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Spring Triticale Varieties Forage Yield, Nutrients Composition and Suitability for Beef Cattle Production

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Abstract

The objective was to explore the potentials of five spring triticale (x*Triticosecale* Wittmack) varieties (AC Ultima, Bunker, Companion, Pronghorn, Taza and Tyndal) for integration into beef cattle feeding systems in the north western Alberta, Canada. This was carried out over four growing seasons (2009 to 2012) at different sites, using RCBD in each year. The crop was cut at late milk stage to determine the silage (SY), dry matter (DMY) and protein (CPY) yields, and nutrition quality. The mean DMY was similar ($P > 0.05$) for all varieties, ranging from 8.14 to 8.53 t ha^{-1}. The forage DM was higher ($P < 0.05$) in 2009 and 2012 growing seasons (8.91 and 9.40 t ha^{-1}, respectively) and lower in 2010 growing season (5.93 t ha^{-1}) than in 2011 (8.33 t ha^{-1}). The forage nutritive values revealed that tested varieties have potentials in terms of protein (7.72-8.32%) and some macro (particularly Ca & K) and micro (especially Fe & Mn) mineral elements and energy contents (62.1-64.1% TDN, 1.51-1.57 Mcal kg^{-1} ME) for pregnant cows that are in the second and third trimester stages. Levels of relative feed value (RFV) was high (110-121) and more than the minimum suggested RFV for mature beef cattle. But levels of P, Mg, Na, S, Cu and Zn were insufficient to meet the suggested amounts needed by a dry gestating cow. The growing seasons appeared to have significant ($P < 0.05$) effects on most of the measured parameters. The implications of these findings on uses of triticale forage in ruminant nutrition and the need for more studies are discussed.

Keywords: triticale (x*Triticosecale* Wittmack), varieties, forage yield, nutritional value, beef cattle, Alberta, Canada

1. Introduction

Cereals such as oats (*Avena sativa*), barley (*Hordeum vulgare* L.) and triticale (x*Triticosecale* Wittmack) can provide excellent supplementary forage, options for extending the grazing season and diversity in crop rotations (Aasen et al., 2004). Recent research by Gill et al. (2013a, 2013b) and Omokanye (2014) have identified forage type barley and oat varieties for beef cattle production in northern Alberta, Canada. Government of Alberta (2012) report shows that north western Alberta (Peace River region) has 4.6% of Alberta's cattle and calves, over 200,000 cattle and calves (with beef cattle dominating).

Triticale is a dual-purpose cereal crop and it therefore has the potential to provide economic benefits for both grain and forage based production systems (Igne et al., 2007). The crop can also be used for ethanol or other bio-industrial uses, with some potential for use in food products (Isaacs, 2013). In western Canada, early triticale breeding research programs were focused on developing varieties for high grain yield with drought-tolerant features for marginal wheat-producing lands. But later research programs concentrated on developing improved animal feed and forage varieties for production under a number of diverse environmental conditions (Salmon, 2004). Research in central Alberta showed triticale emerging as a high yielding silage crop (Baron et al., 2000).

Because of its great adaptation capacity, triticale is a good alternative cereal forage crop to barley and oats in Alberta and could make it an excellent choice for livestock producers (ARD, 2001). When grown for forage production in dryland conditions, triticale has the potential to produce around 10 per cent more forage yield than barley and oats and its forage quality lies between barley and oats (ARD, 2001). When compared to general purpose/feed wheat or barley, triticale showed superior yields on marginal lands and in drought conditions (Isaacs, 2013). With these attributes, triticale has seen a rebirth in interest from farmers in western Canada as a means of crop diversification (Salmon, 2004).

Swath grazing is a winter feeding practice for gestating beef cows on the Canadian Prairies. Swath grazing system involves stockpiling forage for later use and several studies have shown that the system is effective in reducing costs (Entz et al., 2002; McCartney et al., 2004; Baron et al., 2014). The system consolidates standing forage so that it can be apprehended and grazed efficiently in a variety of conditions, including under snow in winter. In a swath grazing trial involving triticale, corn and barley (Baron et al., 2014), triticale yielded 15% more than corn, had similar carrying capacity with corn and had higher utilization (83.7%) than corn (74.7%) and barley (71.7%). Omokanye (2014) has reported a gradual increase in the use of triticale in swath grazing/silage as a monocrop or in mixtures with oat and forage pea, for back grounding calves in northern Alberta.

