Soest (1970) and total N (Association of Official Analytical Chemists, 1990), which was expressed as CP (N × 6.25). Samples from selected accumulation treatments and sampling dates also were analyzed for total nonstructural carbohydrates (TNC) and separated into starch, fructosans (fructans), simple sugars, and sucrose (Smith, 1969).

Data were analyzed statistically in combined analyses (over years and sampling dates) for a randomized complete block design. When treatments or years or sampling date interacted, the analyses were conducted by year or by sampling date and the data were presented by year or by sampling date. A set of meaningful comparisons included in the analysis of variance consisted of a time trend (the J + N treatment excluded) for length of accumulation [linear (L) and quadratic (Q)] and a N rate comparison for the 1 July closing date (1 July vs. J + N). A minimum significant difference (MSD) from the Waller–Duncan *k* ratio ($k = 100$) *t*-test (SAS Institute, 1995) also was determined and included for other comparisons of interest. Linear regression was used to test the relationship between IVDMD and dead tissue among the five accumulation periods evaluated.

RESULTS AND DISCUSSION

Whole Canopy

In Vitro Dry Matter Disappearance

The IVDMD of the whole accumulated canopy showed significant treatment × year, treatment × sample date, and year × sample date interactions. The treatment × year interaction resulted from nonparallel trends and was ignored. The data were analyzed for treatment and year effects by sample date. Delaying the start of forage accumulation from 1 June (longest period) to 1 September (shortest period) resulted in a linear increase in IVDMD at every sampling date (Table 1). Forage accumulated from 1 June had IVDMD concentrations that declined from 570 to less than 500 g kg^{-1} by January. When the start of accumulation was delayed until 1 September, IVDMD concentrations were 717 g kg^{-1} in October and never fell below 600 g kg^{-1} by March. Similar high concentrations also were reported from a 1 September accumulation in Maryland (Archer and Decker, 1977a).

Applying additional N at the 1 July starting date, compared with none, generally increased dry matter yield by mid-November (Burns and Chamblee, 2000) but reduced IVDMD at the October, November, and December sample dates. Differences ($p \leq 0.05$) did not occur between the two treatments from January to March (Table 1).

The 1 August-accumulated forage had lower IVDMD concentrations compared with forage from the 1 September accumulation through the December sampling and was similar from January to March (Table 1). Tall fescue accumulated from 1 August in West Virginia had declined to well below 600 g kg^{-1} by December (Balasko, 1977), but in Tennessee, IVDMD of forage never declined below 600 g kg^{-1} by February (Ross and Reynolds, 1979). The IVDMD concentrations in our study varied among years at the October, January, and February samplings.

A decline in IVDMD of 89 g kg^{-1} (range = 67 to 105 g kg^{-1}) occurred between December and January (Table 1), in agreement with other results (Ross and Reynolds, 1979). A numeric increase in IVDMD is noted in February and March and is attributed, in part, to the mild winter temperature in this environment. Spring green-up can begin in the accumulated forage as early as mid-February, as daytime temperatures may reach 27°C for 10 to 14 d at a time.

Crude Protein Concentrations

The CP concentrations of all accumulated forages averaged 126 g kg^{-1} (range for five accumulation treatments = 122 to 133 g kg^{-1}) and were not altered by period of accumulation nor by the addition of N at the 1 July starting date. Crude protein concentrations were different among sampling dates and years, which is attributed mainly to yearly differences in concentrations in October (Table 2). A general consistency in CP concentrations during the winter has been reported by others across the tall fescue transition zone (Taylor and

Table 1. Mean in vitro dry matter disappearance of tall fescue sampled from October to March following summer accumulation (oven-dry basis).

