Cutting frequency and cutting height effects on forage quality of rough fescue and Parry oat grass

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Willms, W.D. and Beauchemin, K.A. 1991. **Cutting frequency and cutting height effects on forage quality of rough fescue and Parry oat grass.** Can. J. Anim. Sci. **71**: 87–96. An experiment was conducted to determine the qualitative response of rough fescue (*Festuca scabrella* var. *campestris*) and Parry oat grass (*Danthonia parryi*) to five cutting frequencies and three cutting heights. Beginning in mid-May, the same plants were cut every 1, 2, 4, 8, or 16 wk, during a 16-wk period, at heights of either 5, 10, or 15 cm above ground level. The treatments were repeated in 3 consecutive years on the same plants. Crude protein (CP), lignin, and calcium (Ca) were significantly greater for Parry oat grass than for rough fescue, which had greater acid detergent fiber (ADF) and phosphorus (P) concentrations. Increasing cutting frequency in the first year reduced acid detergent-insoluble nitrogen (ADIN), ADF, and lignin but increased CP and in vitro digestibility of dry matter (IVD) in both forages. Repeated treatment over 3 yr tended to increase ADF and Ca but reduce CP, P, and IVD. In the first year of treatment, CP yields in rough fescue and Parry oat grass were greatest with 2 or 4 cuts during the growing season. However, in the second year of treatment, CP yield was greatest with one or two cuts in rough fescue and with four cuts in Parry oat grass. The data confirm the benefits of repeated grazing within a year to maintain high quality forage but demonstrate the need to limit the frequency of repeated grazing to avoid deterioration and maximize nutrient yield. Nutrient yields and, presumably, benefits to livestock would be greater at a lower grazing frequency on rough fescue than on Parry oat grass.

Key words: *Festuca scabrella* var. *campestris, Danthonia parryi*, crude protein, acid detergent fiber, in vitro digestibility, forage quality

Willms, W. D. and Beauchemin, K. A. 1991. **Effets de la fréquence et de la hauteur de coupe sur la qualité du fourrage de la fétuque rude et de la danthonie de Parry.** Can. J. Anim. Sci. **71**: 87–96. On a fait une expérience pour déterminer la réaction qualitative de la fétuque rude (*Festuca scabrella* var. *campestris*) et de la danthonie de Parry (*Danthonia parryi*) à cinq fréquences et à trois hauteurs de coupe. En commençant à la mi-mai, les mêmes plants ont été fauchés chaque 1, 2, 4, 8 ou 16 semaines, au cours d'une période de 16 semaines, à des hauteurs de 5, 10 ou 15 cm au-dessus du niveau du sol. Les traitements ont été répétés pendant trois années consécutives sur les mêmes plants. Les teneurs en protéines totales (CP), en lignine et en calcium (Ca) sont significativement plus élevées pour la danthonie de Parry que pour la fétuque rude qui présente néanmoins des concentrations en fibre au détergent acide (ADF) et en phosphore (P) plus élevées. L'augmentation de la fréquence de coupe au cours de la première année réduit les teneurs en azote insoluble au détergent acide (ADIN), ADF et en lignine, mais augmente la concentration de CP et la digestibilité in vitro de la matière sèche (IVD) des deux fourrages. La répétition du traitement pendant trois ans a tendance à accroître les teneurs en ADF et en Ca, mais à réduire les concentrations de CP, de P et l'IVD. Au cours de la première année de traitement, les rendements de CP de la fétuque rude et de la danthonie de Parry sont plus élevés avec 2 ou 4 coupes au cours de la saison de croissance. Mais au cours de la deuxième année de traitement, le rendement de CP est plus élevé avec 1 ou 2 coupes de la fétuque rude et 4 coupes de la danthonie de Parry. Les données confirment les avantages à tirer de la paissance répétée au cours d'une année pour maintenir la haute qualité du fourrage, mais soulignent la nécessité de limiter sa fréquence pour éviter sa détérioration et pour maximiser le rendement d'éléments nutritifs. Ce dernier, et présumément les avantages pour les bestiaux, seraient plus considérables à une fréquence de paissance moindre de la fétuque de la danthonie.

