

Accumulation Period for Stockpiling Perennial Forages in the Western Canadian Prairie Parkland

Vern S. Baron,* A. Campbell Dick, Myron Bjorge, and Grant Lastiwka

ABSTRACT

Grazing stockpiled perennial forage can reduce a beef producer's winter feeding costs. The objective of this study was to determine optimum rest or accumulation periods for perennial forage species adapted to the western Canadian parkland. The research was conducted for 3 yr at Lacombe, AB, Canada. Stockpiled forage grass and alfalfa species (*Medicago sativa* L., *M. falcata* L.), with four accumulation periods, were harvested (second cut) on 15 October after a first cut on one of four dates: 1 July, 15 July, 1 August, or 15 August. Forage yield and nutritive value were determined for each period-species combination. Nutritive value measurements included concentrations of in vitro digestible organic matter (IVDOM), crude protein, water-soluble carbohydrates (WSC), and neutral detergent fiber (NDF). 'Algonquin' alfalfa yielded more than 'SC MF3713' alfalfa and all grasses during 1998 (Year 1) when cut on or after 1 August. However, by 2000 the yield differences among species had decreased at periods beginning 1 and 15 August. Meadow brome (*Bromus riparius* Rhem.) had stable yields from year to year and was similar to or greater than Algonquin at the 15 July period. Brome and alfalfa species required an accumulation period beginning as early as 15 July, while others required first cutting as early as 1 July to provide adequate stockpiled yield. Alfalfa nutritive value decreased more with longer accumulation periods than grasses. Neutral detergent fiber and WSC concentrations of creeping red fescue (*Festuca rubra* L.) did not change substantially with accumulation period, making it desirable for stockpiling, given a long accumulation period.

STOCKPILING PERENNIAL FORAGE for fall and winter feeding is a cheaper alternative to feeding conserved forage (Johnson and Wand, 1999; Riesterer et al., 2000). Success of stockpiling depends on choice of species, accumulation period, and soil nutrient management (Matches and Burns, 1995). In a companion study to the present work (Baron et al., 2004), alfalfa was suitable for stockpiling only when grazed in September and October. This was because of the rapid decline in nutritive value after heavy frost and severe yield loss over winter due to leaf loss. Although several grass species provided sufficient yield when stockpiled, meadow brome provided consistently high yield from year to year, while species commonly found in permanent pastures such as Kentucky bluegrass (*Poa pratensis* L.) and creeping red fescue generally had lower yields. However, creeping

red fescue and meadow brome provided nutritive value suitable for cows (*Bos taurus*) in mid-pregnancy through September and October and were superior to others by April.

The conclusions of Baron et al. (2004) from a previous study were based on the same accumulation, or rest period between first and second cuts, beginning in early July. Length of the dry matter accumulation period is usually dependent on the timing of the first cut or grazing, with later first-cuts having shorter accumulation periods between cutting and the end of the growing season. Length of accumulation period, leaf death, and susceptibility to weathering in stockpiled pasture systems are interrelated factors that influence yield and nutritive value. As the accumulation period increases, so does yield, but nutritive value declines. Part of the reason for decline in nutritive value with time is due to leaf death (Ocumpaugh and Matches, 1977; Burns and Chamblee, 2000a, 2000b; Johnson and Wand, 1999).

Yield response to accumulation period is impacted by a species' ability to regrow new leaf material rapidly during the climatic conditions that prevail in late summer and fall (Ocumpaugh and Matches, 1977; Matches and Burns, 1995). Nutritive value response to accumulation period is impacted by species' capability to retain green leaves in the canopy under the same climatic stresses and shade of the upper leaf canopy. Besides leaf senescence, which is accompanied by translocation of sugars and protein from dying leaves (Ocumpaugh and Matches, 1977; Matches and Burns, 1995), some species may increase leaf sugar concentrations during fall, while others may not (Taylor and Templeton, 1976). In tall fescue (*Festuca arundinacea* Schreb.), a relatively short accumulation period was associated with higher leaf sugar concentrations. Sugar concentrations peaked during fall and then declined in winter. Change in leaf total nonstructural sugar concentration was essentially due to changes in sucrose and fructose concentrations (Burns and Chamblee, 2000b).

