

Summer Accumulation of Tall Fescue at Low Elevations in the Piedmont: I. Fall Yield and Nutritive Value

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ABSTRACT

Summer accumulation of tall fescue (*Festuca arundinacea* Schreb.) for fall and winter use in the Piedmont, a region of the USA of moderate fall and winter temperatures and open winters of frequent rainfall, has not been well documented. We determined in this 5-yr study the yield and nutritive value in mid-November of tall fescue accumulated monthly from 1 June to 1 September. A fifth treatment included an additional 67 kg N ha⁻¹ applied at the 1 July accumulation date. The site was a Cecil clay loam (fine, kaolinitic, thermic Typic Kanhapludults) soil and the treatments were arranged in a randomized complete block design with four replicates. Summer accumulations yielded from 3280 to 4130 kg ha⁻¹ with a mean linear ($P \leq 0.05$) reduction in dry matter of 195 kg ha⁻¹ for each week's delay in accumulation from 1 June until 1 September. In two of the three years, highest ($P \leq 0.05$) dry matter yields (DMY) resulted from the 1 June date (4070 to 5440 kg ha⁻¹) and lowest ($P \leq 0.05$) from the 1 September date (1010 and 860 g kg⁻¹). Repeated summer accumulations did not alter DMY ($P < 0.01$) in subsequent falls or in the following spring. At mid-November in vitro dry matter disappearance (IVDMD) had increased 30 g kg⁻¹ for each 30-d delay in accumulation from 1 June to 1 September, but no change occurred in crude protein (CP) (mean = 120 g kg⁻¹). Summer accumulation of tall fescue for fall grazing can be practiced in the lower Piedmont with accumulation beginning as early as 1 June.

TALL FESCUE is the major temperate, perennial forage grown in the transition zone between the temperate north and the subtropical south (Burns and Chamblee, 1979). This region, referred to as the tall fescue transition zone, extends from Missouri on the west, across southern Illinois and Indiana on the north, to North Carolina on the east, and is extremely variable in climatic and edaphic conditions. Accumulating tall fescue for fall grazing in the more temperate portion of this transition zone has been favorable as in Missouri (Matches, 1979) and further east at the higher elevations in Kentucky (Lexington at 378 m; Taylor and Templeton, 1976), West Virginia (Morgantown at 295 m; Collins and Balasko, 1981a, b), Virginia (Blacksburg at 686 m; Rayburn et al., 1979), and Tennessee (Knoxville at 287 m; Fribourg and Loveland, 1978). In general, well-fertilized tall fescue accumulated from 1.8 to 3.8 Mg ha⁻¹ among these sites for fall-winter use. Highest DMY generally occurred by mid-November with some yield reduction thereafter. Crude protein ranged from 95 to 116 g kg⁻¹ in accumulated forage harvested in mid-winter.

Southeast of the Appalachian Mountains and consequently at the lower elevations (<150 m) of the tall

fescue transition zone, the fall-winter climatic conditions are appreciably different. In this part of the transition zone, mainly the Piedmont and Coastal Plains, the climate is modified by the Appalachian Mountains to the west and the Atlantic Ocean to the east. Moisture in winter occurs mainly as rainfall and freezing rain. Occasional snow events of 20 to 40 cm occur, generally in March, and snow cover prevails only a few days. Further, temperatures in January and February can shift quickly from day/night temperatures of 16 to 24°C/4 to 7°C to periods of 7 to 9°C/-15 to -12°C. Such temperature shifts and associated periods of high rainfall may adversely affect both nutritive value (Rayburn et al., 1979; Fribourg and Bell, 1984) and yield of accumulated forage (Pearce et al., 1965) and may reduce forage utilization.

Fall-winter utilization efficiency can be improved, however, through intensive grazing practices (Mueller et al., 1995), but data are lacking on the yield potential and nutritive value of accumulated tall fescue across the Piedmont. In Maryland, which is north of the transition zone and at a low elevation (<100 m), well-fertilized accumulated tall fescue yielded 4.0 Mg ha⁻¹ (Archer and Decker, 1977a). By late December yields had declined to 3.2 Mg ha⁻¹, which was attributed to leaf death and decay. Up until late December, neither CP nor IVDMD concentrations were altered by accumulation period. Crude protein in the forage averaged 136 g kg⁻¹ and IVDMD averaged 669 g kg⁻¹.