Mots clés: *Festuca scabrella* var. *campestris, Danthonia parryi*, protéines totales, fibre au détergent acide, digestibilité in vitro, qualité du fourrage

Rough fescue (*Festuca scabrella* var. *campestris*) is the dominant climax species of the rough fescue grasslands in southwestern Alberta. Although rough fescue may form nearly pure stands, Parry oat grass (*Danthonia parryi*) is usually found in association with it throughout the region (Johnston and Dormaar 1970) and may dominate on sites having shallow soils (Looman 1969; Moss and Campbell 1947). Both species are tufted with mostly basal leaves and few reproductive tillers. Rough fescue is a large plant with a vegetative portion that grows to 50 cm in height (Johnston 1961) whereas Parry oat grass reaches 20 cm. Rough fescue is deep rooted and, of the native species, is the most productive forage on good range condition in the foothills region. Stout et al. (1981) found that cumulative yield of rough fescue reached a maximum by the end of July.

Grazing affects the relative proportions of each species in the grassland. Even light grazing reduces the proportion of rough fescue and increases Parry oat grass (Looman 1969). As a result, Parry oat grass is often the dominant forage species on grazed range (Moss 1955). In one study, grazing reduced the proportion of rough fescue from 42% with no grazing to 38% with light grazing (1.2 animal unit months (AUM) ha^{-1}) and to 2% with very heavy grazing (4.8 AUM ha^{-1}), while Parry oat grass increased from 19% of basal area with no grazing to 48% with heavy grazing (2.4 AUM ha^{-1}) but decreased to 35% with very heavy grazing (Willms et al. 1985).

Forage quality is affected by plant species and phenology, among other factors (Johnston and Bezeau 1962; Hickman 1975). Forage quality generally declines with senescence as nutrients are translocated from aging tissue to areas of meristematic activity, and fiber constituents increase. While regrowth tissue will have greater concentrations of nutrients and be more digestible, the net seasonal benefit to the herbivore will be a function of total dry matter yield.

Time-controlled grazing, at an appropriate schedule, and grazing height could maintain plant vigor and maximize productivity. A test of this hypothesis is difficult within the context of grazing systems, which require large expenditures of resources. However, an indication of plant response might be obtained with cutting, to simulate grazing, in a controlled experiment and an assessment of forage quality to predict livestock response. Therefore, a study was conducted to measure the effects of simulated grazing during the growing season, in relation to cutting frequency and height, on quality parameters of rough fescue and Parry oat grass forage. The parameters included crude protein (CP), phosphorus (P), calcium (Ca), acid detergent fiber (ADF), acid detergent-insoluble nitrogen (ADIN), lignin, and in vitro dry matter digestibility (IVD). Dry matter response was reported previously (Willms 1991).

MATERIALS AND METHODS

Site description

This study was conducted in the Porcupine Hills of southwestern Alberta at the Agriculture Canada Research Substation at Stavely about 85 km northwest of Lethbridge. The vegetation is representative of the Rough Fescue Association described by Moss and Campbell (1947). The soils are classified as Orthic Black Chernozemic developed on till overlying sandstone. Annual precipitation data at the substation were not available, but on two areas within 65 km and similar proximity to the mountains precipitation averaged 614 mm. The study area was located on a southwest slope with less than 5% grade. The area experienced either no grazing or only light fall grazing from 1949 until 1982, when it was fenced to exclude livestock.

Methods

The effects of cutting height and cutting frequency were evaluated in a 3×5 factorial experiment with two or three replications in a completely random design. Plants were cut at either 5-cm (H5), 10-cm (H10), or 15-cm (H15) heights and at 1-, 2-, 4-, 8-, or 16-wk intervals, over a 16-wk period from 15 May to the end of August, to result in cutting frequencies of 16 (F16), 8 (F8), 4(F4), 2 (F2), or 1(F1), respectively. The treatments were repeated over 3 consecutive years on the same plants and the whole experiment was repeated on contiguous sites by initiating new trials in 1983, 1984, and 1985 for rough fescue and in 1984 and 1985 for Parry oat grass.