No research has been conducted on optimizing accumulation period for stockpiled forage species adapted to the western Canadian Parkland. For species that require relatively short accumulation periods to attain target yields for grazing, the resultant nutritive value may be high enough to allow utilization of pastures by livestock classes other than beef cows. Therefore, length of accumulation period, as well as time of utilization, may be factors that affect the efficient use of stockpiled forage species. Our hypothesis is that species adapted to the western parkland and used for stockpiling will vary for optimum period of dry matter accumulation as deter-

V.S. Baron and A.C. Dick, Western Forage/Beef Group, Agriculture and Agri-Food Canada, Research Centre, 6000 C&E Trail, Lacombe, AB, Canada T4L 1W1; and M. Bjorge and G. Lastiwka, Western Forage/Beef Group, Alberta Agriculture, Food and Rural Development, Research Centre, 6000 C&E Trail, Lacombe, AB, Canada T4L 1W1. Contribution no. 1070. Received 15 Jan. 2005. *Corresponding author (baronv@agr.gc.ca).

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677 S. Segoe Rd., Madison, WI 53711 USA

Abbreviations: IVDOM, in vitro digestible organic matter; NDF, neutral detergent fiber; WSC, water-soluble carbohydrates.

mined by regrowth yield and nutritive value. The objective of this study was to determine optimum rest or accumulation periods for perennial forages used for stockpiling in the western Canadian Parkland.

MATERIALS AND METHODS

The experiment was established in mid-May of 1997 on fallowed ground at Lacombe, AB, Canada (52°28' N lat; 113°45' W long; 847 m) on an Orthic Black Chernozemic 'Ponoka' clay loam soil (Udic Borrolls). Four accumulation period main plots were randomly established within each of three replicates and seven forage species subplots were randomized within each main plot. Each subplot (3 by 6 m) consisted of 12 rows, 25 cm apart, planted with a double-disk drill at the recommended rate (pure live seed equivalent) for each species (Aasen et al., 1994). The species represented were Algonquin alfalfa, SC MF3713 alfalfa, 'Manchar' smooth bromegrass (*Bromus inermis* Leyss.), 'Paddock' meadow bromegrass, 'Kay' orchardgrass (*Dactylis glomerata* L.), 'Troy' Kentucky bluegrass, and 'Bo-real' creeping red fescue. Before seeding, fertilizer was broadcast to supply 15, 27, 12, and 11 kg ha⁻¹ of N, P, K, and S, respectively. Following the establishment year, all plots received annual broadcast fertilizer applications of 100 N, 26 P, and 50 K kg ha⁻¹. Application of all N, P, and K occurred in late April or early May.

Within each replicate, the initial growth was removed from one accumulation period main plot on 1 July, 15 July, 1 August, or 15 August, respectively, by clipping with a Carter harvester (Carter Manufacturing Co., Brookston, IN) to a height of 7.5 cm. No observations were made on this initial clipping. Regrowth (stockpiled forage) from all plots was harvested on approximately 15 October. Four of the center-most rows were cut from each subplot. A subsample of approximately 500 g was taken for percentage dry matter determination and for subsequent chemical analysis. Subsamples were dried at 50°C for 72 h for determination of dry matter concentration. Then they were ground, first through a Wiley mill (Model 4; Arthur H. Thomas Co., Philadelphia, PA) equipped with a 2-mm screen and then through a Cyclone mill (Model MS; UD Corp., Boulder, CO) using a 1.0-mm screen, before determination of forage nutritive value. Immediately after the second cut a 30-cm section of a guard row was removed at the same cutting height. This subsample was either separated immediately or frozen (-20°C) until separation of dead and live material could occur. Subsamples of dead and live material were dried separately as described previously. Green and dead percentages of the total subsample were determined on a dry matter basis, and green yield calculated from the dry matter yield and percentage green material.

Total N concentration of samples was measured using the

Dumas method (Etheridge et al., 1998) with a Leco C and N determinator (Model CN 2000, Leco Corp., St. Joseph, MI). Crude protein was estimated by multiplying N concentration by 6.25. In vitro digestible organic matter concentration (IVDOM) was measured with direct acidification during a 24-h second stage pepsin digestion (Marten and Barnes, 1980). Neutral detergent fiber (NDF) was determined as described by Van Soest and Robertson (1980). Water-soluble carbohydrate (WSC) concentration was determined after Thomas (1977) using the phenol-sulfuric method for colorimetric assessment of reducing sugars, using fructose as the standard.

