Forage quality of seeded native grasses in the fall season on the Canadian Prairie Provinces

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Jefferson, P. G., McCaughey, W. P., May, K., Woosaree, J. and McFarlane, L. 2004. **Forage quality of seeded native grasses in the fall season on the Canadian Prairie Provinces.** Can. J. Plant Sci. **84**: 503–509. There is renewed interest in re-seeding native grasses in the prairie region of western Canada but there is limited information on their forage quality for fall grazing. We evaluated forage quality in early fall of nine native and one introduced grass species for 2 to 4 yr at five locations. The neutral detergent fiber (NDF) was high due to the advanced growth stage of the plants but varied among grass species at all sites. Western wheatgrass, *Pascopyrum smithii*, exhibited the lowest NDF and highest in vitro organic matter digestibility (IVOMD). Northern wheatgrass, *Elymus lanceolatus*, exhibited the highest crude protein while western wheatgrass ranked second highest for crude protein. Indiangrass, *Sorghastrum nutans*, exhibited the highest P and Ca concentrations, while green needle grass, *Nasella viridula*, and mammoth wildrye, *Leymus racemosus*, exhibited the lowest concentrations. Acid detergent fiber (ADF) was not highly correlated to IVOMD, presumably due to the mature phenological stage at sampling. Western wheatgrass forage was nutritionally adequate to maintain a dry beef cow during the second trimester of pregnancy. Other species did not “cure on the stem” as had been previously reported and would require supplementary energy and protein to be utilized for fall pastures.

Key words: Forage quality, fiber, protein, P, C_4 grasses, C_3 grasses

Jefferson, P. G., McCaughey, W. P., May, K., Woosaree, J. et McFarlane, L. 2004. **Qualité des fourrages automnaux après ensemencement de graminées indigènes dans les provinces des Prairies canadiennes**. Can. J. Plant Sci. **84**: 503–509. On commence à s’intéresser au réensemencement des pâturages avec des graminées indigènes dans la région des Prairies de l’Ouest canadien, mais on sait peu de choses sur la qualité des fourrages pour la paissance à l’automne. Deux à quatre années durant, les auteurs ont évalué la qualité de neuf graminées indigènes et d’une espèce exotique au début de l’automne, à cinq sites. Le stade de croissance avancé des plantes entraîne une forte concentration de fibres au détergent neutre (FDN), mais celle-ci varie d’une espèce à l’autre, aux différents endroits. L’agropyre de l’Ouest (*Pascospyrum smithii*) présentait la plus faible FDN et la meilleure digestibilité de la matière organique *in vitro* (DMOIV). L’agropyre velu (*Elymus lanceolatus*) avait la plus forte concentration de protéines brutes, suivi par l’agropyre de l’Ouest. Le faux-sorgho penché (*Sorghastrum nutans*) se dénotait par la plus forte teneur en P et en Ca, alors que la stipe verte (*Nasella viridula*) et l’élyme des sables (*Leymus racemosus*) avait la plus basse. La concentration de fibres au détergent acide n’est pas étroitement corrélée à la DMOIV, sans doute à cause du stade de maturité des plantes lors de l’échantillonnage. Sur le plan nutritif, le foin d’agropyre de l’Ouest permet d’entretenir une vache à viande tarie durant le deuxième trimestre de sa gestation. D’autres espèces profitent toutefois moins des tiges et auraient besoin d’un supplément d’énergie et de protéines lorsqu’elles sont mises à l’herbe à l’automne.

