Winter weathering effects on corn grown for grazing in a short-season area

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Baron, V. S., Najda, H. G., McCartney, D. H., Bjorge, M. and Lastiwka, G. W. 2003. **Winter weathering effects on corn grown for grazing in a short-season area**. Can. J. Plant Sci. **83**: 333–341. Winter grazing can reduce over-winter feeding costs of beef cows and, recently, the selection and marketing of corn (*Zea mays* L.) varieties for grazing has increased the interest of Alberta beef producers. The objective of this study was to compare grazing corn varieties with early conventional corn hybrids for winter grazing potential. Five corn varieties (one grazing, one short-stature and three conventional types) were compared for whole-plant yield and forage quality at Lacombe and Brooks, AB, at four harvest times (two in September, one in December and one in January), in each of 2 yr. Forage quality analyses were in vitro digestible organic matter (IVDOM), neutral (NDF) and acid detergent fiber (ADF) and crude protein concentration. Averaged over varieties and years, yield decreased ($P \leq 0.05$) by 13% between September and January at Lacombe, and by 39 and 16% at Brooks in 1999 and 2000, respectively. At Brooks, yield losses from September to January, averaged over years were 38 to 18% for a grazing and a conventional variety, respectively. At Lacombe, IVDOM concentration declined ($P \leq 0.05$) by 6.3 and 3.6% between September and January during 1999 and 2000, respectively; NDF concentration increased ($P \leq 0.05$) by 10% over the same interval for both years. At Lacombe there were no differences among varieties for nutritive value by January harvests. Trends for reduced forage quality with harvest were not clear at Brooks but the grazing-type variety had higher ($P \leq 0.05$) NDF and ADF concentrations than the other varieties after the first harvest. In general, projected energy and crude protein concentrations of corn during winter exceeded minimum requirements and were adequate, respectively, for non-lactating, pregnant beef cows. Grazing and short stature corn varieties were not superior to early conventional corn genotypes for winter grazing potential. Thus, choice of variety for winter grazing should be made on the basis of cost of production and early maturity.

Key words: Weathering, corn, *Zea mays* L., nutritive value, yield loss, winter grazing potential

Baron, V. S., Najda, H. G., McCartney, D. H., Bjorge, M. et Lastiwka, G. W. 2003. **Effets de l'hiver sur le maïs destiné à la paissance dans les régions à courte période végétative**. Can. J. Plant Sci. **83**: 333–341. En hiver, on peut réduire le coût d'engraissement des vaches de boucherie en les amenant paître. La sélection et la mise en marché récentes de variétés de maïs (*Zea mays* L.) pour la paissance a éveillé l'intérêt des producteurs de bœuf de l'Alberta. L'étude devait comparer le potentiel de paissance hivernal de ces variétés à celui d'hybrides ordinaires. Les auteurs ont comparé le rendement global de la plante et la qualité du fourrage de cinq variétés (une destinée à la paissance, une naine et trois ordinaires) à Lacombe et à Brooks (Alberta) pendant deux ans, à quatre périodes de récolte (deux en septembre, une en décembre et la dernière en janvier). Pour déterminer la qualité du fourrage, ils ont dosé la concentration de matière organique digestible *in vitro* (IVDOM), la quantité de fibres au détergent neutre (NDF) et acide (ADF) et la teneur en protéines. Une fois la moyenne pour les variétés et les deux années établie, on constate que le rendement a diminué ($P \leq 0,05$) de 13 % entre septembre et janvier à Lacombe, contre 39 % et 16 % en 1999 et 2000, respectivement, à Brooks. Après calcul de la moyenne pour les deux années, les baisses de rendement observées à Brooks de septembre à janvier variaient de 38 % à 18 % pour la variété de paissance et les variétés ordinaires, respectivement. À Lacombe, les auteurs rapportent une diminution ($P \leq 0,05$) de 6,3 % et de 3,6 % de l'IVDOM, de septembre à janvier, en 1999 et en 2000, respectivement; la concentration de NDF, en revanche, avait augmenté ($P \leq 0,05$) de 10 % durant le même intervalle, chaque année. À Lacombe, les diverses variétés avaient la même valeur nutritive à leur récolte, en janvier. À Brooks, la détérioration de la qualité fourragère selon le moment de la récolte n'est pas claire, mais la variété destinée à la paissance présentait une plus forte concentration ($P \leq 0,05$) de NDF et de ADF que les autres variétés après la première coupe. Dans l'ensemble, la quantité d'énergie et de protéines brutes prévue pour le maïs en hiver dépassait les exigences minimales et était suffisante, respectivement, pour les vaches de boucherie gravides, non en lactation. Le maïs de paissance et le maïs nain ne sont pas meilleurs que les variétés hâtives ordinaires en ce qui concerne le potentiel de paissance hivernal. On devrait donc choisir les variétés que les animaux paîtront en hiver d'après les coûts de production et la précocité.