At the southern extreme of the tall fescue transition zone (Tallassee, AL), Kentucky-31 tall fescue accumulated from mid-September, after a summer rest, yielded 2.9 Mg ha⁻¹ by February (Berry and Hoveland, 1969); however, no information was provided on the nutritive value of the forage. The objective of our study was to determine the yield potential and associated nutritive value differences by mid-November of tall fescue accumulated for different periods during the summer. The potential carryover effects from repeated summer accumulation on fall DMY and on subsequent spring production also were determined.

MATERIALS AND METHODS

The experiment was conducted at the Reedy Creek Road Field Laboratory at Raleigh, NC. The site (123 m elevation) was a Cecil clay loam soil that was topdressed at seeding with 3.4 Mg ha⁻¹ of dolomitic limestone and 23, 29, and 56 kg ha⁻¹ of N, P, and K, respectively. 'Kentucky 31' tall fescue was uniformly seeded in the fall at 49 kg ha⁻¹ and an excellent stand was obtained. Sufficient land was seeded and uniformly managed during the experiment to permit a previously unused

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Abbreviations: ADF, acid detergent fiber; CELL, cellulose; CP, crude protein; DMY, dry matter yield; IVDMD, in vitro dry matter disappearance; NDF, neutral detergent fiber.

land area for forage accumulation during the summer for each of three years. The stand was 85.7% infected with endophytic fungus [*Neotyphodium coenophialum* Glen, Bacon and Hamlin (comb. novo) Morgan-Jones Gams]. The study was conducted into Year 5 to obtain carryover effects.

Five treatments were evaluated in a randomized complete block design with four replicates. The land area was stratified by replicate and the area needed to initiate summer accumulation in each of three years was randomly assigned within each replicate. The five treatments were then randomly assigned within each land replicate. The experiment was topdressed annually with 35 and 201 kg ha⁻¹ of P and K, respectively. All treatments received 112 kg N ha⁻¹ on 1 March and 90 kg N ha⁻¹ on 25 August as a topdress of ammonium nitrate for a seasonal total of 202 kg N ha⁻¹. The general N application for summer forage accumulation was delayed until 25 August to avoid stand loss (Hallock et al., 1973). The treatments consisted of four periods of forage accumulation beginning 1 June, 1 July, 1 August, and 1 September. The fifth treatment was a N rate variable with an additional 67 kg N ha⁻¹ applied on 1 July (J + N), giving a seasonal total of 269 kg N ha⁻¹.

Each plot (1.9 × 4.6 m) was halved (0.95 m) and one-half was randomly assigned for yield estimates with harvest made only in mid-November. The other one-half was designated for monthly sampling from October through mid-March to estimate changes in nutritive value. These data are reported elsewhere (Burns and Chamblee, 2000).

The experiment was initiated the year following seeding by uniformly cutting the entire experimental area from about 18 cm to a 5-cm stubble until 1 June. The forage was removed from the plots and discarded. Thereafter, in Year 1, the forage was similarly removed from the area up to the appropriate accumulation dates. The unused areas designated for initial summer accumulations in Years 2 and 3 of the study were kept uniformly harvested as above until their use. Yield estimates were obtained by harvesting a 0.62 by 4.6 m swath with a sickle-bar mower set to cut to a 5-cm stubble. The fresh weight from each plot was recorded and a subsample was obtained and dried at 75°C and used for DMV determination. An additional subsample was obtained after the first year for hand separation into tall fescue and weeds and further separated into green and dead tissue. The green tissue was used to determine green DMV and the tall fescue fractions were used for nutritive value determinations.