Mots clés: Qualité des fourrages, fibres, protéines, P, graminées C_4, graminées C_3

There has been a revival of interest in native grass species of the Northern Great Plains for reclamation seedings, wildlife habitat restoration (Wark et al. 1995), landscaping, and for pasture and rangeland seedings in the southern prairie region of western Canada (Abouguendia 1995). One common rationale among the many users of native plant species is that native grasses are more sustainable and less invasive of neighboring native rangeland than exotic or introduced forage species. Whatever the rationale for seeding native species, these grasses must be defoliated at regular intervals to maintain a healthy ecosystem. There are many reasons to seed native grasses on the Western Canadian Prairie landscape, but in the end, these sites will most likely be grazed by domestic beef cattle. Jefferson et al. (1997) reported that seeded native grasses can be “stockpiled” for early fall grazing by dry, pregnant beef cows. In this scenario, grazing is deferred during the growing season until early fall (September–October) and forage “cures-on-the-stem” as phenological maturity advances for each species in the plant community. Forage quality declines with advancing phenological maturity of grasses (Buxton 1996). Stockpiling native grasses for fall pasture by beef cows may result in low and variable forage quality.

The forage quality of several native grass species has been determined in the past (Smoliak and Bezeau 1967) but not for species that are of interest today. To further confuse our understanding of forage quality of native grasses, comments about forage quality are often made in taxonomic or ecological references (Budd et al. 1979) without any sup-

Abbreviations: **ADF**, acid detergent fiber; **IVOMD**, in vitro organic matter digestibility; **NDF**, neutral detergent fiber

Table 1. Mean NDF concentration of 10 native grasses over 2 yr at Brandon, Lethbridge, Melfort and Vegreville and over 4 yr at Swift Current sites when harvested in September or October

Species	Brandon clay soil	Brandon sandy soil	Lethbridge	Melfort	Swift Current dryland	Swift Current irrigation	Vegreville	Mean
	($g\ kg^{-1}$)							
Cool-season grasses								
Northern wheatgrass	624	634	652	652	690	639	694	658
Green needlegrass	682	685	720	678	723	706	709	704
Mammoth wildrye	624	634	618	615	663	634	654	637
Western wheatgrass	563	570	601	579	580	570	610	582
Warm-season grasses								
Big bluestem	689	645	710	587	656	645	–	662
Switchgrass	658	635	692	–	666	656	–	660
Prairie sandreed	600	662	712	590	703	675	655	674
Sideoats grama	690	645	710	–	695	638	–	669
Little bluestem	677	665	708	–	679	626	–	668
Indiangrass	658	601	676	–	656	624	–	644
$LSD_{0.05}$	30	19	27	28	17	26	26	16

porting data. The use of re-seeded native grass species for early fall grazing has been proposed (Abouguendia 1995; Jefferson et al. 1997) but more information about their forage quality is needed.

The detergent fiber system for determining nutritive value of forages is based on correlative relationships between fiber constituents and in vitro or in vivo digestibility of grasses (Van Soest 1982). Neutral detergent fiber (NDF) determines cell wall concentration of forage and is correlated to ruminant intake (Van Soest 1982). Acid detergent fiber residue contains cellulose, lignin, and silica so the use of ADF to predict forage digestibility has varied with species (Van Soest 1982). Buxton (1996) indicated that most forage quality laboratories are relying on ADF concentrations to predict digestibility of grasses. This correlative relationship is based on samples ranging from vegetative to dormant, seed-ripe stage and relies on a broad range of both ADF and IVOMD concentrations. We found no reports where this assumption was tested for dormant native grasses utilized for fall grazing.

The objective of this research was to determine the forage quality characteristics of nine native grasses and one introduced grass species grown for 2 to 4 yr at seven sites (five geographic locations) across the prairie region of western Canada and harvested in September and October. A secondary objective was to examine the relationship between ADF and IVOMD of the grass species.