	Sample date					
Item	**15 Oct.**	**13 Nov.**	**10 Dec.**	**8 Jan.**	**5 Feb.**	**5 March**
	g kg^{-1}					
Date accumulation began						
1 June	570†	620	595	490	495	529
1 July (J)	624	640	629	524	529	564
J + N‡	576	566	565	497	493	523
1 Aug.	669	670	639	572	575	587
1 Sept.	717	711	699	600	612	623
Significance						
Trend§	L	L	L	L	L	L
J vs. J + N	0.03	<0.01	0.01	NS	NS	0.08
MSD¶	64	38	39	39	47	47
Year						
One	602#	662	636	545	578	577
Two	623	630	632	522	497	577
Three	669	633	609	544	548	542
Significance						
MSD	32	NS	NS	22	41	NS
Mean	631	642	625	537	541	565

† Values are the mean of four replicates and 3 yr ($n = 12$).
‡ 67 kg of N ha^{-1} was applied 1 July in addition to the 90 kg N ha^{-1} applied to all treatments on 25 August.
§ The highest significant ($P \leq 0.05$) component is given with L = linear (J + N not included).
¶ MSD = minimum significant difference from the Waller–Duncan *k* ratio ($K = 100$) *t*-test.
# Values are the mean of four replicates and five treatments ($n = 20$).

Templeton, 1976; Rayburn et al., 1979; Collins and Balasko, 1981b).

The year effect on CP concentrations in the summer-accumulated forage was large (Table 2). In Year 1, CP concentration averaged 158 g kg^{-1} during the fall–winter period and never fell below 120 g kg^{-1} for any of the summer accumulation treatments. In Year 2, CP concentrations averaged only 105 g kg^{-1} for the fall–winter period. As in Year 1, highest CP concentrations occurred at the October sampling (128 g kg^{-1}) but declined to 109 g kg^{-1} in November. At the October sampling in Year 3 CP concentration was closer to Year 1 than Year 2, but declined in November and December, similar to Year 2 at the January to March samplings. Applying additional N (J + N treatment) would guard against extremely low CP concentrations, as occurred in Year 2. The J + N treatment not only increased CP concentrations during the winter but also increased dry matter yield of the summer-accumulated forage (Burns and Chamblee, 2000).

Total Nonstructural Carbohydrates

Concentration of TNC from an October and December sampling ranged from 103 to 157 g kg^{-1} during the 3-yr study (Table 3). Delaying the time of accumulation from 1 June to 1 September increased TNC concentrations quadratically. The quadratic response is attributed to the increased TNC concentration in the 1 September accumulation (Pearce et al., 1965). Highest TNC concentrations of 209 g kg^{-1} in Year 1 and 216 g kg^{-1} in Year 2 occurred in the 1 September-accumulated forage.

Table 2. Crude protein concentration of tall fescue sampled from October to March following summer accumulation (oven-dry basis).

	Sample date					
Item	**15 Oct.**	**13 Nov.**	**10 Dec.**	**8 Jan.**	**5 Feb.**	**5 March**
	g kg^{-1}					
Date accumulation began						
Exp. mean	154†	128	110	111	120	135
MSD‡	31					
Year effects						
Year 1						
Mean	175§	148	131	140	159	197
Range	160–192	142–151	122–141	121–154	144–169	181–213
Year 2						
Mean	128	109	91	95	102	105
Range	120–135	104–121	84–109	78–117	81–130	100–117
Year 3						
Mean	158	128	108	98	99	104
Range	153–166	125–131	97–115	88–111	89–109	100–112
Significance						
MSD	16	13	12	11	12	6
CV (%)	7.1	9.0	11.9	10.8	8.3	3.9

† Each value is the mean of five treatments and three replicates for 3 yr ($n = 45$).
‡ MSD = minimum significant difference from the Waller–Duncan *k* ratio ($k = 100$) *t*-test.
§ Each value is the mean of five treatments and three replicates ($n = 15$).

Table 3. Total nonstructural carbohydrates (TNC) and constituent fractions of tall fescue sampled in October and December following summer accumulation (oven-dry basis).