Mots clés: Intempéries, maïs, *Zea mays* L., valeur nutritive, baisse de rendement, potentiel de paissance hivernal

Grazing beef cows during late fall and winter is of interest to producers because savings can be made through reduced harvesting, hauling, and feeding conserved forage, and manure removal. Improving body condition (subcutaneous fat deposition) of cows in fall and early winter (Adams et al.

Abbreviations: **ADF**, acid detergent fiber; **CHU,** corn heat units; **IVDOM**, in vitro digestible organic matter; **NDF**, neutral detergent fiber

1986) can make additional savings in winter feed requirements. In southern Alberta, Willms et al. (1993) observed that beef cows grazing annual forages (winter wheat and standing corn) in the fall had more back-fat and required less feed to maintain condition during winter than cows grazing rough fescue. Savings of $47.00 per animal were realized compared to cows wintered in drylot.

Winter grazing has not been the norm in the Parkland region of the Canadian prairies, and corn has rarely been used as a grazing crop. However, there are reports of corn grazing by beef cows (Willms et al. 1993) in the southern prairies. Corn residue is commonly used as a winter feed for beef cows where corn is adapted (Wedin and Klopfenstein 1995). Whole-plant corn and corn residues have nutritional and physical characteristics suitable for grazing cows in winter. Both energy and protein levels of residues (Gutierrez-Ornelas and Klopfenstein 1991) and whole-plant corn (Willms et al. 1993) should be adequate for non-lactating cows [National Research Council (NRC) 1996]. Corn plants are tall and may stand above snow, allowing cows to graze in the presence of snow, which could be a problem for alternative species such as perennial grasses (Willms et al. 1993).

Recent marketing of specialty corn varieties in western Canada has increased interest in grazing corn (Anonymous 2000; Lyseng 2000). Additionally, a combination of the availability of very early, conventionally bred corn hybrids with accumulated corn heat unit (CHU) maturity rating of 2000 to 2250, and warmer than normal temperatures during the past few years has allowed reasonable corn silage production (Aasen 2001, personal communication) in cooler regions (less than 2200 CHU). Mean seasonal CHU accumulation from 1993 to 1998 was 2370 at Lacombe Research Centre (Baron, unpublished data). The specialty corn varieties are Amaizing Graze and Canamaize. Canamaize is a short-stature variety, developed in Canada and adapted to the southern prairies (2100 CHU rating). Its use is appealing, because it can be planted with conventional small-grain equipment (Lyseng 2000). However, there is little information regarding forage yield and quality since it was initially intended for grain production. Amaizing Graze was bred specifically for, and is adapted to, grazing in regions with growing conditions similar to the USA Corn Belt. Farmer testimonials indicate very high carrying capacities for wintering beef cows grazing Amaizing Graze (Anonymous 2000).

Information needed to choose corn varieties for winter grazing in the Parkland area of Alberta is lacking. Dry matter yield, nutritive value and decline in yield and nutritive value due to weather (frost, rain, snow and wind) during fall and winter, should be considered, as well as cost of seed, planting and weed control. Yield and quality of standing corn throughout winter are important, because stover and grain covered by snow may be inaccessible. In studies from other regions, losses of whole-plant corn dry matter have ranged from 50 to 70% (Lamm and Ward 1981; Willms et al. 1993). Losses for whole-plant digestibility during fall (August to mid-October) were minimal, but large losses of stalk and leaves occurred when harvest was delayed into November in New Brunswick (Calder et al. 1977).

Our hypothesis was that there are no differences for winter grazing potential among corn hybrids available to producers in Alberta. The objective of this study was to compare specialty corn varieties with conventionally bred, short-season corn genotypes for whole-plant yield, nutritive value and weathering loss.

MATERIALS AND METHODS

Research sites were established on a Black Orthic Chernozem loamy soil at Lacombe, AB (52°28′N; 113°45′W; 847 m) and on a Brown Orthic Chernozem silt loam soil at Brooks, AB (50°33′N; 111°51′W; 747 m) in 1999 and 2000. Five corn varieties were randomized in plots, 6 m by 6 m, within each of three replicates at each site. Varieties used were Pioneer 39K72, 39N03, and 39T68 from Pioneer Hi-Bred Ltd., Chatham, ON, which were rated at 2150, 2000 and 2250 CHU maturity, respectively; Amaizing Graze 101 from Baldridge Hybrids, Cherry Fork, OH, with no maturity rating; and Canamaize from Canamaize Seed Inc., Minto, MB, with a 2100 CHU rating. Plots consisted of 16 rows for Canamaize and eight rows for the other varieties. All varieties, except Canamaize, were hand-planted in 76-cm rows and thinned to 75 000 plants ha^{-1}. Canamaize was hand-planted in 38-cm rows and thinned to 150 000 plants ha^{-1}. Canamaize is a short-stature variety. The seed producer and distributor recommended planting at relatively high populations and in narrower rows than conventional varieties (Lyseng 2000). Thinning occurred at the six-leaf stage. Corn was planted on 5 May in both 1999 and 2000 at Lacombe and 28 May and 9 May at Brooks in 1999 and 2000, respectively. Prior to planting fertilizer-N (200 kg ha^{-1}), P_2O_5 and K_2O (40 kg ha^{-1}), were broadcast and worked in. Weeds were controlled chemically using Laddock {(bentazon [3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] and atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine]} post emergence at a rate of 3.2 l ha^{-1}, and hand-weeded so that plots were weed-free. Irrigation water, 100 mm in 1999 and 275 mm in 2000, was applied at the Brooks location.