MATERIALS AND METHODS

General

Seeds of native species representing cultivars or experimental lines were obtained from the USDA Natural Resources Conservation Service, Plant Materials Center, Bismarck, North Dakota. These entries represented the northern-most adapted seed sources of several warm-season (C_4) grasses, namely: switchgrass, *Panicum virgatum* L. cv. Dacotah; indiangrass, *Sorghastrum nutans* (L.) Nash cv. Tomahawk; little bluestem, *Schizachyrium scoparium* (Michx.) Nash cv. Badlands; big bluestem, *Andropogon gerardii* Vitman cv. Bison; prairie sandreed, *Calamovilfa longifolia* (Hook.) Scribn. cv. Goshen and ND-95; and sideoats grama, *Bouteloua curtipendula* (Michx.) Torr. cv. Killdeer. Seeds of several cool-season (C_3) native species were also obtained, namely: western wheatgrass, *Pascopyrum smithii* (Rydb.) A. Love cv. Rodan and Rosana; green needlegrass, *Nasella viridula* (Trin.) Barkworth (syn. *Stipa viridula* Trin.) cv. Lodorm; and thickspike wheatgrass, *Elymus lanceolatus* (Scribn. & J.G. Sm.) [syn. *Agropyron dasystachyum* (Hook.) Scribn.& J.G. Sm.] (Canadian common name is northern wheatgrass) cv. Critana. One introduced grass, mammoth wildrye [*Leymus racemosus* (Lam.) Tzvelev (Syn. *Elymus giganteus* Vahl.) cv. ND-691], from the former USSR was included for study as it was deemed to have wildlife habitat potential and has been seeded for soil conservation on sand dunes and other dry sites in Washington state (Alderson and Sharp1994). Purple prairie clover [*Petalostemon purpureum* (Vent.) Rydb.] was included as a native legume in mixture with each grass as a main plot treatment (i.e., grass monoculture vs. grass-clover mixture. Each of the native species occurs in native rangeland of the Canadian prairie provinces (Budd et al. 1979) but switchgrass and indiangrass were described as occurring rarely in this region. The seeding rate was approximately 300 pure live seed (PLS) m^{-2} for the grasses and 100 PLS m^{-2} for the purple prairie clover. Experimental design at each site was a split plot with legume treatments, with or without purple prairie clover, as main plots and 12 grass cultivars as subplots with four replications. The sites were Brandon Manitoba (49°50′N, 99°57′W), Melfort, Saskatchewan (52°52′N, 104°37′W), Swift Current, Saskatchewan (50°16′N, 107°44′W), Vegreville, Alberta (53°30′N, 112°03′W), and Lethbridge, Alberta (49°42′N, 112°49′W). Additional sites were added for the comparison of two soil types, sandy soil and clay soil at Brandon and an irrigated and a dryland site at Swift Current, for a total of seven experimental sites (Table 1). For more details on experimental layout, plot

Table 2 . Mean IVOMD concentration of 10 native grasses over 2 yr at Brandon, Lethbridge, Melfort and Vegreville and over 4 yr at Swift Current sites when harvested in September or October

Species	Brandon clay soil	Brandon sandy soil	Lethbridge	Melfort	Swift Current dryland	Swift Current irrigation	Vegreville	Mean
	($g\ kg^{-1}$)							
Cool-season grasses								
Northern wheatgrass	461	460	491	484	411	478	447	459
Green needlegrass	433	433	420	494	408	415	435	430
Mammoth wildrye	459	450	471	492	430	474	466	462
Western wheatgrass	520	513	553	542	502	514	510	520
Warm-season grasses								
Big bluestem	407	390	427	542	414	495	–	446
Switchgrass	436	453	438	–	438	503	–	464
Prairie sandreed	504	423	482	540	437	501	488	476
Sideoats grama	430	432	447	–	461	550	–	479
Little bluestem	411	408	421	–	424	534	–	446
Indiangrass	436	434	469	–	478	522	–	477
$LSD_{0.05}$	22	19	21	23	18	32	20	10

design, row spacing, site management, persistence, forage yield, and ground cover changes see Jefferson et al. (2002). Trials were seeded in May or June of 1992 or 1993 depending on the site.