Data were subjected to analysis of variance as a split plot in space and time for perennial crops (Steel and Torrie, 1980) using the SAS GLM procedure (SAS Inst., 1989). Years were treated as a repeated subunit. The four accumulation periods were main plots and seven forage species treatments were the subplots. Only data of regrowth material from the four accumulation periods were considered in this study, as they were the stockpiled materials of interest. The three-factor interaction of year, accumulation periods, and species was used to test the two-factor interactions. When significant *F* tests ($P \leq 0.05$) occurred, mean separation was achieved using least significant differences calculated from appropriate error terms as described by Gomez and Gomez (1984). Hereinafter references to significant differences between means indicate a probability level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Temperature was not yield-limiting during the accumulation or regrowth phase, which occurred during July, August, and early September. Precipitation did vary among years. Total rainfall for these 3 mo was 153, 257, and 243 mm in 1998, 1999, and 2000, respectively, compared with an average of 186 mm.

The main effects of species, accumulation period, and year were consistently significant for most variables (Table 1). The two-factor interactions of species × accumulation period, species × year, and year × accumulation period were almost always significant. The three-way interaction of year × accumulation period × species was significant for three of seven variables.

Stockpiled Forage Yield

It is desirable to produce at least 2000 kg ha⁻¹ of forage before grazing because grazing efficiency is reduced as forage mass decreases below 2000 kg ha⁻¹ (Coleman, 1992). Also, adequate quantities of available

Table 1. Significance of year, species, and accumulation period and interactions within analyses of variance for forage yield and quality of regrowth of seven perennial forage species cut initially 1 July, 15 July, 1 August, and 15 August with regrowth harvest 15 October of 1998, 1999, and 2000.

Effect	Stockpiled yield	Percent dead	Green yield	Crude protein	IVDOM†	NDF	WSC
Accumulation period	***	*	***	**	**	***	**
Species	***	**	***	***	***	***	***
Species × period	**	NS	**	**	**	***	***
Year	**	NS	**	***	**	**	**
Year × period	**	**	*	**	NS	**	NS
Year × species	***	***	***	***	NS	*	**
Year × species × period	**	NS	NS	**	NS	NS	*

* Significant *F* test with $P \leq 0.05$. NS indicates that the *F* test was not significant $P > 0.05$.

** Significant *F* test with $P \leq 0.01$.

*** Significant *F* test with $P \leq 0.001$.

† IVDOM is in vitro digestible organic matter, NDF is neutral detergent fiber, and WSC is water soluble carbohydrate.

stockpiled forage are needed to facilitate apprehension through snow. Except for the dry year of 1998, all species attained 2000 kg ha⁻¹ when the accumulation phase began 15 July or earlier (Table 2). During 1998 alfalfa and bromegrass species accumulated >2000 kg ha⁻¹ of dry matter when the accumulation period began 15 July, but the other species did not. Only Algonquin alfalfa exceeded 2000 kg ha⁻¹ in 2 of 3 yr when the accumulation period began 15 August.

Generally, stockpiled dry matter increased with the length of the accumulation period, although the magnitude of the difference between periods decreased as accumulation period became shorter. Averaged over species, stockpiled yield ranged from 4.3 to 7.3, 2.5 to 4.9, and 1.5 to 2.8 times greater if the accumulation period began 1 July, 15 July, and 1 August, respectively, compared with 15 August (Table 2).

In 1998 Algonquin alfalfa was the highest or among the highest yielding species for all accumulation periods; the difference between Algonquin and the grasses was most apparent for the two August accumulation periods. However, yield of Algonquin decreased from 1998 to 2000 at all but the 15 July accumulation period. Yield of SC MF3713 alfalfa was more stable among years and accumulation periods than Algonquin. SC MF3713 alfalfa had lower yield than Algonquin in 1998, but by 2000 was similar due to Algonquin's declining yield trend with years. By contrast the grass species increased

Table 2. Stockpiled yield of seven forage species with four accumulation periods, harvested in mid-October during 3 yr, at Lacombe, AB, Canada.