For each trial, 150 plants were systematically selected within 5-m-wide belts, by taking the first suitable plants encountered and randomly partitioning them equally (10) among treatments. Parry oat grass plants were selected within the same belts as were rough fescue plants in 1984 and 1985. Plants were considered suitable for selection if they were clearly defined by purity and boundary. During the first week of May each year, all newly selected plants were pretreated by cutting to a height of 15 cm and clearing litter and competing vegetation in a 5-cm-wide perimeter around the base. Cutting at this time removed standing litter but also a small quantity of green herbage from most rough fescue plants. The green herbage was hand-separated from the litter and added to the total yield of the plant. The first scheduled cutting was then begun on 15 May for F16, 22 May for F8, 5 June for F4, 3 July for F2, and 28 Aug. for F1. These dates were adhered to for trials begun in each year and for repeated treatments in subsequent years. The treatments were applied by cutting plants to the required heights. Throughout the summer, plants invading within the 5-cm perimeter were removed.

Harvested herbage was oven-dried at 70°C, harvests were composited by treatment within a year and ground through a laboratory mill equipped with a 1-mm screen. Forages were subsampled and subsequently analyzed for CP by calorimetric determination of Kjeldahl nitrogen (×6.25) using an autoanalyser (Technicon Instruments Corp., New York, NY). ADF was determined according to the Association of Official Agricultural Chemists (AOAC) (1984) method 7.076 using filter paper instead of sintered glass crucibles, and ADIN was determined by macro Kjeldahl analysis of filter papers and acid detergent-insoluble residues. Lignin was determined using 72% H_2SO_4 according to AOAC (1984) method 7.077. Ca was determined using atomic absorption spectrophotometry according to AOAC (1984) method 3.015; and P was analyzed using an autoanalyser. IVD was determined as outlined by Troelsen (1971).

Effects of cutting frequency and height, and their interaction, on nutrient constituents were determined using the General Linear Model program (Statistical Analysis System Institute, Inc. 1982) for a completely randomized design with a factorial arrangement of treatments. Cutting frequency was first transformed to a natural log scale, and then degrees of freedom for cutting frequency and height were partitioned into single degree of freedom polynomial contrasts to determine significant trends. Nutrient constituents were evaluated for the 1st year of treatment by combining individual trials initiated in different years. Year of cutting was considered to be a random variable and its interaction with individual main effects, or their interaction, was the appropriate error term for specific F-ratios.

CP, ADF, and IVD yields were determined for each treatment from estimates of dry matter yield (Willms 1991) and composition in the first and second years of treatment.

The data were analyzed for each year as described above for nutrient constituents. The effect of repeated cutting (times), over 3 successive years, on nutrient constituents was evaluated by regression analysis for each cutting frequency class. Cutting height ($n=3$) was pooled with year of cutting ($n=3$ for rough fescue and $n=2$ for Parry oat grass) for 9 or 6 independent values at each cutting time. The effect of cutting frequency (x=cutting frequency) on nutrient response to repeated annual cutting (y= coefficients of previously determined regressions) was analyzed with regression analysis.

Data for rough fescue and Parry oat grass were analyzed separately as well as in a combined analysis for those years when both were studied. Where the analyses were combined by species, only the variables pertaining to species effects are reported.

RESULTS

In the 1st year of cutting, frequency had a significant ($P<0.05$) effect on most nutrients in rough fescue and Parry oat grass (Table 1). Increased cutting frequency increased CP, P, and IVD but reduced ADIN, ADF, and lignin in both species; Ca also decreased in rough fescue. Decreased cutting height, in rough fescue, reduced CP and IVD but increased P and, in Parry oat grass, reduced Ca but increased lignin and P ($P<0.05$).