Four harvests were randomly assigned to even-numbered rows. Two harvests were taken from one of these rows as sufficient plants per row allowed all plants to be guarded. All locations were randomly assigned. Corn was harvested on 10 and 28 September, 14 December, and 20 January at Lacombe in 1999/2000 and on 14 and 28 September, 14 December and 17 January at Lacombe in 2000/2001. Harvest dates at Brooks were 15 and 30 September, 13 December and 13 January in 1999/2000 and 14 and 28 September, 18 December and 15 January in 2000/2001. The harvests in September were designed to ensure one harvest before and one just after the first killing frost. At each harvest eight plants were removed at ground level. If ears were present, plants were separated into stover and ear components and each weighed fresh. Three plants were sub-sampled for stover and five for ears. These sub-samples were chopped mechanically and a portion of each retained to be weighed fresh and after drying for 96 h at 50°C. Sub-samples were used to determine dry matter percentage of respective components and saved for subsequent forage

Table 1. Monthly and long-term average monthly precipitation and monthly mean and long-term monthly temperature at Lacombe and Brooks, AB from May to January during 1999, 2000 and 2001

	Monthly precipitation				Monthly mean temperature			
	1999	2000	2001	Avg.[z]	1999	2000	2001	Avg.
Month	(mm)				(°C)			
				Lacombe				
January	44.0	12.9	2.1	19.1	–13.0	–13.2	–4.0	–13.8
May	61.4	50.2	42.4	50.2	8.6	8.7	10.5	9.9
June	71.0	106.8	91.0	82.3	12.5	12.8	12.9	13.6
July	190.6	149.0	122.6	79.8	13.9	16.3	15.9	16.1
August	71.2	66.4	23.0	65.0	15.4	14.4	16.4	14.9
September	4.0	26.0	12.8	41.8	9.9	9.5	11.8	11.9
October	5.6	6.8	9.9	20.2	4.6	4.2	3.3	4.5
November	9.7	3.2	18.5	17.0	–2.0	–4.6	–1.8	–4.5
December	0.4	6.5	2.4	17.0	–3.2	–12.9	–11.6	–10.8
Total	457.9	427.8	324.7	392.4				
				Brooks				
January	7.6	2.4	4.4	18.4	–11.5	–11.4	–3.7	–12.5
May	39.8	12.8	9.4	39.1	10.1	11.3	13.1	11.4
June	115	28.6	43.6	65.5	14.3	15.1	15.5	15.9
July	110.2	3.4	13.8	38.1	16.2	20.2	19.8	18.4
August	47.2	31.4	1.4	36.4	18.2	18.3	20.0	17.5
September	2.4	24.4	16.6	38.8	11.8	11.8	14.2	11.6
October	5.2	4.8	8.4	16	6.8	6.4	5.2	6.4
November	5.6	2.2	9.4	14.9	2.6	–5.0	1.6	–3.7
December	5.4	1.8	2.0	18.3	–1.0	–12.2	9.7	–10.3
Total	338.4	111.6	109.0	285.5				

[z]Average of 93 yr at Lacombe and 33 yr at Brooks.

quality assays. Yields of ear and stover were calculated, and then added to determine whole-plant dry matter yield.

Forage Quality Assays

Dried subsamples of stover and ear were ground, first through a Wiley mill (Model no. 4; Arthur H. Thomas Co., Philadelphia, PA) equipped with a 2-mm screen and then through a Cyclone mill (Model MS; UD Corporation, Boulder, CO) using a 1.0-mm screen, prior to quality determinations. The samples were analyzed for total N with a Leco Carbon and Nitrogen Determinator (Model CN 2000, Leco Corp., St. Joseph, MI).

Crude protein concentration was calculated as 6.25 × N concentration. In vitro digestible organic matter concentration was measured with direct acidification during a 24-h second-stage pepsin digestion (Marten and Barnes 1980). Neutral detergent fiber and ADF concentrations were determined following the method of Van Soest and Robertson (1980). After values were obtained on a dry matter basis for stover and ear components, a weighted concentration based on a percentage of respective components was determined for the whole-plant.