Sample Collection

Biomass productivity was estimated by hand clipping at the Swift Current sites, by use of a Carter (Carter Manufacturing, Brookston, IN) flail harvester at the Brandon and Lethbridge sites, by use of a Swift (Swift Machine and Welding, Swift Current, SK) flail harvester at Vegreville and by use of a Haldrup (J. Haldrup Logstor, Denmark) harvester at Melfort. Methodologies for forage sample collection differed among the five locations, but we considered that any effect of methodology would contribute to the location effect in the data analysis. Harvesting dates ranged from early September to early October when all species were post-seed maturity. Purple prairie clover establishment was variable among sites so forage quality was determined on grass monoculture plots only. The Brandon, Vegreville, Lethbridge, and Melfort sites were sampled for 2 yr (1994 to 1995) while Swift Current sites sampled for 4 yr (1994 to 1997). At all sites, a sub-sample of biomass was weighed, dried in forced-air (45 to 60°C) ovens to a constant weight. The dried samples were ground in a Wiley mill to pass through a 1-mm screen, labeled and placed in glass jars.

Laboratory Procedures

In vitro organic matter digestibility (Tilley and Terry 1963) as modified by Troelsen and Hanel (1966) was determined for each sample. Fistulated sheep used for the collection of rumen fluid were fed a standard bromegrass (*Bromus inermis* L.)/alfalfa (*Medicago sativa* L.) forage diet and cared for in accordance with the Canadian Council on Animal Care guidelines (Olfert et al. 1993). Nitrogen concentration was determined (Association of Official Analytical Chemists 1984). Phosphorus concentration was colorimetrically determined after the samples had been digested with sulphuric acid (Varley 1966). Calcium concentration was determined after a nitric-perchloric acid digestion (Miller 1998).

Statistics

Heterogeneity of error variances among the 18 site-years of data was determined by Bartlett's test (Steel and Torrie 1980) for each forage quality variable. The results indicated that error variances were heterogeneous for all measured variables. Differences among years within a site were less than differences among sites so analysis of variance (ANOVA) was calculated for site data averaged over the appropriate number of years. ANOVA was calculated with JMP software (SAS Institute, Inc.1995) based on the split-plot design. When grass species effect was significant at $\alpha = 0.05$, a Fisher's protected LSD value was calculated from the error mean square for mean separation testing. Cultivars of western wheatgrass and prairie sandreed did not differ from each other so we present a species mean for all parameters. Site-year means (n = 4 replications per site) were used to develop linear regressions of IVOMD from ADF concentrations for each species.

RESULTS AND DISCUSSION

Fiber and Digestibility

Grass species differed significantly ($P < 0.05$) for NDF, ADF, and IVOMD at all seven locations. Western wheatgrass exhibited the lowest NDF concentration at all seven sites (Table 1). Western wheatgrass was significantly lower in NDF concentration than the second lowest entry at five locations, namely Brandon-clay, Brandon-sandy, Swift Current-dryland, Swift Current-irrigation, and Vegreville. This was also evident for the overall mean NDF concentration where western wheatgrass was 55 $g\ kg^{-1}$ lower than the second lowest entry, mammoth wildrye. Green needlegrass exhibited the highest NDF concentrations at six locations while sideoats grama had the highest NDF concentration at

Table 3. Mean N concentration of 10 native grasses over 2 yr at Brandon, Lethbridge, Melfort and Vegreville and over 4 yr at Swift Current sites when harvested in September or October

Species	Brandon clay soil	Brandon sandy soil	Lethbridge	Melfort	Swift Current dryland	Swift Current irrigation	Vegreville	Mean
				($g\ kg^{-1}$)				
Cool-season grasses								
Northern wheatgrass	13.6	13.2	16.0	15.2	9.6	13.1	10.0	12.6
Green needlegrass	9.3	9.8	12.5	13.0	8.1	9.0	7.9	9.7
Mammoth wildrye	12.4	13.8	14.9	15.2	9.1	10.7	10.1	11.8
Western wheatgrass	12.8	13.6	15.3	17.2	10.5	10.2	9.6	12.2
Warm-season grasses								
Big bluestem	5.3	7.8	6.9	17.8	5.2	8.3	–	7.1
Switchgrass	6.2	7.0	7.8	–	4.7	8.4	–	7.3
Prairie sandreed	13.1	11.5	9.3	18.7	7.4	12.4	9.1	11.0
Sideoats grama	7.0	8.1	8.2	–	6.3	14.2	–	9.4
Little bluestem	7.8	8.1	8.2	–	6.8	15.3	–	9.5
Indiangrass	7.1	10.3	8.0	–	8.1	13.8	–	9.6
$LSD_{0.05}$	2.0	1.2	1.2	2.5	1.3	2.8	1.2	0.9