Parry oat grass had less ($P<0.01$) ADF but more ($P<0.01$) CP, lignin, and Ca than rough fescue. Rough fescue and Parry oat grass had a different ($P<0.05$) effect on CP, P, and IVD, in relation to cutting frequency, and on CP in relation to cutting height (Table 1). Species responses to cutting frequency were expressed mostly in terms of magnitude; the trends were similar. However, cutting height affected CP concentration in an opposite manner between species.

Repeated treatment over 3 successive years resulted in an increase of ADIN, ADF and Ca but a decrease of CP, P, and IVD in at

Table 1. Chemical constituents[z] and in vitro dry matter digestibility (IVD) in the 1st year of treatment of two grass species in relation to cutting frequency[y] and height

	Crude protein	ADIN[x]	ADF	Lignin	Ca	P	IVD
	(% of dry matter)						
			Rough fescue				
Frequency (no./16 wk)							
1	5.71	9.41	42.3	3.22	0.28	0.07	45.5
2	8.69	7.98	41.4	2.79	0.27	0.11	49.1
4	11.76	6.27	39.7	2.24	0.24	0.16	54.6
8	14.93	5.19	39.1	2.16	0.24	0.22	56.8
16	15.76	4.84	39.6	2.46	0.20	0.27	55.0
SEM	0.22	0.40	0.10	0.11	0.013	0.004	0.85
Height (cm)							
5	10.58	6.50	40.2	2.83	0.22	0.17	50.9
10	11.52	6.29	40.5	2.48	0.23	0.17	52.4
15	11.63	5.91	40.6	2.44	0.27	0.16	52.9
SEM	0.17	0.31	0.25	0.09	0.010	0.003	0.66
Source of variation							
Frequency (F)							
Linear	<0.001	0.001	0.006	0.038	0.029	<0.001	<0.001
Quadratic	<0.001	0.011	0.017	0.002	0.242	<0.001	<0.001
Cubic	0.010	0.256	0.249	0.084	0.795	0.020	0.049
Height (H)							
Linear	0.036	0.307	0.249	0.129	0.055	0.019	0.022
Quadratic	0.464	0.734	0.621	0.424	0.476	0.179	0.401
F × H	0.544	0.095	0.150	0.624	0.386	0.292	0.645
			Parry oat grass				
Frequency (no./16 wk)							
1	7.54	10.61	40.3	4.02	0.42	0.07	47.3
2	11.69	6.20	37.1	3.22	0.41	0.14	53.2
4	13.90	5.89	36.8	3.30	0.39	0.18	54.0
8	14.83	6.03	35.2	2.67	0.35	0.19	54.7
16	16.03	5.85	35.1	2.78	0.37	0.21	57.5
SEM	0.36	0.49	0.32	0.15	0.016	0.006	0.88
Height (cm)							
5	13.21	6.53	36.4	3.21	0.36	0.17	54.2
10	12.80	6.59	37.3	3.22	0.39	0.16	53.2
15	12.21	6.55	37.0	3.07	0.42	0.14	52.4
SEM	0.28	0.38	0.31	0.11	0.013	0.005	0.68
Frequency (F)							
Linear	<0.001	0.003	0.005	0.012	0.150	0.004	0.007
Quadratic	0.002	0.003	0.014	0.026	0.188	0.040	0.089
Cubic	0.014	0.003	0.133	0.387	0.646	0.113	0.052
Height (H)							
Linear	0.093	0.737	0.308	0.049	0.014	0.016	0.392
Quadratic	0.755	0.764	0.085	0.093	0.752	0.989	0.646
F × H	0.437	0.557	0.329	0.635	0.272	0.216	0.849
Species (S)	<0.001	0.051	<0.001	<0.001	<0.001	<0.613	0.589
S × F	0.001	0.105	0.157	0.212	0.852	0.001	0.021
S × H	0.005	0.788	0.472	0.100	0.926	0.607	0.067