Species	Accumulation period beginning				LSD1†
	1 July	15 July	1 Aug.	15 Aug.	
	kg ha ⁻¹				
	1998				
Algonquin alfalfa	6130	4460	4180	2490	440
SC MF3713 alfalfa	4630	3420	1940	360	
Meadow bromegrass	5080	4480	1760	1500	
Smooth bromegrass	6480	2950	600	770	
Orchardgrass	4520	1830	1200	1020	
Kentucky bluegrass	3430	1640	1330	1200	
Creeping red fescue	3330	1580	950	750	
	1999				
Algonquin alfalfa	7150	3770	2950	2640	440
SC MF3713 alfalfa	5160	2580	1270	560	
Meadow bromegrass	6850	5740	2560	920	
Smooth bromegrass	7460	5540	1410	970	
Orchardgrass	5820	4830	2140	1100	
Kentucky bluegrass	5490	5530	2470	1390	
Creeping red fescue	4520	5350	2410	670	
	2000				
Algonquin alfalfa	4260	3540	1710	880	440
SC MF3713 alfalfa	3380	3510	1900	490	
Meadow bromegrass	6410	4480	2410	800	
Smooth bromegrass	6300	3390	2110	290	
Orchardgrass	5600	4310	2640	710	
Kentucky bluegrass	6100	2810	2470	1080	
Creeping red fescue	5620	3360	1880	930	
	NS‡				
LSD2§	980				

† LSD1 is valid for comparison of accumulation periods within species within or across years.

‡ NS indicates that there are no significant differences between means during 2000 at the 15 August accumulation period ($P \leq 0.05$).

§ LSD2 is valid for comparison of species within accumulation period within or across years.

in yield with years. This was especially true for species such as Kentucky bluegrass, creeping red fescue, and orchardgrass. The impact was such that in the dry year, 1998, these grass species yielded <2000 kg ha⁻¹ after the 1 July accumulation period. In the other years they yielded close to or above that level for the 1 August period and earlier. Meadow and smooth bromegrass provided relatively high and stable stockpiled yields for the first two accumulation periods in all years. Meadow bromegrass maintained adequate stockpiled yield for grazing until the 1 August accumulation period in all but 1998. Only Algonquin alfalfa had adequate stockpiled forage yield, when accumulation period was as short as the 1 August period, but this advantage disappeared by the final year.

Dead Vegetative Material

There was a general trend for more dead material in the sward with longer accumulation periods, but this was not consistent over years giving rise to the significant accumulation period \times year interaction (Table 1). The pattern was observed during years of above average rainfall, but not in 1998 when rainfall was below normal (Table 3). Ocumpaugh and Matches (1977) observed an increase in dead material in tall fescue swards during dry years, and in their study, nutritive value was affected negatively. However, the reverse was true in the current study for 1999 and 2000. When the accumulation period began 1 August, there was less dead material in the sward than when it began 1 July. In 1998, the percentage dead material in the sward was higher for the 15 August accumulation period than when it began 15 July or 1 August. Generally the alfalfa species had less dead material in the sward than the grass species (Table 4), but the differences were not always significant. Kentucky bluegrass and creeping red fescue had highest losses during 1998 and were significantly different from the

Table 3. Percent dead, stockpiled green yield, and neutral detergent fiber concentration for stockpiled forage harvested in mid-October after four accumulation periods at Lacombe, AB, Canada.

Year	Accumulation period beginning				LSD1†
	1 July	15 July	1 Aug.	15 Aug.	
	Percent dead, %				
1998	21.9	18.7	18.4	26.6	7.3
1999	23.1	18.9	11.8	15.6	
2000	35.7	29.0	18.3	16.7	
LSD2‡	8.9				
	Green yield, kg ha ⁻¹				
1998	4760	3380	2830	1810	686
1999	3660	2690	1380	400	
2000	4270	3950	1840	870	
LSD2‡	396				
	NDF§, g kg ⁻¹				
1998	568	485	429	421	30
1999	501	497	430	409	
2000	592	548	507	480	
LSD2‡	25				

† LSD1 is valid for comparison of accumulation periods within years.

‡ LSD2 is valid for comparison of years within accumulation periods.

§ NDF is neutral detergent fiber.

alfalfas, whereas in the other years percentage dead material of these species was close to average.