Brandon-clay. Green needlegrass exhibited the highest NDF concentration for the overall means and it was significantly higher than prairie sandreed, which had the second highest (Table 1).

It was noted earlier that western wheatgrass and green needlegrass are cool-season or C_3 grasses. The warm-season or C_4 grasses were generally intermediate in NDF concentration except at the sites where they were not adapted and did not grow (Vegreville and Melfort). These results indicate that intake of western wheatgrass should be much higher than for green needlegrass when stockpiled for fall grazing.

Western wheatgrass also exhibited the lowest ADF concentration at each site and for the mean across sites (data not shown). It was significantly lower in ADF concentration than the second lowest species at five sites and for the mean across sites. Northern wheatgrass had the highest ADF concentrations at Brandon-sand, Melfort, Swift Current-dryland and Vegreville, while big bluestem had the highest ADF concentration at Brandon-clay and Lethbridge. Green needlegrass exhibited the highest ADF concentration at Swift Current-irrigation and for the mean across sites. Lethbridge and Brandon-clay were the best sites for warm-season grass biomass and persistence (Jefferson et. al 2002). At such locations, it is possible that big bluestem would have lower forage quality for grazing than other cool- or warm-season grasses.

Warm-season or C_4 grasses have a higher proportion of vascular tissue in their leaves and thicker cell walls in the vascular parenchyma cells than cool-season or C_3 grasses (Van Soest 1982). Therefore, we had expected higher NDF and ADF concentrations in warm-season grasses than cool-season grasses in this study. Green needlegrass exhibited the highest NDF concentrations while northern wheatgrass exhibited the highest ADF concentrations, which is contrary to our expectation for these cool-season species. We speculate that this result could be attributed to testing these warm-season grass cultivars at their northern limit of adaptation. Sanderson and Wolf (1995) reported a similar positive relationship between fiber concentration and accumulated temperature (degree days) for switchgrass grown in Texas. In the cooler climate of the Canadian prairies, the fiber concentration of warm-season grasses may be limited by temperature.

Western wheatgrass exhibited the highest IVOMD among the grasses at all sites except Swift Current-irrigation (Table 2). Sideoats grama had the highest IVOMD at Swift Current-irrigation and western wheatgrass was only fourth highest at this site. When averaged over all sites, western wheatgrass exhibited the highest IVOMD. Green needlegrass exhibited the lowest IVOMD concentration at Lethbridge, Swift Current-dryland, Swift Current-irrigation, and Vegreville while big bluestem had the lowest IVOMD concentration at Brandon-clay and Brandon-sand sites. At Lethbridge, northern wheatgrass had the lowest IVOMD concentration. When averaged over all sites, green needlegrass exhibited the lowest IVOMD.

The proportion of structural and metabolic components of grasses changes during growth and advancing phenological development (Bélanger et al. 2001). Grasses harvested at very late phenological stage such as we did in this study would be expected to have a high proportion of stem (structural) tissue and a low proportion of cell contents (metabolic). We did not collect data on leaf:stem ratio that might help explain species differences in forage quality or N concentration (Bélanger et al. 2001). We observed that western wheatgrass stem production at Swift Current declined markedly after the second year (1995) and exhibited vegetative growth in the third and fourth years (1996–1997). It is tempting to attribute IVOMD differences among species to changes in leaf:stem ratio. A similar shift to vegetative growth was observed for northern wheatgrass and yet it had 91 $g\ kg^{-1}$ lower IVOMD than western wheatgrass at the Swift Current-dryland site (Table 2). This result suggests that forage quality differences among species may be more complex than changing leaf:stem ratio.