[z] ADIN, acid detergent-insoluble nitrogen; ADF, acid detergent fiber; Ca, calcium; P, phosphorus; IVD, in vitro dry matter digestibility.
[y] Analyzed after transforming with the natural log scale.
[x] Expressed as percent of total nitrogen.

least one cutting frequency class in rough fescue ($P<0.05$, Table 2). In Parry oat grass, ADIN, ADF and lignin increased while IVD decreased in at least one frequency class ($P<0.05$, Table 2). The effect of repeated cutting over years was influenced by cutting frequency for CP, P, and Ca in rough fescue. Increasing the cutting frequency resulted in an increasingly greater reduction of CP and P and a decreasingly smaller increase of Ca with repeated treatment ($P<0.05$, Table 2).

The mean yields of CP, ADF, and IVD within each cutting height and frequency treatment are shown in Table 3 and the significance of polynomial coefficients describing trends for each factor are shown in Table 4. In rough fescue, the effect of cutting height on CP, ADF, and IVD yields varied in relation to cutting frequency ($P<0.05$, Tables 3 and 4). In the 1st year of treatment, CP yields were greatest at F4-H5 and least at F1-H15 while both ADF and IVD yields were greatest at F1-H5 and least at F16-H5. In the 2nd year of treatment, CP yields were greatest at F1-H10 and least at F16-H5; ADF and IVD yields decreased ($P<0.05$) with increased cutting frequency and decreased cutting height (Tables 3 and 4).

Yields of CP, ADF, and IVD in Parry oat grass were affected ($P<0.05$) by cutting frequency but not by height ($P>0.05$). Increased cutting frequency resulted in increased CP in the 1st year of treatment and decreased ADF and IVD in the 2nd year of treatment (Tables 3 and 4). Rough fescue produced more ($P<0.01$) ADF and IVD than Parry oat grass in both the 1st and 2nd years of treatment and more CP in the 1st year of treatment (Tables 3 and 4). However, yields of CP responded differently ($P<0.05$) to cutting height between species in the 1st year, whereas yields of CP, ADF, and IVD responded differently ($P<0.05$) to both cutting frequency and height between species in the 2nd year.

Precipitation over the period of the study was about 50% of average for the site (Table 5) except in 1986 when it was 74% of average.

Table 2. Regression coefficients for effects of successive cutting over 3 yr (x) on chemical constituents[y] and in vitro dry matter digestibility (IVD) (y, % of dry matter) of rough fescue and Parry oat grass for each cutting frequency class, and regression coefficients for effects of cutting frequency (x) on previous coefficients (y)

	Crude protein	ADIN[z]	ADF	Lignin	Ca	P	IVD
			Rough fescue				
Cutting frequency							
1	0.0916	0.7238	0.7166	0.0944	0.0248	−0.0038	0.6232
2	−0.1426	−0.5951	1.0454*	−0.1253	0.0517	−0.0096*	−0.2444
4	−1.0057*	−0.0363	1.4892*	−0.0660	0.0579*	−0.0281*	−1.3411
8	−2.8184*	0.8791*	2.6713*	−0.0494	0.0621*	−0.0529*	−2.7260*
16	−2.8442*	1.5288*	2.4566*	−0.1657	0.0298	−0.0813*	−2.1972
INTERCEPT	−0.1366	0.8339	2.1997	0.1274	0.0615	0.0014	−1.2809
COEFFICIENT	−0.2481*	−0.0154	0.0810	−0.0293	−0.0040*	−0.0061*	−0.0128
			Parry oat grass				
Cuitting frequency							
1	−0.2736	2.0877*	1.0486*	−0.0712	0.0182	0.0032	−2.0631*
2	−0.4536	1.0088	0.3974	0.0367	0.0011	−0.0079	−1.9071*
4	−0.3098	0.9114*	0.0826	−0.2407	−0.0045	−0.0087	−1.1763
8	−0.3129	1.2161*	1.6134*	0.2697*	0.0162	−0.0096	−1.6239*
16	−0.8805	1.0818	1.4719*	0.1147	−0.0076	−0.0296	−3.8327*
INTERCEPT	−0.5285	1.3896	0.7197	−0.0247	0.0015	−0.0003	0.4243
COEFFICIENT	−0.0017	0.0002	0.0984	0.0088	−0.0013	−0.0014	−0.2109

[z]ADIN, acid detergent-insoluble nitrogen; ADF, acid detergent fiber; Ca, calcium; P, phosphorus; IVD, in vitro dry matter digestibility.
[y]Expressed as percent of total nitrogen.
*Coefficients significant at $P<0.05$.