Item	TNC	Nonstructural carbohydrate fractions			
		Simple sugars	Sucrose	Fructan	Starch
	g kg^{-1}				
Date accumulation began					
1 June	123†	28	33	58	4
1 July (J)	118	28	35	50	5
J + N‡	103	27	26	45	5
1 Aug.	124	28	33	56	7
1 Sept.	157	30	47	74	6
Significance					
Trend§	Q	NS	L	Q	L
J vs. J + N	NS	NS	NS	NS	NS
MSD¶	12	–	12	17	2
Year					
One	117#	15	44	55	5
Two	148	37	33	73	5
Three	109	33	28	41	6
MSD	16	4	7	11	NS
Sample date					
15 Oct.	99††	20	31	40	8
10 Dec.	151	37	39	73	2
Significance	0.03	NS	NS	0.01	0.01
Mean	125	28	35	57	5

† Each value is the mean of two sample dates and three replicates for 3 yr ($n = 18$).
‡ 67 kg of N ha^{-1} was applied 1 July in addition to the 90 kg N ha^{-1} applied to all treatments on 25 August.
§ The highest significant ($P \leq 0.05$) component is given with L = linear and Q = quadratic (J + N not included); NS = not significant.
¶ MSD = Minimum significant difference from the Waller–Duncan *k* ratio ($k = 100$) *t*-test.
# Each value is the mean of five treatments and two sample dates and three replicates ($n = 30$).
†† Each value is the mean of five treatments and three replicates for 3 yr ($n = 45$).

The changes in TNC were associated mainly with sucrose and fructan concentrations (Table 3), which contributed more than 73% of the TNC. Applying 67 kg N ha^{-1} on 1 July did not alter TNC concentration.

Total nonstructural carbohydrates in the accumulated forage differed among years, with Year 2 having higher average concentrations (Table 3). Year differences also are reflected in simple sugars, sucrose, and fructan concentrations. The increase in TNC from the October to the December sampling was mainly due to increased fructan concentrations. Increased TNC concentration occurred as the accumulation date was delayed to September and sampling delayed from October to December, which is consistent with the literature (Balasko, 1977; Rayburn et al., 1979; Collins and Balasko, 1981b).

Fiber Fractions

Neutral detergent fiber concentration in the accumulated forage decreased linearly at each sampling date

Table 4. Neutral detergent fiber concentrations of tall fescue sampled from October to March following summer accumulation (oven-dry basis).

Item	Sample date					
	15 Oct.	13 Nov.	10 Dec.	8 Jan.	5 Feb.	5 March
	g kg^{-1}					
Date accumulation began						
1 June	538†	543	540	616	636	633
1 July (J)‡	530	523	535	606	624	616
J + N	560	551	561	623	640	637
1 Aug.	512	496	531	604	611	615
1 Sept.	475	463	497	577	594	596
Significance						
Trend§	L	L	L	L	L	L
J vs. J + N	0.06	NS¶	NS	NS	NS	0.04
MSD#	32	38	35	22	28	21
Year						
One	535††	472	501	577	555	565
Two	528	527	530	615	654	613
Three	507	548	568	623	654	681
Significance						
MSD	20	47	23	7	12	12
Mean	523	515	533	605	621	619

† Each value is the mean of two sample dates and three replicates for 3 yr ($n = 9$).
‡ 67 kg of N ha^{-1} was applied 1 July in addition to the 90 kg N ha^{-1} applied to all treatments on 25 August.
§ The highest significant ($P \leq 0.05$) component is given with L = linear (J + N not included).
¶ NS = Not significant.
# MSD = Minimum significant difference from the Waller–Duncan *k* ratio ($k = 100$) *t*-test.
†† Each value is the mean of five treatments and two sample dates and three replicates ($n = 15$).

Table 5. Changes in the proportion of green tissue from tall fescue sampled from October to March following summer accumulation (oven-dry basis).