Green Vegetative Material

Green yield represents the aggregate of higher nutritive value dry matter, since green leaves have higher nutritive value than dead leaves (Burns and Chamblee, 2000b). Coleman (1992) reviewed research indicating that dry matter intake was more closely correlated with green yield than dry matter yield. Green yield decreased as length of accumulation period decreased (Table 3). During 1999 and 2000 a division between the longest and shortest two accumulation periods became evident with the latter accumulation periods having numerically less green material than 2000 kg ha⁻¹ and were significantly lower than the longer periods.

Averaged over accumulation periods, trends for green yield among species and years reflected those of stockpiled yield and percentage dead discussed previously. Between 1998 and 2000, green yield of Algonquin alfalfa declined by 50% (Table 4). In 1999 and 2000 orchardgrass, Kentucky bluegrass, and creeping red fescue green yields were close to double that of 1998. Green yield of meadow bromegrass was stable over years compared with the other species, when averaged over accumulation period.

Table 4. Percent dead, stockpiled green yield, and neutral detergent fiber concentration of seven forage species harvested in mid-October, averaged over four accumulation periods during 3 yr at Lacombe, AB, Canada.

Species	Year			LSD1†
	1998	1999	2000	
	Percent dead, %			
Algonquin alfalfa	4.8	23.0	15.3	9.7
SC MF3713 alfalfa	12.2	16.2	16.0	
Meadow bromegrass	23.5	17.7	26.2	
Smooth bromegrass	15.2	12.3	43.9	
Orchardgrass	24.6	17.4	27.1	
Kentucky bluegrass	33.9	20.3	24.7	
Creeping red fescue	32.6	15.9	21.4	
LSD2§	NS‡			
	11.4			
	Green yield, kg ha ⁻¹			
Algonquin alfalfa	4130	3365	2090	483
SC MF3713 alfalfa	2360	2050	1690	
Meadow bromegrass	2450	3250	2500	
Smooth bromegrass	2240	3450	1560	
Orchardgrass	1600	2690	2230	
Kentucky bluegrass	1260	2890	2270	
Creeping red fescue	1110	2700	2200	
LSD2§	693			
	NDF¶, g kg ⁻¹			
Algonquin alfalfa	439	426	584	8
SC MF3713 alfalfa	396	407	512	
Meadow bromegrass	500	482	524	
Smooth bromegrass	492	481	562	
Orchardgrass	500	479	541	
Kentucky bluegrass	573	520	564	
Creeping red fescue	431	402	477	
LSD2§	14			

† LSD1 is valid for comparison of years within species for respective variables.
 ‡ NS indicates that there are no significant differences between means during 1999 for percent dead material (*P* ≤ 0.05).
 § LSD2 is valid for comparison of species within years for respective variables.
 ¶ NDF is neutral detergent fiber.

Averaged over years, green yield of species decreased to levels ranging from 11 to 38% from longest to shortest accumulation period (Table 5). Among all species Algonquin alfalfa exhibited the least decline in green yield (38%) with accumulation period, averaged over years; however this advantage is negated by the decrease in stockpiled yield (Table 2) shown with years for the 15 August accumulation period. By the 1 August accumulation period green yield of smooth bromegrass had declined to 19% of the 1 July period, compared with a species average of 42%. Smooth bromegrass had the significantly highest green yield among grass species at the 1 July accumulation period and was numerically the lowest species by the 1 August period.

Amounts of forage required for stockpiled grazing place a practical limit on the utility of forage accumulated in the periods after 15 July. Climatic risks of low rainfall and time of cutting effects on winter kill in alfalfa may cause producers to extend accumulation periods to begin before 1 August. McKenzie and McLean (1980) observed that alfalfa was predisposed to winter kill when harvested in August or early September in a similar environment and that 3-yr-old stands were more severely injured than 2-yr-old stands. This may partially explain the decline in stockpiled yields of Algonquin alfalfa when the accumulation period began 1 August and later (Table 2). The poorer regrowth of SC MF3713 alfalfa with shorter accumulation periods might necessi-

Table 5. Green yield, in vitro digestible organic matter, and neutral detergent fiber concentration for seven forage species with four accumulation periods, harvested in mid-October averaged over 3 yr, at Lacombe, AB, Canada.