Table 3. Yield response of nutrient constituents[z] and in vitro dry matter digestibility (IVD) in rough fescue and Parry oat grass plants to cutting frequency and height after 1 or 2 yr of treatment

	CP (g)			ADF (g)			IVD (g)		
	Height (cm)								
Frequency	5	10	15	5	10	15	5	10	15
Year 1									
Rough fescue									
1	2.57	2.04	1.78	20.37	15.22	11.88	21.93	16.44	12.79
2	2.88	3.20	2.52	15.41	14.82	10.97	13.66	18.64	16.62
4	4.03	3.58	3.29	13.90	12.06	10.88	18.64	16.62	14.77
8	2.71	3.40	3.24	7.10	8.90	8.43	10.47	12.75	12.16
16	1.83	2.47	2.86	4.90	6.02	6.96	6.47	8.48	10.05
SEM		0.22			0.78			0.92	
Parry oat grass									
1	1.16	0.66	0.40	6.53	3.37	2.23	7.88	4.02	2.69
2	1.80	0.77	0.76	5.45	2.72	2.33	8.28	3.75	3.50
4	1.27	1.20	0.51	2.96	3.29	1.61	4.75	4.67	2.17
8	0.97	1.08	0.92	2.22	2.52	2.31	3.60	3.89	3.56
16	1.06	1.19	0.92	2.28	2.56	2.11	3.77	4.25	3.49
SEM		0.20			0.75			1.10	
Year 2									
Rough fescue									
1	2.12	2.25	1.88	14.91	15.86	16.80	15.76	17.01	16.74
2	1.04	1.92	2.05	5.28	8.44	10.08	5.96	9.81	11.38
4	0.35	0.64	1.44	1.36	2.42	6.00	1.70	3.19	7.30
8	0.14	0.18	0.52	0.51	0.69	2.03	0.40	0.68	2.59
16	0.05	0.13	0.52	0.20	0.68	1.76	0.00	0.58	2.28
SEM		0.17			0.78			0.79	
Parry oat grass									
1	0.72	0.58	0.38	3.01	3.24	2.64	3.49	3.67	2.83
2	0.72	0.69	0.65	2.33	2.49	3.07	3.17	3.22	3.99
4	0.64	0.85	0.87	1.62	2.35	2.65	2.35	3.47	3.72
8	0.40	0.67	0.66	0.99	1.77	1.77	1.39	2.59	1.31
16	0.21	0.67	0.59	0.53	1.84	1.69	0.71	2.47	2.33
SEM		0.14			0.53			0.64	

[z]CP, crude protein; ADF, acid detergent fiber; IVD, in vitro dry matter digestibility.
SEM, Standard error mean.

Monthly precipitation also fluctuated considerably with substantial deviation from the average.

DISCUSSION

Designing grazing systems for efficient livestock production requires an understanding of the effects of timing and height of grazing on the herbage produced and the chemical composition of herbage available for grazing. Rough fescue and Parry oat grass respond differently to defoliation. The nutrient composition of both grasses was affected by grazing pressure, as simulated by manual cutting, but Parry oat grass had greater concentrations of CP, ADIN, lignin, and Ca, and smaller concentrations of P, than rough fescue. However, because Parry oat grass produced considerably less dry matter than rough fescue (Willms 1991), nutrient yields for all constituents were also less.