	Year 2					Year 3					
	13 Nov.	10 Dec.	8 Jan.	6 Feb.	5 Mar.	15 Oct.	12 Nov.	10 Dec.	8 Jan.	4 Feb.	3 Mar.
	%										
Date accumulation began											
1 June	**54†**	**43**	**35**	**26**	**37**	**71**	**67**	**57**	**38**	**23**	**23**
1 July (J)	**55**	**47**	**35**	**26**	**39**	**78**	**67**	**57**	**37**	**22**	**25**
J + N‡	**51**	**46**	**34**	**24**	**34**	**66**	**50**	**44**	**30**	**24**	**22**
1 Aug.	**56**	**48**	**38**	**27**	**39**	**81**	**71**	**61**	**39**	**26**	**27**
1 Sept.	**70**	**54**	**41**	**27**	**41**	**87**	**77**	**62**	**42**	**32**	**25**
Mean	**57**	**47**	**37**	**26**	**38**	**76**	**66**	**56**	**37**	**25**	**25**
Significance											
Trend§	**Q**	**L**	**L**	**NS**	**NS**	**L**	**L**	**NS**	**NS**	**NS**	**NS**
J vs. J + N	**NS**	**NS**	**NS**	**NS**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**NS**	**NS**	**NS**
MSD¶	**7**	**7**	**5**	**–**	**4**	**8**	**6**	**7**	**–**	**8**	**–**

† Each value is the mean of four replicates.

‡ 67 kg N ha^{-1} was applied 1 July in addition to 90 kg N ha^{-1} applied to all treatments on 25 August.

§ The highest significant ($P \leq 0.05$) component is given with Q = quadratic and L = linear (J + N not included); NS = not significant.

¶ MSD = Minimum significant difference from the Waller–Duncan *k* ratio ($k = 100$) *t*-test.

as the summer accumulation period was delayed from 1 June to 1 September (Table 4). Adding an additional 67 kg N ha^{-1} at the 1 July starting date resulted in higher NDF concentration only at the 15 October and 5 March sampling dates. Of significance is the 72 g kg^{-1} (range = 62 to 80 g kg^{-1} for all treatments) increase in NDF between the December and January sampling dates (Table 4). This is reflected in the mean decline in IVDMD of 89 g kg^{-1} between the December and January sampling dates (Table 1). The retention of high IVDMD of accumulated forage from 15 October until 10 December is attributed to the increase in TNC concentration (Table 3) while NDF concentrations increased little during this time. The NDF concentration differed among years for each sample date, but no clear trend was evident (Table 4). The NDF concentrations reported by Ross and Reynolds (1979) for a mid- to late-August accumulation date were generally lower than reported here. They averaged about 400 g kg^{-1} in November and approached 600 g kg^{-1} by January in one year but were <500 g kg^{-1} by January in a second year.

Proportion of Green and Dead Tissue

The proportion of green tall fescue tissue in the accumulated forage, determined in Years 2 and 3 of this study, averaged 57% in November of Year 2 and declined to a low of 26% by February (Table 5). In Year 3, the canopy was highest (76%) in green tissue in October and declined to a low of 25% by early March. Reducing the length of the summer accumulation period increased the proportion of green tissue at the November, December, and January samplings in Year 2 and at the October and November sampling in Year 3. Thereafter, the influence of the accumulation period diminished. By January, the mean proportion of green tissue was 37% and declined to 26% at the February sampling (Table 5). The general trend between October or November and the February sampling was a decline in the percentage of green tissue, which agrees with Taylor and Templeton (1976) and Archer and Decker (1977b). Three points, however, warrant mentioning. First, in Year 2, a 12 percentage unit increase in green tissue occurred between February and March and is attributed to new growth, a frequent occurrence at this time in this environment. Second, in Year 3, a 19 percentage unit decrease occurred in green tissue between December and January and is attributed mainly to frost injury. Third, essentially no change in the proportion of green tissue occurred in Year 3 between the Feburary and March samplings. This is in conflict with the large increase in green tissue noted in Year 2, but is representative of a dry, late spring that would delay new growth.