Statistical Analyses

Data from the two locations were separated because of the prevalence of significant ($P \le 0.05$) year × location × variety × harvest interactions after preliminary ANOVA. Data presented were subjected to ANOVA using the SAS GLM procedure (SAS Institute, Inc. 1989) in a split plot arrangement for data taken over time in an experimental layout for annual crops (Gomez and Gomez 1983). Year was the main-plot, with variety and harvest sub-plots, tested with different error terms. A summary for levels of significance from *F*-tests is shown in Table 2. Where the *F*-test indicated a significant effect ($P \le 0.05$) means were separated with LSD ($P = 0.05$) using error terms as indicated by Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Climate and Maturity

Mean monthly temperatures were below average at both locations during 1999 and near normal during 2000 (Table 1). This was reflected in CHU accumulation. Corn heat unit accumulation from planting until first killing frost (–2°C) were 1784 at Lacombe and 2036 at Brooks in 1999. Comparable figures for 2000 were 1949 at Lacombe and 2311 at Brooks. Long-term average CHU accumulation at Lacombe and Brooks are 1860 and 2350, respectively. Delayed planting because of cold wet weather at Brooks in 1999 reduced heat unit accumulation. A frost (–2.5°C) on 9 June at Lacombe caused spot damage. Killing frosts (< –2.0°C) occurred at both locations before the second harvest. Fall frosts occurred at Lacombe on 25 and 23 September in 1999 and 2000, respectively, and at Brooks on 19 and 22 September in 1999 and 2000, respectively. Soil moisture was never limiting at either location. To relate CHU accumulation to other thermal unit maturity rating systems see Dwyer et al. (1999).

Silking occurred during mid-to-late August at both locations in 1999, except for Amaizing Graze, which did not silk at either location. The earliest of varieties (Canamaize and Pioneer 39N03) reached Growth Stage 7 (Hanway 1963), but very little kernel formation occurred beyond Growth Stage 6 for Pioneer 39K72 and Pioneer 39T68. Because silking occurred in late July at Brooks in 2000, corn (except Amaizing Graze) was in the early stages of kernel filling

Table 2. Significance of sources of variability for corn grown for grazing at Lacombe and Brooks, AB, harvested at four times and during 2 yr

Source	Dependent variable					
	Yield	% ear	IVDOM[z]	NDF	ADF	Protein
			Lacombe			
Year	**	NS	**	**	NS	NS
Replicate	NS	NS	NS	NS	NS	NS
$Error_a$						
Harvest	**	**	**	**	**	**
Year × harvest	NS	NS	**	NS	NS	**
$Error_b$						
Variety	**	**	**	**	**	**
Year × variety	NS	*	NS	NS	NS	NS
Harvest × variety	NS	**	NS	NS	NS	*
Year × harvest × variety	NS	**	NS	NS	*	**
$Error_c$						
			Brooks			
Year	NS	**	**	*	NS	NS
Replicate	NS	NS	NS	NS	NS	NS
$Error_a$						
Harvest	**	**	**	*	*	**
Year × harvest	**	**	NS	**	**	NS
$Error_b$						
Variety	**	**	NS	**	**	*
Year × variety	NS	NS	NS	NS	NS	**
Harvest × variety	*	**	*	**	**	**
Year × harvest × variety	NS	**	*	NS	**	**
$Error_c$						

[z]IVDOM, in vitro digestible organic matter; NDF, neutral detergent fiber; ADF, acid detergent fiber; protein, crude protein.
**, *, Significant at $P < 0.05$ and $P < 0.01$, repectively; NS, not significant ($P > 0.05$).

Table 3. Two-year mean whole-plant dry matter yield of corn varieties grown for grazing at Lacombe and Brooks, AB, harvested four times during the fall and winter

Variety	Harvest date[z]				
	Mid Sept.	Late Sept.	December (t ha^{-1})	January	Mean
			Lacombe		
Pioneer 39K72	9.76	10.25	8.24	8.40	9.04
Pioneer 39N03	8.19	9.56	7.35	6.50	7.60
Pioneer 39T68	9.51	9.79	8.46	8.72	9.10
Amaizing Graze	11.22	9.34	8.55	9.25	9.59
Canamaize	7.95	7.88	6.42	7.52	7.55
Mean	9.30	9.40	7.70	8.20	8.83
LSD1[y]			1.66		
LSD2			0.84		
			Brooks		
Pioneer 39K72	13.36	13.44	10.07	9.69	11.64
Pioneer 39N03	10.67	11.85	9.15	8.37	10.01
Pioneer 39T68	12.65	14.00	11.93	11.50	12.52
Amaizing Graze	9.64	12.15	7.53	7.73	9.26
Canamaize	9.78	9.93	7.95	7.72	8.85
Mean	11.58	12.86	9.67	9.32	10.86
LSD1[x]			1.66		
LSD2			1.70		

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 December, and 20 January; Lacombe 2000 were on 14 and 28 September, 14 December and 17 January; Harvests for Brooks 1999 were on 15 and 30 September, 13 December and 13 January; Brooks 2000 were on 14 and 28 September, 18 December and 15 January.
[y]LSD1 is difference ($P \leq 0.05$) between two variety means, within Lacombe, averaged over harvest dates and years. LSD2 is difference ($P \leq 0.05$) between two harvest date means, for Lacombe, averaged over varieties and years.
[x]LSD1 is difference ($P \leq 0.05$) between two means within harvest dates (columns) for Brooks. LSD2 is difference ($P \leq 0.05$) between two means within variety (rows) for Brooks.