Frequent cutting, as is likely to occur with regrazing of patches in a season-long grazing system or with rapid movement through a rotation grazing system, resulted in improved quality for both forage species as indicated by

Table 4. Statistical analyses (showing probabilities) of the yield response of chemical constituents[z] of rough fescue and Parry oat grass plants to cutting frequency[y] and height in the 1st and 2nd year of treatment (means in Table 3)

Source	CP	ADF	IVD
Year 1			
Rough fescue			
Frequency (F)			
Linear	0.507	<0.001	<0.001
Quadratic	0.006	0.021	0.700
Cubic	0.008	0.899	0.155
Height (H)			
Linear	0.828	0.073	0.078
Quadratic	0.350	0.563	0.446
F × H	0.028	<0.001	0.001
Parry oat grass			
Frequency (F)			
Linear	0.040	0.091	0.209
Quadratic	0.065	0.197	0.354
Cubic	0.008	0.740	0.277
Height (H)			
Linear	0.081	0.111	0.130
Quadratic	0.944	0.865	0.755
F × H	0.192	0.182	0.240
Species (S)	<0.001	<0.001	<0.001
S × F	0.818	0.427	0.384
S × H	0.049	0.099	0.084
Year 2			
Rough fescue			
Frequency (F)			
Linear	<0.001	0.008	<0.001
Quadratic	0.002	0.008	0.001
Cubic	0.166	0.036	0.026
Height (H)			
Linear	0.005	0.008	0.005
Quadratic	0.719	0.419	0.718
F × H	0.023	0.313	0.067
Parry oat grass			
Frequency (F)			
Linear	0.185	0.001	0.006
Quadratic	0.264	0.014	0.088
Cubic	0.129	0.246	0.116
Height (H)			
Linear	0.535	0.168	0.271
Quadratic	0.372	0.111	0.134
F × H	0.377	0.805	0.586
Species (S)	0.106	<0.001	<0.001
S × F	<0.001	<0.001	<0.001
S × H	0.005	0.010	0.012

[z]CP, crude protein; ADF, acid detergent fiber; IVD, in vitro dry matter digestibility.
[y]Analyzed after transforming with the natural log scale.

Table 5. Precipitation during the growing season at the Stavely Range Research Substation from 1983 to 1987

	April	May	June	July	August	Total
	(mm)					
1983	30	21	28	57	32	168
1984	23	46	71	27	1	168
1985	20	23	0	31	99	173
1986	11	52	78	77	38	256
1987	22	3	27	63	60	175
Long-term mean[z]	64	70	99	55	60	348

[z]Based on 30-yr average.

reduced ADF and lignin and increased CP and P contents. In contrast, cutting height had little effect on the nutrient value of forages.

Nutrient yields for rough fescue in the 1st year were greatest at the mid- or high frequency of cutting range. By the 2nd year of repeated treatment, nutrient yields were greatest with only one or two cuts. This shift was caused by a severe reduction of dry matter yields when plants were cut more than once (Willms 1991) and by a decline of nutrients over successive years of repeated cutting (Table 2).

Cutting frequency altered the age of leaf tissue that was harvested, and thereby affected their mineral and fiber composition. Frequent cutting ensured that mineral losses from the leaves, by leaching and translocation, were reduced and that a greater proportion of assimilates was harvested. Leaf nitrogen declines with age of the leaf but nitrogen uptake and translocation to aboveground tissue is also stimulated with grazing (Whicker and Detling 1988). Furthermore, defoliation may enhance photosynthesis of the remaining leaves which raises their nitrogen levels (Gifford and Marshall 1973).

The decrease of IVD and increase of ADF, lignin, and Ca with reduced cutting frequency was associated with increasing age of plant tissue harvested and followed trends similar to those defined with plant senescence (Bezeau and Johnston 1962; Johnston and Bezeau 1962; Hickman 1975). Calcium increases in concentration in older leaves because it is not translocated as are nitrogen and P (Chapin 1980).