Two types of carryover effects were evaluated. One was the potential effect on DMV by repeating the same accumulation treatment year after year on the same land area. The other carryover effect was the potential influence of the previous summer's accumulation on the subsequent spring's growth. Carryover in the former case was achieved by continuing the same summer accumulation treatments on the plots used for accumulation in Year 1 (repeated in Years 2, 3, and 4), in Year 2 (repeated in Years 3 and 4), and in Year 3 (repeated in Year 4). The latter carryover effects were determined by obtaining spring DMV from the same plots used for summer accumulation the previous fall. Data were obtained in the spring (Year 2) following initial summer accumulation (Year 1) and in the subsequent three springs (ending spring of Year 5) following repeated summer accumulations in Years 2, 3, and 4. All plots were harvested at the same time in the spring when forage reached about 25 cm. They were cut to a 5-cm stubble, with the last harvest occurring by 1 June (the first summer accumulation date). Subsequent regrowth on plots of the other accumulation dates was discarded as appropriate. Consequently, the seasonal dry matter production from tall fescue is estimated only by the 1 June treatment by adding

the spring yield and the dry matter accumulated by the mid-November harvest of the same year.

Samples of the accumulated forage were obtained from the mid-November harvest as described by Burns and Chamblee (2000) and quick frozen in liquid nitrogen (−195°C), transferred to a freezer (−16°C) for storage, freeze-dried, ground in a Wiley mill to pass a 1-mm screen, and returned to the freezer until analyzed. All samples were analyzed for IVDMD (Burns and Cope, 1974) and neutral detergent fiber (NDF), acid detergent fiber (ADF), permanganate lignin, and neutral detergent ash (Goering and Van Soest, 1970). Cellulose (CELL) was determined by subtracting lignin plus ash from ADF and hemicellulose was determined by subtracting ADF from NDF. Total N was determined according to the Association of Official Analytical Chemists (1990) and expressed as CP (N × 6.25). Dry matter was determined by vacuum oven and all analyses were expressed on an oven-dry basis.

Data were analyzed statistically in combined analyses (over years) for a randomized complete block design. When treatments interacted with years, the analyses were conducted by year and the data were presented by year. 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 accumulation 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.

RESULTS AND DISCUSSION

Climatological Data

Rainfall varied among years during this study (Table 1). For the forage-accumulating phase (1 June through mid-November), Year 1 had above-average rainfall in June followed by rainfall deficits (−15 to −67 mm) in each month until the November harvest. Temperature was below average in July and August but above average through November. Rainfall was near average in Year 2 during June, August, and September, but was below average in July, October, and November. Temperatures were below normal from June through November. In Year 3, rainfall alternated from above average in July, September, and November to below average in June, August, and October. Temperatures were above average in August through November. Below-average rainfall occurred for June, July, and August in Year 4 with a wetter period occurring in September and October. Temperatures were below average in August through November. These variations in rainfall and temperature greatly influence soil moisture status relative to the initiation date for accumulating tall fescue growth and can have a large effect on the final DMV accumulated by mid-November.

Initial Summer Accumulation

Dry Matter Yield

Delaying the start of accumulation from 1 June to 1 September showed a linear reduction in accumulated tall fescue by mid-November in Years 1 and 3 (Table 2). Regression analyses showed a reduction in DMV of 282 (SE = 40) kg ha⁻¹ for each week's delay in

Table 1. Climatological data recorded approximately 5 km from the experimental site.†

Month	30-yr mean		Departures from 30-yr mean							
			Year 1		Year 2		Year 3		Year 4	
	Rainfall	Temperature	Rainfall	Temperature	Rainfall	Temperature	Rainfall	Temperature	Rainfall	Temperature
	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C
May	96	20.0	13	-1.7	110	0.0	13	0.4	35	-0.3
June	107	24.1	143	0.0	10	-1.4	-50	-0.4	-28	0.2
July	136	25.7	-60	-0.8	-88	-0.6	43	-1.1	-103	0.6
August	133	25.1	-15	-0.2	-3	-0.3	-70	1.0	-85	-0.6
September	93	22.1	-67	1.1	-3	-0.9	50	0.3	55	-0.5
October	73	16.1	-53	0.9	-40	-2.1	-40	1.1	30	-2.5
November	64	10.4	-55	2.6	-25	-0.7	45	1.9	-23	-4.2
December	82	6.0	85	0.3	23	1.1	25	0.4	25	-2.3
January	83	5.4	30	4.9	73	1.8	-5	-1.6	-10	-7.7
February	94	6.1	-13	0.4	-13	0.8	-45	4.4	-30	-1.6
March	92	10.2	-3	2.9	70	-1.2	-8	3.9	55	2.3
April	84	15.2	-45	0.4	-35	-3.7	-70	0.7	-30	1.7