(Growth Stage 7). At Lacombe, it was between Stages 6 and 7. Whether stage of maturity is important to grazing corn is debatable because there are no storage implications as there are for silage (Daynard 1978).

Whole-plant Yield and Yield Components

At Lacombe, whole-plant yields averaged over varieties decreased ($P \leq 0.05$) from September to December and January harvests. At Lacombe whole-plant yield was simi-

Table 4. Percent ear of corn grown for grazing at Lacombe and Brooks, AB, for 2 yr and harvested four times during fall and winter

	Lacombe harvests[z]					Brooks harvests[z]				
	Mid Sept.	Late Sept.	December	January	Mean	Mid Sept.	Late Sept.	December	January	Mean
						1999				
Pioneer 39K72	19	29	24	22	24	28	46	42	44	40
Pioneer 39N03	18	31	30	23	26	35	54	52	51	48
Pioneer 39T68	18	27	34	28	27	27	38	45	46	39
Amaizing Graze	5	2	1	2	2	0	2	0	0	1
Canamaize	34	48	32	16	32	41	55	40	40	44
Mean	19	27	24	18	22	26	39	36	37	34
						2000				
Pioneer 39K72	19	17	20	24	20	53	59	64	60	59
Pioneer 39N03	31	37	26	31	31	59	62	57	60	59
Pioneer 39T68	19	30	20	29	24	51	55	58	55	55
Amaizing Graze	0	3	0	1	1	0	10	12	12	8
Canamaize	29	35	27	29	30	63	66	66	65	65
Mean	20	22	21	23	22	47	50	50	52	50
LSD1[y]			8					7		
LSD2			7					6		

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 December , 20 January; Lacombe 2000 were on 14 and 28 September, 14 December and 17 January.
[y]LSD1 is difference ($P \leq 0.05$) between two means within columns and years.
LSD2 is difference ($P \leq 0.05$) between two means within rows and locations.

lar ($P > 0.05$) for the first two harvests in September (Table 3), then decreased ($P \leq 0.05$) by about 13% from the second harvest in September until the fourth harvest in January, averaged over both years and varieties. At Lacombe, corn varieties were not impacted differently by weathering in either year. Amaizing Graze yielded more than Canamaize and Pioneer 39N03, but not more than Pioneer 39K72 and Pioneer 39T68, averaged over harvests and years (Table 3).

Yield of corn varieties was affected differently ($P \leq 0.05$) by weathering from September to January at Brooks. Generally, whole-plant yield increased, but not always significantly ($P \leq 0.05$), from the first to second September harvest (Table 3). Then, significant ($P \leq 0.05$) decreases for yield occurred for all varieties between September and December due to weathering. Pioneer 39T68 was highest yielding in late September, with Canamaize lowest; others were intermediate. By January, rankings among varieties had changed. Pioneer 39T68 was significantly ($P \leq 0.05$) higher than the others, but Amaizing Graze had moved from the intermediate group to the low-yielding group. Weathering losses of whole-plant yield as a percentage of the second September harvest ranged from a high of 38% for Amaizing Graze to a low of 18% for Pioneer 39T68, averaged over years. Loss of material from Amaizing Graze was not due to lodging, but due to leaf loss from wind. Lodging (root or stalk lodging) was not prevalent at either location or year.

Yield-loss varied with year and harvest at Brooks, when averaged over varieties (Table 2). At Brooks, in 1999, yield decreased by 39% from late September to January. In 2000, yield at Brooks decreased by 16% from first to last harvest, so that losses were more in line with yield-loss at Lacombe.

It appears that specialty corn varieties were not higher yielding than conventional corn hybrids during September, and weathering losses up to January were at least as high for the specialty types as for conventional types. Whole-plant yield of all varieties was limited by lack of accumulated CHU. Later varieties (maturity is rated for grain maturity) may have a higher whole-plant yield potential than early varieties (Daynard 1978). However, in cool environments (e.g., central and southern Alberta) the advantage for later over earlier varieties diminishes, because time of maximum whole-plant yield and grain maturity converge (Daynard 1978; LeDrew et al. 1984). Amaizing Graze appeared as susceptible to yield-loss due to weathering as other varieties. It is beyond the scope of this study to determine the origin of losses due to weathering. However, visual observations of physical damage to leaves suggested that this was the primary cause of dry matter losses. Precipitation from snowfall was less than 50% of normal during November, December and January (Table 1). Larger losses might have occurred under normal snowfall conditions. Also, losses of dry matter as indicated in the present study are only due to weathering and do not include waste that may occur under actual grazing.