The decrease of ADIN with increased cutting frequency (Table 1) may reflect greater mobility of intracellular nitrogen and its loss from the older tissue of less frequently cut leaves. Although ADIN can also increase during laboratory drying of samples (Van Soest 1982), it is speculated that this effect was minimal, or at least of similar magnitude, for all samples. Since fiber-bound nitrogen (ADIN) is less digestible, about 4% more of the crude protein of frequently grazed leaves will be available to the herbivore.

The effect of cutting height on forage quality was unclear. Although the fibrous constituents in rough fescue, and ADF in Parry oat grass, were not affected by cutting height, P decreased in both grasses and CP increased in rough fescue with increased cutting height (Table 1). Both crude protein and P concentrations were expected to decrease with increased cutting heights because increasingly younger plant material would be included in the sample. Several factors may affect the concentration of minerals and fibrous constituents in treatments of this study. These include the ratio of leaf to stem, the effect of cutting height on regrowth characteristics (yields were accumulative over the season), the rate of senescence within a leaf, the development and emergence of new leaves from the sheath, and the proportion of total leaf included in the sample, which would affect the sensitivity at which the gradient is measured. In comparison with Parry oat grass, self shading in rough fescue is greater owing to its denser canopy and thicker sheath that reduce photosynthetic activity near the base of the tillers, thereby reducing the concentration of assimilates.

The reduction of CP and P in leaf tissue from the 1st to 3rd years of repeated defoliation is a symptom of reduced nutrient availability to the plant (Chapin 1980). This explanation appears reasonable because nutrients were not returned to the soil via feces and nutrient reduction was exacerbated with greater frequency of tissue removal (Table 2), a treatment that produced the highest nutrient concentration.

Cutting frequency probably affected the rate of nutrient demand which, in the 1st year, was greatest in the mid to high cutting frequency range (Table 3). Although Parry oat grass exhibited a trend in nutrient concentration over time similar to that of rough fescue (Table 2), the effect was less severe. This effect may result from lower nutrient demand by Parry oat grass, its productivity being considerably less (Willms 1991). Although total nitrogen is high in the Rough Fescue Grassland soils, nitrogen can limit production because most is organically combined, therefore slowing its release (Dormaar et al. 1990). By the 2nd year, nutrient yields (Table 3) were affected by the changes in both nutrient concentrations and dry matter production over that period.

Rough fescue and Parry oat grass offer distinctly different opportunities for grazing management. Rough fescue is relatively intolerant to grazing during the growing season whereas Parry oat grass is most productive with multiple harvests (Willms 1991). This results in an increase in the proportion of Parry oat grass and decrease of rough fescue when grazed at moderate stocking rates or higher. In addition to its higher nutrient value compared with rough fescue, Parry oat grass was also grazed in preference to rough fescue during the growing season. However, rough fescue is much more productive than Parry oat grass, although both species are low in nutrient quality after senescence (Bezeau and Johnston 1962; Johnston and Bezeau 1962). Therefore, the grazing options are to manage Parry oat grass for use during the growing season or to delay grazing until after senescence and manage for rough fescue. The first option would ensure that forage quality is adequate for all classes of cattle, but forage yields and range condition would be compromised; the second option would result in maximum yields but forage quality may be limiting for some classes of livestock (National Research Council 1984).

Results from this study indicate that beef can be produced from the Rough Fescue Grasslands by grazing after the growing season. Grazing at this time would yield the most dry matter (Willms 1991), nutrients, and digestible dry matter, and allow heavy utilization of plants without jeopardizing their health. However, quality will continue to deteriorate and, therefore, care should be taken to ensure that nutrient requirements are met to produce expected animal performance.

This study examined fixed defoliation schedules that may be representative of time-controlled or short-duration grazing systems. However, other scenarios may exist that could lead to different conclusions. For example, a system of rest rotation may overcome the nutrient losses experienced with repeated defoliation as well as maintain dry matter production from grazing sensitive species such as rough fescue. This information is not presently available and more work needs to be done to define the optimum grazing schedule. Nevertheless, this study shows the importance of managing for specific objectives and identifies the need to examine grazing results for periods of more than 1 yr.

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