Species	Accumulation period beginning				LSD1†
	1 July	15 July	1 Aug.	15 Aug.	
	Green yield, kg ha ⁻¹				
Algonquin alfalfa	4760	3380	2830	1810	483
SC MF3713 alfalfa	3660	2690	1380	400	
Meadow bromegrass	4270	3950	1840	870	
Smooth bromegrass	5230	2860	1010	560	
Orchardgrass	3630	2660	1590	800	
Kentucky bluegrass	3420	2490	1740	890	
Creeping red fescue	3153	2890	1470	600	
LSD2‡	924				
	IVDOM§, g kg ⁻¹				
Algonquin alfalfa	545	665	665	730	20
SC MF3713 alfalfa	639	660	741	792	
Meadow bromegrass	662	684	675	701	
Smooth bromegrass	583	654	657	693	
Orchardgrass	715	642	675	680	
Kentucky bluegrass	571	605	682	633	
Creeping red fescue	645	666	721	651	
LSD2‡	53				
	NDF§, g kg ⁻¹				
Algonquin alfalfa	551	515	373	309	20
SC MF3713 alfalfa	561	444	316	324	
Meadow bromegrass	574	519	468	446	
Smooth bromegrass	560	542	481	465	
Orchardgrass	566	534	484	442	
Kentucky bluegrass	619	555	526	510	
Creeping red fescue	436	444	430	437	
LSD2‡	24				

† LSD1 is valid for comparison of accumulation periods within species.
 ‡ LSD2 is valid for comparison of species within accumulation periods within or across years.
 § IVDOM is in vitro digestible organic matter; NDF is neutral detergent fiber.

tate the extension of accumulation periods to begin before 1 August.

Except in the dry year (1998), all species provided adequate stockpiled yields for grazing when the initial cutting date was 15 July. For the grasses, there appeared to be a division (higher vs. lower) in green yield between 15 July and 1 August accumulation periods. The difference was more pronounced in 1999 and 2000 (wet years) than in 1998 for stockpiled yield.

Species found in older permanent pastures, such as Kentucky bluegrass and creeping red fescue, yielded less than meadow bromegrass in 2 of 3 of 3 yr for the 1 and 15 July accumulation periods. Insufficient forage for grazing through snow may result if accumulation periods commence as late as 15 August. To reduce this risk, accumulation periods for predominately grass stands should begin as early as 15 July. If dry weather conditions dictate, accumulation periods for creeping red fescue and Kentucky bluegrass should start as early as 1 July. The relatively high dead percentages for creeping red fescue and Kentucky bluegrass in 1998 (Table 4) also indicate their susceptibility to dry weather.

Crude Protein

Generally, crude protein concentration of stockpiled forage increased with successively shorter accumulation periods (Table 6). However, averaged over species the difference between longest and shortest periods decreased from 76 to 24 g kg⁻¹ from 1998 to 2000 and protein concentration was higher for all accumulation

Table 6. Crude protein concentration of stockpiled forage for seven forage species with four accumulation periods during 3 yr, at Lacombe, AB, Canada.

Species	Accumulation period beginning				LSD1†
	1 July	15 July	1 Aug.	15 Aug.	
	g kg ⁻¹				
	1998				
'Algonquin' alfalfa	181	200	250	290	
'SC MF3713' alfalfa	176	209	300	273	
Meadow bromegrass	126	116	132	166	
Smooth bromegrass	81	142	203	237	15
Orchardgrass	105	120	148	163	
Kentucky bluegrass	173	175	202	203	
Creeping red fescue	134	164	201	171	
	1999				
'Algonquin' alfalfa	115	133	177	184	
'SC MF3713' alfalfa	135	152	199	185	
Meadow bromegrass	77	75	97	128	
Smooth bromegrass	55	77	117	135	15
Orchardgrass	84	84	88	124	
Kentucky bluegrass	94	97	120	135	
Creeping red fescue	75	80	82	122	
	2000				
'Algonquin' alfalfa	130	151	214	237	
'SC MF3713' alfalfa	153	136	250	234	
Meadow bromegrass	118	82	91	124	
Smooth bromegrass	78	74	111	145	15
Orchardgrass	127	103	63	140	
Kentucky bluegrass	99	97	112	130	
Creeping red fescue	98	79	95	111	
LSD2‡	31				

† LSD1 is valid for comparison of accumulation periods within species within or across years.