Digestibility and ADF concentrations for prairie sandreed and little bluestem grown in Nebraska and harvested in October (Northup and Nichols 1998) were similar to those

Table 4. Mean P concentration of 10 native grasses over 2 yr at Brandon, Lethbridge, Melfort and Vegreville and over 4 yr at Swift Current sites when harvested in September or October

Species	Brandon clay soil	Brandon sandy soil	Lethbridge	Melfort	Swift Current dryland	Swift Current irrigation	Vegreville	Mean
					($g\ kg^{-1}$)			
Cool-season grasses								
Northern wheatgrass	1.63	1.64	1.38	1.18	1.20	1.80	0.97	1.40
Green needlegrass	1.21	1.26	0.98	0.91	1.14	1.58	0.79	1.16
Mammoth wildrye	1.12	1.08	0.97	0.98	0.81	1.08	0.74	0.95
Western wheatgrass	1.52	1.40	1.21	1.34	1.12	1.59	0.90	1.30
Warm-season grasses								
Big bluestem	1.34	1.36	0.59	1.39	1.55	1.45	–	1.29
Switchgrass	1.30	1.10	0.69	–	1.67	1.33	–	1.29
Prairie sandreed	1.58	1.33	0.80	1.60	1.34	1.56	0.95	1.32
Sideoats grama	1.22	1.22	0.70	–	1.49	1.81	–	1.31
Little bluestem	1.33	1.01	0.81	–	2.33	2.12	–	1.60
Indiangrass	1.59	1.51	0.80	–	2.80	2.38	–	1.71
$LSD_{0.05}$	0.15	0.21	0.12	0.19	0.28	0.32	0.11	0.12

Table 5. Mean Ca concentration of 10 native grasses over 2 yr at Brandon, Lethbridge, Melfort and Vegreville and over 4 yr at Swift Current sites when harvested in September or October

Species	Brandon clay soil	Brandon sandy soil	Lethbridge	Melfort	Swift Current dryland	Swift Current irrigation	Vegreville	Mean
					($g\ kg^{-1}$)			
Cool-season grasses								
Northern wheatgrass	4.64	5.75	5.77	4.27	3.31	4.15	3.56	4.26
Green needlegrass	4.03	5.87	4.40	3.70	2.51	3.09	3.00	3.50
Mammoth wildrye	4.62	6.29	7.95	4.20	2.51	4.14	4.06	4.46
Western wheatgrass	4.18	5.95	5.45	4.15	3.02	3.85	3.68	4.06
Warm-season grasses								
Big bluestem	5.28	6.00	5.27	4.83	4.36	4.23	–	4.72
Switchgrass	6.53	8.32	7.75	–	4.31	5.75	–	5.97
Prairie sandreed	6.58	6.24	4.53	5.05	2.71	3.15	4.19	3.93
Sideoats grama	3.96	6.58	4.34	–	2.67	4.25	–	4.09
Little bluestem	4.81	5.60	4.18	–	3.18	4.00	–	4.09
Indiangrass	5.43	8.77	5.83	–	4.36	5.35	–	5.68
$LSD_{0.05}$	0.88	0.87	0.63	0.42	0.32	0.62	0.39	0.42

observed in our study. A mixture of big bluestem, little bluestem, indiangrass, and switchgrass prairie hay from Kansas, USA, had digestibility of 496 g kg^{-1} (Löest et al. 2001) which was similar to values for these species in our study. The addition of non-protein N (NPN) supplements to the Kansas prairie hay improved digestibility to 590 g kg^{-1} (Löest et al. 2001). These researchers concluded that NPN supplementation would permit better utilization of dormant native grass forage by grazing beef cows.