In general, adding 67 kg of N ha^{-1} 1 July, compared

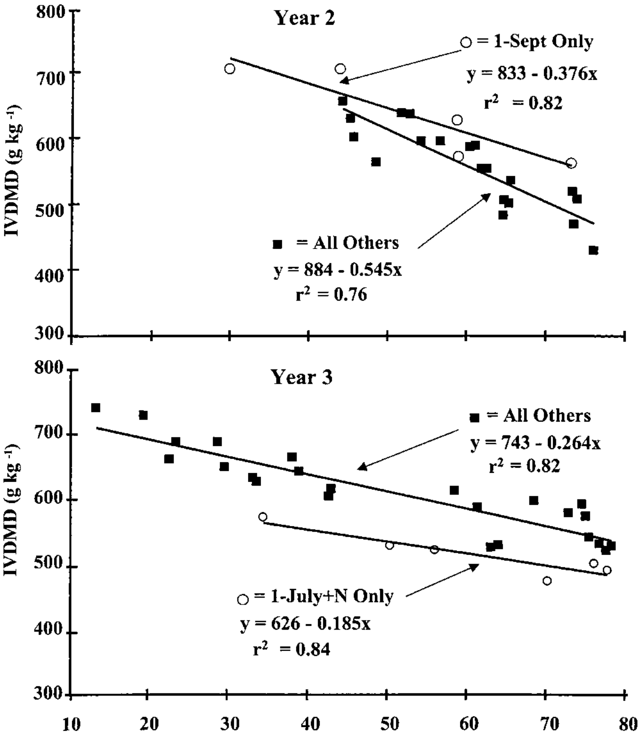

Fig. 1. Relationship between in vitro dry matter disappearance (IVDMD) and the percentage of dead tall fescue tissue in summer-accumulated forage in Years 2 and 3. Data are shown for accumulation dates beginning 1 June, 1 July, 1 July + 67 kg N ha^{-1}, 1 August, and 1 September, for five fall–winter sampling dates in Year 2, and six fall–winter sampling dates in Year 3. Each value is the mean of four replicates.

with adding none, had no affect on the percentage green tissue in Year 2, except at the March sampling (Table 5). The lower percentage green tissue (34 vs. 39% with no N) is attributed to delayed spring growth due to the quantity of the accumulated forage. In Year 3, applying N 1 July reduced the percentage of green tissue at the October, November, and December sampling. This reduction is attributed, in part, to additional shading that probably occurred in the canopy, as dry matter yield was approximately 23% greater than in Year 2 (Pearce et al., 1965). These differences disappeared, however, as the winter progressed.

Regressing IVDMD of the accumulated forage against dead tissue showed the 1 June, 1 July, J + N, and 1 August accumulations in Year 2 to have similar characteristics (similar slopes) with an average decline in IVDMD of 55 g kg^{-1} for each 10 percentage unit increase in dead tissue (Fig. 1). The 1 September-accumulated forage had a different slope as IVDMD declined only 38 g kg^{-1} for each 10 percentage units increase in dead tissue. This agrees with a 34 g kg^{-1} decline in IVDMD for each 10 percentage units increase in dead tissue from a 10 September accumulation reported by Archer and Decker (1977b). In their study, however, sampling was conducted only through December. In Year 3 of our study, the 1 June, 1 July, 1 August, and 1 September accumulations had similar slopes with a 26 g kg^{-1} decline in IVDMD for each 10 percentage unit increase in dead tissue. In this year, the J + N treatment was different, having lower IVDMD in October that declined 19 g kg^{-1} with each 10 percentage units increase in dead tissue.