† Data recorded at the Raleigh-Durham International Airport and reported by the National Oceanic and Atmospheric Administration.

accumulation in Year 1 and 107 (SE = 24) kg ha⁻¹ in Year 3. The relationship was quadratic in Year 2, which resulted from no change in accumulated DMY between 1 July and 1 August (Table 2) and is attributed, in part, to a below normal rainfall in July of 88 mm (Table 1). Averaging the 3-yr DMY from the initial accumulation plots showed a linear ($P = 0.02$) reduction of 195 (SE = 28) kg ha⁻¹ for each week's delay in accumulation between 1 June and 1 September.

Applying additional N at the 1 July starting date (J + N) compared with delaying N application until August (1 July accumulation) resulted in more DMY in all three years (Table 2). In Year 3, the J + N treatment exceeded yields from the 1 June starting date, while both were similar in Year 2 and the J + N treatment lower in Year 1. Delaying the start of accumulation until 1 September resulted in yields of about 1000 kg ha⁻¹ or less in Years 1 and 2. In Year 3, however, accumulation averaged 3110 kg ha⁻¹ and was similar to DMY obtained from the 1 August accumulation date (Table 2). The similarity in DMY between the 1 August and 1 September accumulations is attributed mainly to a moderately dry August (rainfall departure of -70 mm) resulting in little growth between 1 August and 1 September. Because September and November had favorable growing condi-

tions with above-normal rainfall (50 and 45 mm, respectively) and temperature (Table 1), DMY from the 1 August accumulation in Year 3 was comparable with Years 1 and 2 but much higher for the 1 September accumulation.

A numeric comparison of DMY obtained in this study with those further west and north at higher elevations is difficult because of a lack in commonality among the different experiments. Generally, DMY similar to those reported for the 1 August accumulation (mean = 3210 kg ha⁻¹) were achieved at Blacksburg by accumulating forage beginning in July (mean = 3217 kg ha⁻¹) (Rayburn et al., 1979), while to the north at Morgantown, yields only reached approximately 2500 kg ha⁻¹ when accumulated from 15 June (Collins and Balasko, 1981a). Further south and west at Lexington, DMY averaged 3374 kg ha⁻¹, similar to our results. In the more temperate western side of the transition zone, at Columbia, MO, DMY averaged only 1400 kg ha⁻¹ from an early August accumulation with subfreezing temperatures stopping growth by early November (Ocumpaugh and Matches, 1977). The DMY of forage accumulated from 1 to 10 September ranged from 908 kg ha⁻¹ at Blacksburg (Rayburn et al., 1979) to 1036 kg ha⁻¹ at Knoxville (Fribourg and Loveland, 1978), compared with 1660 kg

Table 2. The influence of accumulation time on tall fescue dry matter yield, proportion of green tall fescue, green dry matter yield, and weeds when harvested in mid-November (oven-dry basis).

Date accumulation began	Green tissue								
	Dry matter yield			Proportion tall fescue		Yield		Weeds	
	Year 1	Year 2	Year 3	Year 2	Year 3	Year 2	Year 3	Year 2	Year 3
	kg ha ⁻¹			%		kg ha ⁻¹		%	
1 June	5440†	4070	4520	54	67	1980	2980	10	2
1 July (J)	3490	3460	4210	55	67	1690	2770	11	2
J + N‡	4800	4530	5580	51	50	2210	2630	5	4
1 August	2920	3500	3210	56	71	1800	2150	8	6
1 September	1010	860	3110	70	77	570	2360	5	1
Mean	3530	3280	4130	57	66	1650	2580	8	3
Significance									
Trend§	L	Q	L	Q	L	Q	L	NS	NS
J vs. J + N	<0.01	<0.01	<0.01	NS	<0.01	<0.01	NS	NS	NS
MSD¶	590	570	500	7	6	310	600	–	–

† Values are 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 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.