The values observed for IVOMD were not as high as normally observed for forage crops during the growing season, but reflect the mature phenological growth stage of the forage that was harvested in September or October. The range of values is equivalent to poor quality tame hay at best and to crop residues at worst. Feeds with low quality but at the same time, of low cost, are foundational to a competitive beef cow/calf sector in the semiarid prairie region of western Canada. Jefferson et al. (1999) reported similar IVOMD concentrations for mixed native species forage harvested at the end of July or 2 mo earlier in the growing season. Forage quality of warm-season grass species for late summer and early fall grazing has been the subject of considerable debate in the absence of hard data. Abouguendia (1995) argued that forage quality of warm-season grasses should be superior to cool-season grasses during the late summer and early fall due to their later growth initiation and late phenological maturity. Forage quality of western wheatgrass from a rangeland site near Lethbridge declined markedly during the fall (Smoliak and Bezeau 1967) while an introduced grass, Russian wildrye (*Psathyrostachys juncea*), maintained its quality. However, our results indicate that western wheatgrass exhibits the best potential forage digestibility for fall grazing of stockpiled, reseeded native grasses.

Mineral Concentrations

Nitrogen concentrations were significantly different among the 10 grass species (Table 3), but results were more variable than those for fiber and digestibility.

Table 6. Linear regression coefficients for IVOMD concentration prediction from ADF concentration of 10 native grasses over all site-year means

Species	*n*	Slope	Intercept	R^2	RMSE[z]
Cool-season grasses					
Northern wheatgrass	18	–0.91**	81.0**	0.44**	2.9
Green needlegrass	18	–0.68**	69.6**	0.29**	2.7
Mammoth wildrye	18	–0.56	67.9**	0.15	2.8
Western wheatgrass	36	–0.68**	73.2**	0.18**	2.8
Warm-season grasses					
Big bluestem	17	–0.92*	78.4**	0.24*	5.5
Switchgrass	16	–0.72	71.9**	0.12	4.7
Prairie sandreed	33	–0.62**	70.3**	0.20**	4.2
Sideoats grama	15	–1.28**	93.4**	0.58**	3.8
Little bluestem	16	–1.04**	82.4**	0.39**	4.5
Indiangrass	12	–1.23**	92.2**	0.51**	4.1

[z]RMSE, root mean square error.
*, ** Significantly different from zero at $P = 0.05$ and $P = 0.01$, respectively.

Northern wheatgrass exhibited the highest N concentrations at two sites, mammoth wildrye was the highest at two sites, western wheatgrass, prairie sandreed, and little bluestem each had the highest N concentrations at one site. Big bluestem had the lowest N concentration at three sites, green needlegrass at two sites and switchgrass at two sites. When averaged over all sites, northern wheatgrass had the highest N concentration while big bluestem had the lowest. There was no fertilizer N added in this study. These N concentrations are lower than those reported by Jefferson et al. (1999), presumably because N is reallocated to root and crown protein storage during hardening in the fall. Reallocation of N belowground could result in lower N concentrations during September–October compared to July–August sampling dates of Jefferson et al. (1999). The inconsistent N concentration differences among grasses suggest that edaphic and climatic factors have greater influence on this mineral than does grass species per se. For example, soil N concentration, N mineralization, soil water content and precipitation will all have an influence on the N available for uptake by the growing plants. N concentrations for prairie sandreed and little bluestem were higher in our study than for results from Nebraska (Northup and Nichols 1998).

Indiangrass and little bluestem had higher P concentration than northern wheatgrass, western wheatgrass, big bluestem, switchgrass, prairie sandreed or sideoats grama (Table 4). Mammoth wildrye had the lowest concentration of P while green needlegrass had the second lowest. We observed similar P concentrations in western wheatgrass as reported for Montana (Grings et al. 1996). P concentrations in Montana ranged from 0.8 to 1.3 g kg^{-1} (Grings et al. 1996) while our observations ranged from 0.9 to 1.5 g kg^{-1} (Table 4).