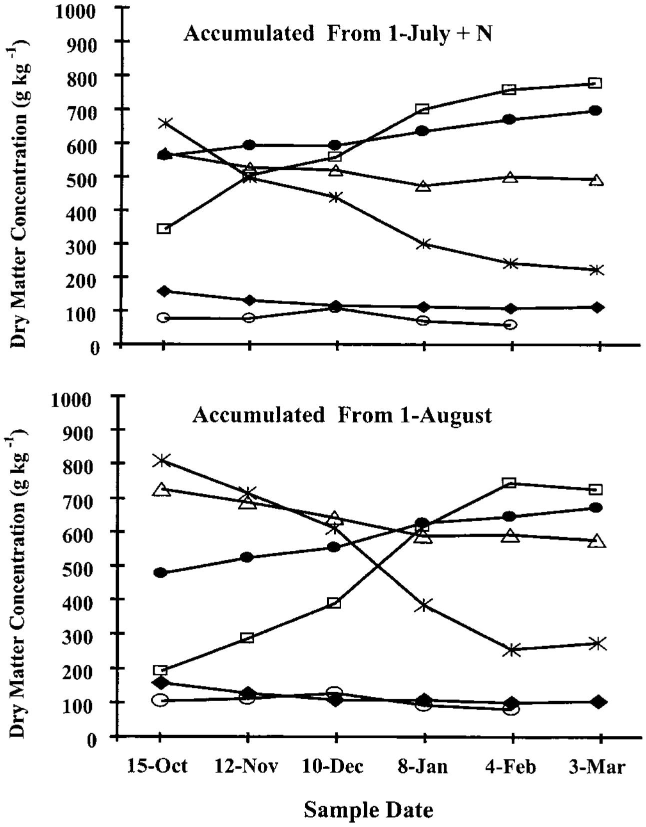

Fig. 2. Changes from October to March in the proportion of green (*) and dead (□) tissue and in vitro dry matter disappearance (△), crude protein, (◆), total nonstructural carbohydrates (○), and neutral detergent fiber (●) concentrations in tall fescue accumulated from 1 July + 67 kg^{-1} N ha^{-1} and 1 August in Year 3. The SE were 4.4% for green tissue, 29 g kg^{-1} for in vitro dry matter disappearance, 10 g kg^{-1} for crude protein, 13 g kg^{-1} for total nonstructural carbohydrates, and 16 g kg^{-1} for neutral detergent fiber.

The relationship between green and dead tissue and the nutritive value of the accumulated forage is demonstrated by selecting the J + N and 1 August treatments in Year 3 (accumulated canopy not contaminated by early spring growth). A general decline in IVDMD and CP and an increase in NDF is noted as the proportion of green tissue declined and dead tissue increased as the winter progressed (Fig. 2). Although the date at which the green and dead tissue were approximately equal (lines intersect) differed between the J + N (mid-November) and the 1 August (late December) accumulated forages, the trends were similar. This raises the question about the quantity of the green and dead tissue and their nutritive value in the accumulated forage relative to the quality of the total canopy (Tables 1, 3, and 4). This issue is addressed in the next section.

Green and Dead Tissue

Green Tissue

The tissue that remained green in our study retained high IVDMD through the winter (Table 6). Green tissue at the November sampling from the J + N, 1 August, and 1 September treatments was similar in IVDMD in Years 2 and 3. By December, the IVDMD from the 1 September-accumulated forage was higher than either the J + N or 1 August accumulation, and the latter two were similar. The same relationship held in February in Year 2, but in Year 3 all three summer accumulations were similar in IVDMD (mean = 749 g kg^{-1}). The IVDMD of the green tissue from the 1 September accumulation was higher than reported by Archer and Decker (1977b) from a 10 September accumulation.

Crude protein concentrations in the green tissue (data not shown) were similar between the J + N and 1 August accumulations for both years averaging 119 g kg^{-1} for the winter (SE = 10). The same average CP concentrations in green leaves from a mid-August accumulation were obtained in Kentucky for a November, December, and February sampling (Taylor and Templeton, 1976).

Forage accumulated from 1 August had a peak TNC concentration of 200 g kg^{-1} in December and then declined (Table 7). The concentrations in December in our study were similar to those reported from Taylor and Templeton (1976) for December and February. Of the TNC, starch was present in smallest concentration and was not altered by time of sampling or by year. Sucrose and fructans made up 91% of the TNC and accounted for the major changes that occurred in TNC during the sampling period. Differences between years were noted only for sucrose (44 g kg^{-1} in Year 2 vs. 53 g kg^{-1} in Year 3).