Table 3. Changes in concentrations of in vitro dry matter disappearance (IVDMD), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEMI), cellulose (CELL), and lignin of tall fescue accumulated four different time periods and harvested mid-November (oven-dry basis).

Item	IVDMD	CP	NDF	ADF	HEMI	CELL	Lignin
	g kg ⁻¹						
Date accumulation began							
1 June	620†	126	543	313	230	247	55
1 July (J)	640	127	523	316	207	254	52
J + N‡	566	132	551	327	225	257	60
1 August	670	128	496	283	213	235	38
1 September	711	128	463	273	190	221	43
Significance							
Trend§	L	NS	L	L	L	Q	L
J vs. J + N	<0.01	0.09	NS	NS	NS	NS	NS
MSD¶	38	–	38	16	36	13	10
Year							
One	662#	148	472	291	181	233	46
Two	630	109	527	301	226	239	51
Three	633	128	548	317	231	256	52
Significance							
MSD	NS	13	47	23	NS	12	NS
Mean	642	128	515	303	213	243	50

† Each value for IVDMD is the mean of four replicates for 3 yr ($n = 12$) and the other variable the mean of three replicates for 3 yr ($n = 9$).

‡ 67 kg N ha⁻¹ 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 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 for IVDMD is the mean of five treatments and four replicates ($n = 20$) and the other variables the mean of five treatments and three replicates ($n = 15$).

ha⁻¹ in our study. At Fairland, MD, a far northeastern location at a low elevation in the tall fescue transition zone, DMY accumulated from 10 September averaged 3930 kg ha⁻¹. This was greater than the 2900 kg ha⁻¹ reported from the south-central edge of the transition zone at Tallahassee, AL (Berry and Hoveland, 1969).

Nutritive Value

The IVDMD from the accumulated forage harvested in November ranged from 566 to 711 g kg⁻¹ with a mean of 642 g kg⁻¹ (Table 3). Delaying the starting date of accumulation from 1 June to 1 September resulted in a linear increase in IVDMD of 30 g kg⁻¹ for each 30-d delay in accumulation. Associated was a linear decrease in NDF of 26 g kg⁻¹ for every 30-d delay in the starting date (Table 3). Although cool season grasses have lower fiber constituents than warm season grass, ADF concentrations of <300 g kg⁻¹ and CELL and lignin concentrations of <240 and 50 g kg⁻¹, respectively, occurred in the August- and September-accumulated forages (Table 3). Such low fiber constituent concentrations indicate forage of high nutritive value, which is reflected in the relatively high IVDMD of the August and September accumulations (Table 3). High IVDMD of 760 g kg⁻¹ also were reported by Ross and Reynolds (1979) for similar aged regrowth. Crude protein concentrations were not altered by the accumulation period (Table 3) and were similar to concentrations reported by Ross and Reynolds (1979).

Applying N at the 1 July starting date, compared with none, resulted in lowest IVDMD (566 g kg⁻¹) but similar concentrations of NDF, ADF, and other fiber constituents (Table 3). Concentrations of CP, NDF, ADF, and CELL differed among years and were associated with differences in DMY and proportions of green tissue.

Botanical and Tissue Separations

The percentage of weeds from the November harvest was similar among treatments but different ($P < 0.01$) between years (Table 2). The accumulated forage was further separated into green and dead tissue because a higher proportion of green tissue has been associated with higher nutritive value (Taylor and Templeton, 1976). Percentage green tissue of tall fescue was lower in Year 2 than in Year 3 (Table 2). Reducing the period of accumulation increased the percentage of green tall fescue tissue quadratically in Year 2 and linearly in Year 3. The shortest period of summer accumulation (1 September) contained the most green tall fescue tissue in November. Similar studies in Kentucky (Taylor and Templeton, 1976) and Maryland (Archer and Decker, 1977b) reported green tissue proportions from a comparable November harvest of 75%, and within the range reported here. Applying N at the 1 July accumulation date vs. none (J + N vs. 1 July treatments) reduced the proportion of green tall fescue tissue from 55 to 51% in Year 2 and from 67 to 50% in Year 3. This same trend was noted in Maryland, but not in Kentucky.