At Lacombe and Brooks, in both years, Amaizing Graze had the lowest percentage ear of whole-plant dry matter at all harvests (Table 4). Canamaize had a higher proportion of ears than the Pioneer hybrids for the September harvests at Lacombe in 1999. Between September and December, Canamaize lost more ear material than the other genotypes and was similar ($P > 0.05$) for ear content to Pioneer 39T68 and 39N03. By January Pioneer 39T68 had a higher proportion of ears than Amaizing Graze. The other Pioneer hybrids were intermediate between Pioneer 39T68 and Canamaize. In 2000 at Lacombe, ear content maximized at the second harvest, with Canamaize, Pioneer 39NO3 and 39T68 having similar and higher ear content than Pioneer 39K72 and Amaizing Graze. Ear content of the former varieties decreased significantly between September and December.

Table 5. In vitro digestible organic matter (IVDOM) concentration of corn varieties grown for grazing at Lacombe and Brooks, AB, for 2 yr and harvested four times during fall and winter

	Lacombe harvests[z]					Brooks harvests[z]				
	Mid Sept.	Late Sept.	December	January	Mean	Mid Sept.	Late Sept.	December	January	Mean
	($g\ kg^{-1}$)									
1999										
Pioneer 39K72	662	714	623	621	655	684	640	652	603	645
Pioneer 39N03	671	723	596	614	651	666	681	628	603	644
Pioneer 39T68	613	695	613	592	628	706	661	632	542	635
Amaizing Graze	686	644	640	650	655	681	617	613	605	629
Canamaize	717	720	637	612	672	724	558	619	606	627
Mean	670	699	622	618	652	692	631	629	592	636
2000										
Pioneer 39K72	738	692	696	694	705	750	785	745	720	750
Pioneer 39N03	741	725	717	714	724	725	748	731	736	735
Pioneer 39T68	701	707	678	710	699	724	764	731	752	743
Amaizing Graze	718	743	691	691	711	737	616	619	667	660
Canamaize	759	762	724	720	741	749	748	760	695	738
Mean	731	726	701	706	716	737	732	0717	714	725
LSD1[y]	27									
LSD2						43				
LSD3						81				

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 December, and 20 January; Lacombe 2000 were on 14 and 28 September, 14 and 17 December.
[y]LSD1 is difference ($P \le 0.05$) between two harvest means, averaged over variety in each year at Lacombe.
LSD2 is difference ($P \le 0.05$) between two harvest means within varieties at Brooks.
LSD3 is difference ($P \le 0.05$) between two variety means within harvest dates at Brooks.

All except Amaizing Graze were similar for ear proportion again in January.

At Brooks ear content tended to maximize at the second harvest in September in 1999, but was as high at the first as second harvests in 2000 (Table 4). Generally, ear content remained more consistent between harvests from September to January at Brooks than at Lacombe. Again, Canamaize and Pioneer 39NO3 were among the highest for ear content by the second September harvest. In 1999, Canamaize decreased in ear content between September and December, but not in 2000. Ears of Canamaize are relatively higher in the canopy than the Pioneer varieties. This may make Canamaize-ears more susceptible to weathering and predation by birds during winter.

Nutritive Value and Loss of Nutritive Value

In vitro digestible organic matter concentration decreased significantly ($P \le 0.05$) from first to last harvest in both years at Lacombe, averaged over varieties (Table 5). Values for IVDOM were greater in 2000 than in 1999. Also, the percentage IVDOM loss over harvests was greater in 1999 than in 2000. By January, IVDOM had declined by about 52 $g\ kg^{-1}$ in 1999 compared to about 25 $g\ kg^{-1}$ in 2000. Averaged over years and harvests, IVDOM concentrations of early maturing Canamaize (707 $g\ kg^{-1}$) and Pioneer 39N03 (680 $g\ kg^{-1}$) were significantly ($P \le 0.05$) greater than Pioneer 39T68 (664 $g\ kg^{-1}$) at Lacombe; Pioneer 39K72 and Amaizing Graze were intermediate (LSD = 23 $g\ kg^{-1}$ between varieties).

There was a general, but not necessarily significant ($P \le 0.05$) decline in IVDOM concentration due to weathering for corn varieties at Brooks in 1999 (Table 5). In 1999, rapid decline in IVDOM occurred for Amaizing Graze and Canamaize between first and second harvests in September. However, by December and January in 1999, there was almost no difference among varieties for IVDOM. Smaller losses in IVDOM among varieties were evident at Brooks in 2000. By January, 2000, Amaizing Graze was lowest for IVDOM, Pioneer 39T68 highest, and the others intermediate.