Green tissue of summer-accumulated forages sampled in December and again in February showed no difference in either NDF (492 g kg^{-1}) or ADF (247 g

Table 6. Mean in vitro dry matter disappearance of green and dead tissue of tall fescue sampled in November, December, and February following summer accumulation, Years 2 and 3 (oven-dry basis).

	Green tissue			Dead tissue		
Item	**November**	**December**	**February**	**November**	**December**	**February**
	g kg^{-1}					
				Year 2		
Date accumulation began						
1 July + N†	670‡	723	719	318	350	261
1 Aug.	641	746	731	411	374	279
1 Sept.	679	816	797	459	410	465
Mean	663	762	749	396	378	335
Significance						
MSD§	NS	43	36	82	46	9
CV (%)	4.6	3.2	2.8	11.8	7.1	1.7
				Year 3		
Date accumulation began						
July + N	641	675	739	292	280	398
1 Aug.	667	701	762	450	449	441
1 Sept.	659	736	747	476	497	442
Mean	656	704	749	406	409	427
Significance						
MSD	NS	28	NS	42	52	NS

† 67 kg N ha^{-1} was applied 1 July in addition to 90 kg N ha^{-1} applied to all treatments on 25 August.
‡ Each value is the mean of four replicates.
§ MSD = Minimum significant difference from the Waller–Duncan *k* ratio (*k* = 100) *t*-test.

kg^{-1}) concentrations (data not shown). Summer starting date for forage accumulation, however, altered both fractions. Delaying summer accumulation from 1 July to 1 August resulted in no change in NDF (497 g kg^{-1}) or ADF (251 g kg^{-1}) when sampled in midwinter. Delaying accumulation until 1 September, however, resulted in midwinter green tissue with the lowest NDF (475 g kg^{-1}) and ADF (237 g kg^{-1}). Green tissue from the 1 September accumulation, however, was similar in NDF (489 g kg^{-1}) and ADF (246 g kg^{-1}) to green tissue from the 1 August accumulation.

An example of the changes in nutritive value of green tissue from October to March is shown for forage accumulated from 1 August in Year 3 (Fig. 3). This year was selected because the accumulated forage was not contaminated with early spring growth. After October, all constituents of the green tissue showed rather constant concentration during the remaining fall–winter period.

Table 7. Total nonstructural carbohydrates (TNC) and constituent concentrations in green and dead tissue of tall fescue sampled from November to February following a 1 August accumulation (oven-dry basis).

		Nonstructural carbohydrate fractions			
Item	**TNC**	**Simple sugars**	**Sucrose**	**Fructan**	**Starch**
	g kg^{-1}				
			Green tissue		
Sample date					
November	111†	6	27	76	2
December	200	12	67	118	4
January	157	15	41	96	2
February	147	8	60	77	2
Significance					
MSD‡	89	NS	37	NS	NS
Mean	154	10	49	92	3
			Dead tissue		
Sample date					
November	22†	2	5	11	4
December	34	6	14	12	3
January	15	3	4	6	3
February	14	2	4	5	3
Significance					
MSD	11	1	5	4	NS
Mean	21	3	7	8	3

† Each value is the mean of three replicates for 2 yr (*n* = 6).
‡ MSD = Minimum significant difference from the Waller–Duncan *k* ratio (*k* = 100) *t*-test.

Dead Tissue

The dead tissue was inferior to the green tissue, as IVDMD never exceeded 500 g kg^{-1} (Table 6). Dead tissue for the J + N and 1 August accumulations was extremely low. These results are consistent with the nutritive value index reported by Taylor and Templeton (1976).