Green DMY (DMY \times percentage green tissue) decreased quadratically in Year 2 and linearly in Year 3 as accumulation period was shortened (Table 2). Year 3, being generally the more favorable of the two, had both higher DMY and a higher proportion of tall fescue that remained green until mid-November. The addition of N at the 1 July accumulation date produced more green DMY than with no added N in Year 2, but not in Year 3. Although the J + N treatment produced higher DMY in Year 3 than in Year 2, the proportion of green tall fescue was low (50%), resulting in green DMY that were similar to those from the 1 June and 1 July accumulations (Table 2).

Table 4. The influence of summer accumulation on dry matter yield in the initial year and on dry matter yield, proportion of green tall fescue, and green dry matter yield from repeated summer accumulations on the same plots in Years 2, 3, and 4 when harvested in mid-November (oven-dry basis).

Date accumulation began	Dry matter yield				Green tissue					
	Initial year†	Repeated accumulation			Proportion tall fescue (repeated accumulation)			Yield (repeated accumulation)		
		Year 2	Year 3	Year 4	Year 2	Year 3	Year 4	Year 2	Year 3	Year 4
		kg ha ⁻¹			%			kg ha ⁻¹		
1 June	5440‡	4190	4440	3730	61	62	71	2490	2730	2550
1 July (J)	3490	3550	4360	3090	61	63	75	2050	2670	2130
J + N§	4800	4670	5790	5030	59	59	68	2640	3390	3340
1 August	2920	3440	3710	2880	64	60	58	2100	2170	2110
1 September	1010	1070	3070	1990	76	68	74	780	2030	1470
Mean	3530	3380	4275	3350	64	62	70	2010	2600	2320
Significance										
Trend¶	L	Q	Q	L	Q	NS	NS	Q	L	L
J vs. J + N	<0.01	<0.01	<0.01	<0.01	NS	NS	NS	<0.01	0.03	<0.01
MSD#	590	460	310	490	4	—	—	340	615	390

† Taken from Table 2.

‡ Values are means 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 L = linear and Q = quadratic (J + N not included); NS = not significant.# MSD = minimum significant differences from the Waller-Duncan k ratio ($k = 100$) t -test.

Carryover Effects

Repeated Summer Accumulation

Summer accumulation on the same plots continued following the initial accumulations in Years 1, 2, and 3. Because repeated accumulation results were similar from plots used in Year 1 vs. Years 2 and 3, only data from Year 1 with repeated summer accumulations in Years 2, 3, and 4 are presented. Adverse carryover effects from repeated accumulation on the same initial accumulation site can be only indirectly addressed in this study because of potential confounding influences of shifting rainfall and temperature patterns during the summer accumulation in the repeat years (Table 1). These shifts can greatly alter the production potential of any one treatment and may be essentially independent of carryover effects.

Carryover effects from repeated summer accumulation on the same plots were minimal. The mean DMY of repeat Years 2, 3, and 4 (Table 4) were similar (within 150 kg ha⁻¹) or numerically greater compared with the initial accumulation year for 1 July (Year 4 is an exception), J + N, 1 August, and 1 September accumulation dates (Table 2). This did not hold, however, for the 1 June accumulation date as highest DMY ($P \leq 0.05$) occurred in the initial year of accumulation (Table 4). This was not repeated in either Year 2 or Year 3 from the initial accumulation plots (Table 2), which corresponds to repeat Years 2 and 3 of the initial Year 1 accumulation site (Table 4). The initial 1 June date accumulated 4070 kg ha⁻¹ in Year 2 and 4520 kg ha⁻¹ in Year 3 (Table 2), which compare closely to the 4190 and 4440 kg ha⁻¹ (Table 4) obtained in repeat Years 2 and 3, respectively, under identical growing conditions. This consistency, along with the same patterns of greater DMY from the J + N accumulation and least DMY from the 1 September date suggest that the above discrepancy is mainly an environmental phenomena and probably not an adverse accumulation influence. Regressing DMY on days accumulated using data from all

three initial accumulation years plus their six repeat years of accumulation ($n = 9$: initial accumulation Site 1 and three repeat years, initial accumulation Site 2 and two repeat years, and initial accumulation Site 3 and one repeat year) gave a linear ($P \leq 0.05$) decrease in DMY of 142 (SE = 23) kg ha⁻¹ for each week that accumulation was delayed from 1 June to 1 September.