Neutral detergent fiber concentration increased significantly ($P \le 0.05$) from September to December and January harvests at Lacombe, averaged over years and varieties (Table 6). Concentrations of NDF increased about 10% due to weathering by January. At Lacombe, averaged over harvests and years, Pioneer 39N03 had significantly lower NDF than Amaizing Graze and Pioneer 39K72; others were intermediate. At Brooks the trend for high NDF with later harvest was not as pronounced as at Lacombe. Averaged over years there was some variation for NDF among varieties and harvests, but the most pronounced difference was the increase in NDF concentration for Amaizing Graze between first and second harvest. Concentration of NDF for Amaizing Graze ranged from 469 to 658 $g\ kg^{-1}$ compared to 433 to 512 $g\ kg^{-1}$ among all other harvests and varieties. This may be related to the very low ear content of Amaizing Graze. The general increases in NDF concentration with harvest may have been (in part) due to leaching of cell-solubles from corn leaves and stalks after frost. This aspect of weathering is described for stockpiled perennial grasses, after frost by Burns and Chamblee (2000).

Acid detergent fiber concentration varied among years, varieties and harvests (Table 7). Increase in ADF with harvest was not as pronounced as the increase in NDF or decrease in IVDOM. At Lacombe there was a tendency for varieties with greater ear formation (e.g., Canamaize) to have lower ADF values at September harvests. Generally, this difference had disappeared by January. At Brooks

Table 6. Two-year mean whole-plant neutral detergent fiber concentrations for corn varieties grown for grazing at Lacombe and Brooks, AB, harvested four times during the fall and winter

Variety	Mid Sept.	Late Sept.	December	January	Mean
			Harvest date[z] ($g\ kg^{-1}$)		
			Lacombe		
Pioneer 39K72	562	547	602	602	578
Pioneer 39N03	503	497	556	570	532
Pioneer 39T68	546	518	604	558	556
Amaizing Graze	514	502	636	598	562
Canamaize	556	556	630	600	586
Mean	536	524	606	586	563
LSD1[y]			23		
LSD2			35		
			Brooks		
Pioneer 39K72	492	506	485	484	492
Pioneer 39N03	461	458	493	433	461
Pioneer 39T68	463	436	471	459	457
Amaizing Graze	469	658	585	604	579
Canamaize	477	447	497	512	483
Mean	472	501	506	498	494
LSD1[x]			58		
LSD2			57		

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 Decemb\er, and 20 January; Lacombe 2000 were on 14 and 28 September, 14 December and 17 January; Harvests for Brooks 1999 were on 15 and 30 September, 13 December and 13 Janember; Brooks 2000 were on 14 and 28 September, 18 December and 15 January.
[y]LSD1 is difference ($P \leq 0.05$) between two harvest means, averaged over varieties and years at Lacombe. LSD2 is difference ($P \leq 0.05$) between two variety means, averaged over harvests and years at Lacombe.
[x]LSD1 is difference ($P \leq 0.05$) between two variety means within columns at Brooks. LSD2 is difference ($P \leq 0.05$) between two harvest means within rows at Brooks.

Table 7. Acid detergent fiber (ADF) concentration of corn varieties grown for grazing at Lacombe and Brooks, AB, for 2 yr and harvested four times during fall and winter

	Lacombe harvests[z]					Brooks harvests[z]				
	Mid Sept.	Late Sept.	December	January	Mean	Mid Sept.	Late Sept.	December	January	Mean
					($g\ kg^{-1}$)					
					1999					
Pioneer 39K72	326	290	335	321	318	287	274	274	277	278
Pioneer 39N03	295	264	288	319	292	266	274	253	255	262
Pioneer 39T68	342	282	314	329	317	262	237	270	268	259
Amaizing Graze	321	348	352	342	341	320	369	368	358	354
Canamaize	259	240	336	341	294	254	199	288	318	265
Mean	309	285	325	330	312	278	271	291	295	284
					2000					
Pioneer 39K72	316	327	364	340	337	255	231	215	249	238
Pioneer 39N03	296	306	320	327	312	229	252	219	251	238
Pioneer 39T68	311	300	340	326	316	267	248	239	244	250
Amaizing Graze	334	294	396	383	352	247	414	370	345	344
Canamaize	278	279	277	364	300	238	263	215	231	237
Mean	307	301	339	348	324	250	286	261	272	267
LSD1[y]			48					56		
LSD2			50					54		

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 December, and 20 January; Lacombe 2000 were on 14 and 28 September, 14 December and 17 January.
[y]LSD1 is difference ($P \leq 0.05$) between two means within columns and years.
LSD2 is difference ($P \leq 0.05$) between two means within rows and locations.

minor variation among varieties occurred with later harvests, but the major trend was that ADF was larger for Amaizing Graze than the other varieties after the first harvest.