Switchgrass and Indiangrass had the highest concentrations of Ca while green needlegrass had the second lowest (Table 5). Western wheatgrass Ca concentrations ranged from 3.0 to 5.9 g kg^{-1} in our study which were lower than the range of 2.2 to 2.4 reported by Grings et al. (1996) at a semiarid site at Miles City, Montana. The Ca concentration results from this study may reflect higher available soil water in western Canada compared to Mile City, Montana, USA.

Low dietary P has been ameliorated by mineral supplementation in beef production systems including extensive native rangelands. However, concern about P pollution in intensive agricultural livestock systems may result in future restrictions on P supplementation (Spears 1996). Low available P in rangeland forages has resulted in the common practice of mineral supplementation on pastures without any prior testing of forage mineral concentrations. However, such testing may be necessary to ensure adequate P and Ca nutrition of grazing livestock while minimizing the risk of over-feeding minerals.

Beef Cattle Requirements

The dietary requirements of 5-yr-old, non-lactating Angus beef cows (*Bos taurus*) in the second trimester of pregnancy (7 to 9 mo after calving) were 700 g protein and 22 Mcal digestible energy per day (National Research Council 2000). Western wheatgrass contained sufficient digestible DM to provide a positive energy balance while all other forages were deficient in energy. Nitrogen concentration of northern wheatgrass and western wheatgrass was sufficient while that of all other grasses was inadequate.

Calcium concentration for all species would meet the dietary requirement of 3.4 g kg^{-1}. Phosphorus concentration of all species except mammoth wildrye was adequate to meet the requirement for 1.2 g kg^{-1}.

Most native grasses evaluated in these trials had inadequate energy and protein for non-lactating, pregnant beef cows grazing in October through December (National Research Council 2000). However, diet selection by grazing animals can result in forage quality of an animal's diet becoming significantly better than that measured on the total sward offered for grazing. Buxton (1996) recommended N fertilization of warm-season grasses to improve their protein concentration for grazing. However, N fertilization is economically risky in water-limited environments where forage yield is primarily controlled by soil water. Low protein of warm-season grasses in Kansas was alleviated by feeding nonprotein N (NPN) supplements (Löest et al. 2002).

Prediction of Digestibility by ADF

The power of regression equations for prediction of IVOMD by ADF can be determined by the proximity of the R^2 value to 1.0. The R^2 values for the grass species in this study range from 0.12 to 0.58 (Table 6). These R^2 values are low, but they are also consistent with those reported for introduced grass species (Van Soest 1982). Van Soest (1982) suggested that the power of prediction or R^2 value of this relationship can be improved by including data from more sites and years of trials. Our study had a large number of site-years for all species, particularly for prairie sand reed and western wheatgrass where we studied two cultivars, and yet we still observed low R^2 values for this relationship. A more robust relationship may be generated by including samples from immature forage (Buxton 1996).

These results suggest that fiber digestibility of these species varies at similar fiber concentrations. For example, northern wheatgrass and green needlegrass had similar ADF concentrations (395 and 397 g kg^{-1}) but differed in IVOMD by 29 g kg^{-1} (Table 2). We conclude that ADF was not a good predictor of forage digestibility for these stockpiled grass species that are harvested at the end of their growing season.

CONCLUSIONS

Forage quality of stockpiled, re-seeded native grass species indicated that western wheatgrass will have sufficient energy, protein and minerals to meet the dietary requirements of non-lactating pregnant beef cows post-weaning in the early fall. Other native grasses will require energy and protein supplementation to support this class of animal during this period. We did not observe forage quality values that support the often cited concept that native grasses "cure-on-the-stem" to provide adequate nutrition in the fall for dry, pregnant beef cows. This concept may in fact, be confounded by diet selection and grazing behavior of the animals during this period.

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