Carryover effects for the proportion of green tall fescue tissue and green DMY also were minimal. Accumulations on the same plots used for initial Year 1 in repeat Years 2 and 3 grew in the same season as initial Years 2 and 3, respectively. Green tall fescue tissue in repeat Year 2 (Table 4) showed the same trend noted for initial Year 2 (Table 2). Repeat Year 3 showed no difference in green tall fescue tissue among accumulations (Table 4) and was in disagreement with initial Year 3 (Table 2), but both showed similar numeric rank. Also, green tissue DMY showed the same trends in repeat Years 2 and 3 (Table 4) as noted for initial Years 2 and 3 (Table 2).

Repeated Summer Accumulation on Subsequent Spring Growth

Carryover effects were evaluated by obtaining DMY for each treatment the spring (Spring 1) following the initial summer of accumulation (Year 1) and each spring thereafter following repeated summer accumulations in Years 2, 3, and 4 (data not shown). Dry matter yields at the first spring (April) harvest in the initial spring and repeat springs 2, 3, and 4 were similar among the plots assigned to the previous summer's accumulation treatments. Yields differed among years, averaging 2310, 910, 1820, and 3290 kg ha⁻¹ in Springs 1, 2, 3, and 4, respectively. Furthermore, total DMY (until 1 June) in each of the four springs also were similar among plots assigned to the previous summer's accumulation treatments (data not shown). Total yields for Springs 1, 2, 3, and 4 averaged 5410 (range = 5260 to 5690 kg ha⁻¹), 2390 (range = 2310 to 2490 kg ha⁻¹), 3150 (range = 3050

to 3250 kg ha⁻¹), and 4300 (range = 4050 to 4670 kg ha⁻¹) kg ha⁻¹, respectively. Different summer accumulation treatments showed no differential carryover effects on subsequent spring DMY. Further, no shifts in stand density were observed from Year 1 to Year 5 in any of the summer accumulation treatments. There was no evidence of fall carryover effects in this experiment. Carryover effects, however, have not been well addressed in the literature. One Tennessee study (Fribourg and Loveland, 1978) showed that accumulating tall fescue in the summer or fall did not affect subsequent spring DMY as noted in our study. To the contrary, a Kentucky study (Taylor and Templeton, 1976) showed that accumulated forage harvested on 1 November or 1 December reduced DMY in the following 15 May harvest.

Management Strategy

Tall fescue can be accumulated in the Piedmont during the summer for fall and winter grazing. Consideration, however, needs to be given to both yield and nutritive value. Starting forage accumulation on 1 September resulted in highest nutritive value, but yield potential was low and extremely variable. For example, in Years 1 and 2 of the three years that forage was initially accumulated (Table 2), DMY was ≤ 1000 kg ha⁻¹. In Year 3, with a more favorable rainfall pattern (Table 1), yields averaged 3100 kg ha⁻¹. Highest yields were obtained from accumulations that started in 1 June and 1 July with additional N (J + N), but the nutritive value was lowest. If young stock are to use the stockpile during the fall and winter, then better nutritive value, as noted for the 1 September- or 1 August-accumulated forage, is paramount and should rule over maximum accumulation. On the other hand, with brood cows, higher DMY of moderate nutritive value would be appropriate.

Early summer accumulation (July) of tall fescue pastures for fall–winter use is a concern at the northern, higher elevations (Rayburn et al., 1979) because it removes these pastures from summer grazing. This is of far less concern across the Piedmont because high summer temperatures (>32°C) and intermittent droughts (2 to 5 wk) cause tall fescue to become unproductive, low in nutritive value, and frequently semi-dormant for several weeks after mid-June. Progressive farmers in this region will graze warm-season grasses during this period and will periodically graze summer growth of tall fescue that may follow periods of rain (Burns and Bagley, 1996). This practice avoids excess accumulations of forage, which favor disease development and the build-up of dead tissue, until the start of accumulation or until fall growth begins.

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