Crude protein concentrations (data not shown) in dead tissue were not altered by length of accumulation, sample date, or year of sampling and averaged 95 g kg^{-1}

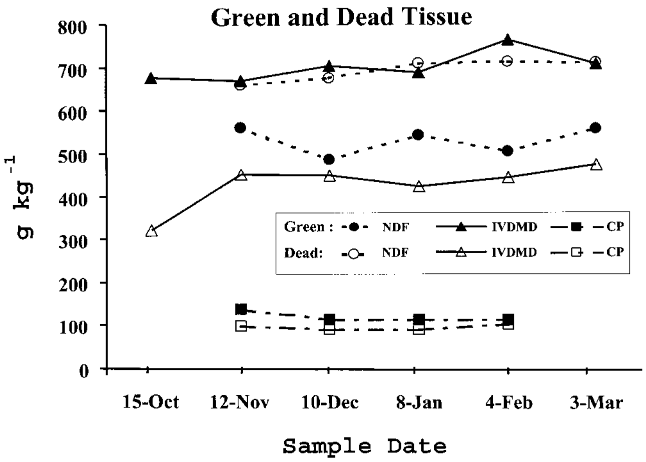

Fig. 3. Changes from October to March for in vitro dry matter disappearance (IVDMD), crude protein (CP), and neutral detergent fiber (NDF) concentrations of green and dead tall fescue tissue accumulated from 1 August in Year 3. The SE were 32 g kg^{-1} for IVDMD, 13 g kg^{-1} for CP, and 8 g kg^{-1} for NDF.

for the winter (SE = 1.3 g kg^{-1}). These concentrations were consistently higher than the 66 to 86 g kg^{-1} from a 15 August accumulation reported by Taylor and Templeton (1976).

The TNC concentrations in the dead tissue from the 1 August accumulation ranged from 34 g kg^{-1} in December to 14 g kg^{-1} by February (Table 7). This trend reflects the changes noted for TNC of green tissue but the green tissue averaged 7.2 times greater in TNC than dead tissue. These changes are similar to those reported for a mid-August accumulation date in Kentucky (Taylor and Templeton, 1976). Although concentrations were low, changes in simple sugars and sucrose contributed to the increase in TNC from the November to December samplings.

Concentrations of NDF (mean = 700 g kg^{-1}) and ADF (mean = 391 g kg^{-1}) of the dead tissue were not altered by date of accumulation, sampling date during the fall–winter, or by the year the study was conducted. Neutral detergent fiber was about 1.4 times and ADF about 1.6 times greater in dead tissue than in green tissue. The consistency in nutritive value from November to March is shown for the 1 August-accumulated forage from Year 3 (Fig. 3). A similar consistency between October and December in NDF of dead tissue also was reported by Taylor and Templeton (1976).

Importance of Green Tissue

The shift in proportion of green and dead tissue was the main contributor to the change during the winter in the nutritive value of the summer-accumulated forage (Fig. 2). This is evident from the decreased IVDMD and increased dead tissue as the fall–winter progressed (Fig. 1), while the nutritive value of either the green tissue or of the dead tissue remained consistent (Fig. 3). The loss of green tissue apparently can be altered by the length of the accumulation period and by the weather conditions during both the summer accumulation period and during the fall–winter use period.

It has been proposed that dead tissue resulting from normal senescence may have different nutritive value than dead tissue caused by frosting (Archer and Decker, 1977b). This is supported by our study, as forage accumulated in Year 3 from the 1 July (N added) starting date had appreciable normal tissue senescence during summer accumulation. This forage had the lowest IVDMD (Fig. 1, Year 3) at the October sampling and decreased little across the total range of dead tissue. Forage from the 1 September starting date in Year 2, however, had little normal senescence during accumulation, but appreciable frost injury occurred after October. In this case, IVDMD was high at the October sampling and remained high during the winter even as the proportion of dead tissue increased (Fig. 1, Year 2).

CONCLUSIONS

The strong relationship between nutritive value of the forage and the proportion of dead tissue provides a winter management strategy for the utilization of summer-accumulated tall fescue. Management that favors a higher proportion of green tissue, such as shorter periods of summer accumulation and use of forage by late December, would favor winter grazing of young stock (National Research Council, 1984). Periodic assessment of the proportion of green and dead tissue in the accumulated forage provides a useful estimate of its relative nutritive value and would help in determining the daily animal response expected from its use. We conclude that summer accumulation of tall fescue at the lower elevations in the Piedmont region of the tall fescue transition zone has as much, if not more, potential as a fall–winter feed than in more temperate environments further north and west.

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