‡ LSD2 is valid for comparison of species within accumulation periods within or across years.

periods in 1998 compared with 1999 and 2000. Although there were exceptions, alfalfa almost always had higher crude protein values than the grass species and there were few differences within alfalfa and grass species groups. An exception was that Kentucky bluegrass was similar to Algonquin alfalfa for the 1 July and 15 July accumulation periods during 1998 and the 1 July period during 1999. Increases in crude protein concentration from longest to shortest accumulation periods varied among years, but alfalfa species and smooth bromegrass generally increased at higher rates than species such as Kentucky bluegrass and creeping red fescue. Among the grass species, this was partly due to the relatively low crude protein concentrations for smooth bromegrass at the two longest accumulation periods.

Crude protein levels of alfalfa (Table 6) were adequate for both gestating and growing animals at all accumulation periods (NRC, 1996). However, most of the grass species would be close to or below the minimum levels (110–120 g kg⁻¹) required by growing animals at the longest accumulation periods, especially in 1999 and 2000. Generally, the grass species would have provided adequate crude protein levels for gestating cows (70 g kg⁻¹), although species such as the bromegrasses, approached the minimum requirement during 1999 at the 1 July accumulation period.

In Vitro Digestible Organic Matter

Generally, IVDOM concentration increased with shorter accumulation periods (Table 5). Exceptions were orchardgrass, which had a lower IVDOM concentration for the 15 July than 1 July accumulation period, and Kentucky bluegrass and creeping red fescue, which had lower IVDOM for 15 August than 1 August accumulation periods. Alfalfa IVDOM concentration increased more from the longest to shortest accumulation period than the grasses (avg. 169 g kg⁻¹ compared with 46 g kg⁻¹). The SC MF3713 alfalfa line had a higher IVDOM than Algonquin for three of the four accumulation periods. Smooth bromegrass IVDOM increased most from longest to shortest accumulation periods among the grasses; Kentucky bluegrass had numerically lowest IVDOM among the grasses in three of four accumulation periods. While variation among accumulation periods did occur, orchardgrass, meadow bromegrass, and creeping red fescue IVDOM concentration varied the least due to length of accumulation period.

Neutral Detergent Fiber

The NDF fraction of stockpiled forage increased with length of the accumulation period. Values for all periods averaged over species were higher in 2000 compared with other years (Table 3). The rate of increase for NDF concentration with accumulation period was lowest in 1999. Averaged over accumulation periods SC MF3713, alfalfa had lower NDF concentrations than Algonquin (Table 4). Creeping red fescue had the lowest NDF among grass species and was significantly lower than Algonquin alfalfa in 2 of 3 yr. Kentucky bluegrass was

among the highest for NDF concentration among all grass species.

Alfalfa species were affected most by length of the accumulation period with NDF concentration increasing approximately 240 g kg^{-1} from the shortest to longest period compared with approximately 93 g kg^{-1} averaged over the grass species (Table 5). The NDF value for creeping red fescue was least affected by accumulation period with no significant change with accumulation period. Also, the NDF level for creeping red fescue was the lowest of all species for the 1 July accumulation period and lowest of all grass species for the 15 July period. The significance is that a 675 kg cow could consume approximately 18.6 kg d^{-1} of creeping red fescue dry matter compared with 14.7 kg d^{-1} , the average of all species at the longest accumulation period (NRC, 1996).

Water-Soluble Carbohydrate

Burns and Chamblee (2000b), indicated that a relatively high WSC concentration appeared to be associated with shorter accumulation periods. The pattern varied among species, but peak WSC concentration occurred at the 15 July and 1 August accumulation periods; the 1 July period was lowest and the 15 August period intermediate (Table 7). Burns and Chamblee (2000b) found WSC concentration to be relatively high in green leaves for tall fescue. In the present study, the greater percentage of dead material in the forage from longer accumulation periods of grass species may be the cause of the lower WSC concentrations in that forage. Averaged over accumulation periods the alfalfa species almost always had the lowest WSC concentrations, although in 1999 Kentucky bluegrass was generally low for WSC and orchardgrass had levels similar to the alfalfa species in 2000. Creeping red fescue had the highest WSC concentration of all species every year; values averaged over accumulation periods were very consistent from year to year.