Coors et al. (1997) observed that as grain content of corn increased, in vitro true digestibility increased slightly and NDF concentration decreased. A slightly higher grain content may have improved nutritive value for some varieties over others and may have played a role in resistance to weathering. Lamm and Ward (1981) found that weathering did not affect nutritive value of grain, but IVDOM concentration decreased 20% in stalks and 28% in leaves and husks; NDF increased 18 and 15% and ADF 18 and 14% in the respective components of corn residue. In the present

Table 8. Crude protein concentration of corn varieties grown for grazing at Lacombe and Brooks, AB, for 2 yr and harvested four times during fall and winter

	Lacombe harvests[z]					Brooks harvests[z]				
	Mid Sept.	Late Sept.	December	January	Mean	Mid Sept.	Late Sept.	December	January	Mean
	($g\ kg^{-1}$)									
1999										
Pioneer 39K72	103	87	86	92	92	89	81	82	83	84
Pioneer 39N03	91	83	84	83	85	82	76	83	79	80
Pioneer 39T68	98	78	78	93	87	88	82	79	79	82
Amaizing Graze	127	93	96	103	105	121	128	85	74	102
Canamaize	111	99	94	88	98	85	64	92	107	87
Mean	106	88	88	92	94	93	86	84	84	87
2000										
Pioneer 39K72	84	79	87	101	88	83	108	97	74	90
Pioneer 39N03	84	74	79	89	82	77	84	89	75	81
Pioneer 39T68	82	78	85	87	83	79	78	73	74	76
Amaizing Graze	98	135	104	104	110	127	44	59	75	76
Canamaize	95	108	93	104	100	81	78	77	85	80
Mean	89	95	90	97	93	89	78	79	77	81
LSD1[y]	13					22				
LSD2	13					18				

[z]Harvests for Lacombe 1999 were on 10 and 28 September, 14 December, and 20 January; Lacombe 2000 were on 14 and 28 September, 14 December and 17January.
[y]LSD1 is difference ($P \leq 0.05$) between two means within columns and years.
LSD2 is difference ($P \leq 0.05$) between two means within rows and locations.

study, grain content was small in all varieties, and Amaizing Graze had no grain development.

Crude protein concentrations varied significantly among years, varieties and harvests at both Lacombe and Brooks (Table 8). Clear cut trends were difficult to find. Amaizing Graze tended to have the highest (not necessarily statistically significant) crude protein concentration at five of eight harvests during September at both locations. However, by January there were usually no varietal differences. Except for the rare occurrence, crude protein concentration was at or above 70 g kg^{-1}, which fulfills the crude protein requirement of a beef cow during early and mid pregnancy (NRC 1996). Thus, nutritionally, the varietal differences in crude protein are of little consequence.

Cow performance while grazing corn during winter can only be estimated from forage quality data shown in this study and is therefore speculative. Calculations from NRC (1996) using overall means of the data indicated that 685-kg cows in mid gestation could satisfy maintenance requirements by consuming 7.5 and 6.0 kg d^{-1} dry matter, at Lacombe and Brooks, respectively. For cows in this physiological stage, lower quantities than this would be required during September when temperatures are warmer and forage quality generally higher, at least at Lacombe. Estimated daily gains approaching 1 kg d^{-1} would be possible if cows consumed to fill. This compares with lower estimated and actual gains by cows (0.25 kg d^{-1}) grazing barley swaths at Lacombe during winter (unpublished), but is in general agreement with the work of Willms et al. (1993). Because these predicted gains are higher than necessary to over winter cows at slightly above maintenance requirements, some form of limit feeding might be economically advantageous from a carrying capacity viewpoint. Modest cow-gains and higher carrying capacity might have to be achieved by managing and limiting daily forage allowance of grazing corn. If corn is to be used effectively, winter grazing studies, in addition to that of Willms et al. (1993), should be carried out to get accurate determinations of grazing efficiency, carrying capacity and effects on cow body condition.

SUMMARY

While some variation existed for whole-plant yield among specialty and conventionally bred corn varieties at these two short season locations, there was no indication that Amaizing Graze and Canamaize offered any yield or yield loss advantage over conventionally bred varieties. In fact, in a short season environment like Lacombe varieties should be as early maturing as possible. At Brooks, where more adapted varieties are available because of a warmer climate than Lacombe, varieties no later than those recommended for grain (i.e., 2300 CHU rating) should be used. Specialty varieties did not minimize losses or provide more nutritious fodder than conventional corn varieties. At Brooks Amaizing Graze was usually one of the lower ranking varieties for nutritive value. In spite of losses in nutritive value and dry matter during winter, levels of energy (as indicated by ADF values) and crude protein for all corn varieties and locations were more than adequate to maintain or provide gains for cows in mid and late pregnancy under normal winter conditions. The decision to use a particular variety should be made on the basis of which one provides the cheapest source of digestible dry matter.

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