The other grass species were more variable for WSC concentration with accumulation period and year than creeping red fescue. For example the bromegrasses, particularly meadow bromegrass, had intermediate to high WSC. In contrast with other species, smooth bromegrass decreased in WSC concentration from longest to shortest accumulation period in 1999 and 2000. Water-soluble carbohydrate concentration of Kentucky bluegrass increased with shorter accumulation periods, but had among the lowest concentrations among the grass species at the 1 July and 15 July accumulation periods in 1998 and 2000. The high WSC for creeping red fescue may play a role in its relatively low NDF concentration (Table 5), as WSC is a soluble component of cells.

In vitro digestibility and NDF concentrations for all accumulation periods indicate that digestible dry matter intakes would have provided energy levels suitable for maintenance of gestating cows (NRC, 1996). Estimated intake and digestibility levels for weaned calves (250 kg) would have limited rate of gain to $<1.0 \text{ kg d}^{-1}$ for almost all species with accumulation periods beginning before 1 August. With accumulation periods beginning

Table 7. Water-soluble carbohydrate concentration of stockpiled forage for seven forage species, cut in mid-October, with four accumulation periods for 3 yr at Lacombe, AB, Canada.

Species	Accumulation period beginning				LSD1†
	1 July	15 July	1 Aug.	15 Aug.	
	g kg ⁻¹				
	1998				
Algonquin alfalfa	51	67	89	90	
SC MF3713 alfalfa	59	85	89	87	
Meadow bromegrass	75	111	97	104	
Smooth bromegrass	92	100	107	92	6
Orchardgrass	84	93	103	105	
Kentucky bluegrass	66	77	88	95	
Creeping red fescue	126	125	129	137	
	1999				
Algonquin alfalfa	68	85	89	93	
SC MF3713 alfalfa	75	101	100	86	
Meadow bromegrass	95	114	104	104	
Smooth bromegrass	120	113	96	102	6
Orchardgrass	101	112	126	116	
Kentucky bluegrass	81	107	117	118	
Creeping red fescue	124	151	138	109	
	2000				
Algonquin alfalfa	69	83	99	102	
SC MF3713 alfalfa	60	100	107	101	
Meadow bromegrass	71	102	122	116	
Smooth bromegrass	123	111	105	74	6
Orchardgrass	60	91	95	118	
Kentucky bluegrass	80	98	111	110	
Creeping red fescue	118	144	137	120	
LSD2‡	15				

† LSD1 is valid for comparison of accumulation periods within species.

‡ LSD2 is valid for comparison of species within accumulation period.

on 1 August, both alfalfa lines would have had nutritive values that would support $>1.0 \text{ kg d}^{-1}$ rate of gain. Except for creeping red fescue, none of the grasses approached this nutritive value until the shortest accumulation period. Creeping red fescue, mostly because of a relatively low NDF concentration, would approach this rate of gain threshold at all accumulation periods. By contrast, Kentucky bluegrass would not be suitable for any animal class, except gestating beef cows (NRC, 1996).

In the current study, nutritive value and stockpiled yield data were collected during mid-October. Other research (Baron et al., 2004) indicated that large losses of yield and nutritive value occurred after this, especially for alfalfa. Creeping red fescue and meadow bromegrass were more resistant to weathering losses of nutritive value than most of the other species after mid-October (Baron et al., 2004).

SUMMARY

Stockpiled forage yield generally decreased as the length of the accumulation period decreased. In general, there was a negative relationship between stockpiled forage nutritive value and the length of the accumulation period. Crude protein and IVDOM concentrations tended to increase, while NDF concentration tended to decrease with shorter regrowth periods. Bromegrass and alfalfa species required an accumulation period beginning as early as mid-July, while others required as long as early-July to provide adequate stockpiled yield in all years. Meadow bromegrass appeared best adapted across years and accumulation periods to stockpiled for-

age management, as indicated by consistent stockpiled forage yield. However, while yield potential of creeping red fescue was reduced during the dry year of 1998, it appeared to be the most consistent species for maintenance of nutritive value over years and accumulation periods. Of the species found in old pastures, it is superior in attributes considered advantageous for stockpiled forage management.

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