The present study was set up to examine plant growth, forage production, nutrients composition and suitability of different triticale varieties for forage production systems of beef cattle operations in north western Alberta, Canada. A secondary objective was to organize field days to show case new technologies for possible adoption, encourage interaction with farmers, and answer questions about the performance of triticale.

2. Methods

2.1 Experimental Sites

From 2009 to 2012 growing seasons, field experiments were conducted on collaborating farmer's fields that were near High Prairie (2009 & 2011; 55°26′ N, 116°29′ W); Valleyview (2010; 55°04′ N, 117°17′ W) and Debolt (2012; 55°21′48.6″ N, 118°10′18.5″ W) in north western Alberta, Canada. The climate of these sites is subarctic or boreal. This climate is characterized by cold winters and cool to mild summers. Monthly records for the growing seasons as well as the 30-year averages of the selected climatic parameters are provided in Table 1.

Table 1. Spring soil moisture (SSM), rainfall, and air temperature in the crop growing seasons for different years and long-term averages (LTA)

	SSM	May	June	July	Total
SSM and rainfall, mm					
2009 High Prairie	100	33	9	92	234
2010 Valleyview	37	36	17	42	132
2011 High Prairie	35	38	166	83	322
2012 Debolt	50	44	87	60	241
LTA	91	42	84	83	303
Maximum temperature, ^oC					
2009 High Prairie		23.6	27.9	29.1	
2010 Valleyview		26.1	27.7	29.3	
2011 High Prairie		25.4	25.2	24.9	
2012 Debolt		23	24.8	32.1	
LTA		16.5	19.4	21.1	
Minimum temperature, ^oC					
2009 High Prairie		-17.5	-2	1.9	
2010 Valleyview		-7.9	-1.1	3.7	
2011 High Prairie		-1.9	-0.9	5.2	
2012 Debolt		-6.2	3.2	4.6	
LTA		4.1	7.9	8.9	

According to Soil Classification Working Group (1998), soil is Ortho Humic Gleysol, dark colour and sandy to clay loam texture at the High Prairie site; Grey Luvisol, loam to clay loam texture at the Valleyview site; and Dark Grey Luvisol, silty clay texture at the Debolt site. Table 2 shows the properties of surface soils (0-15 cm), analyzed in a commercial laboratory following standard laboratory procedures described by Soil and Plant Analysis Council (1999). More details on the methods used are given in Gill et al. (2013a, 2013b)

Table 2. Soil properties at the experimental sites prior to seeding

Site	OM[z] (%)	pH (Water)	CEC[y] (Meq/100 g)	Bray 1-P[x] (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	NO_3-N (ppm)
High Prairie	7.4	6.4	22.4	12	165	2990	675	17
Valleyview	6.3	5.5	17.2	21	185	1350	295	43
Debolt	4	6.4	14	24	191	2040	255	15

Note. [z]: OM, organic matter; [y]: CEC, cation exchange capacity; [x]: Bray 1-P, Bray-1 method of P test.

2.2 Experimental Design and Data Analyses

The study was laid out in a randomized complete block. There were four replications. The data were subjected to analysis of variance (ANOVA) as a split-plot design, with growing seasons (years) as main plots and the triticale varieties as sub-plots, using the GLM procedure (SAS Version 6, 1990). The means were separated by the least significant difference (LSD) at the 0.05 probability level. Significant differences in the text refer to $P<0.05$. Of the 33 monitored parameters, the ANOVA for only 4 (plant height, SY, DMY and Fe) indicated significant variety × year interactions. Therefore, the data were averaged across the years for the triticale varieties and across the triticale varieties for the years. The significant variety × year interaction effects are discussed in the text. Pearson's correlation coefficients (r) were calculated between selected measured parameters

2.3 Triticale Seeding and Management

Five spring triticale varieties (AC Ultima, Bunker, Pronghorn, Taza and Tyndal) were evaluated in 2009, 2010, 2011 and 2012. These varieties were released in Canada between 1999 and 2010. Bunker, Pronghorn, Tyndal and Ultima were grown in all four years. Taza was only grown in 2011 and 2012. The sites had been harrowed by collaborating farmers. Prior to seeding, glyphosate was sprayed as a pre-seed weed control. Each plot was 1.38 m wide (6 rows at 23 cm spacing) and 10 m long. The plots were later trimmed to 6 m length for harvest. The triticale varieties were seeded at 263 viable seeds m^{-2}, with a 6-row Fabro plot drill on May 23 in 2009, May 16 in 2010, May 20 in 2011, and May 13 in 2012. The drill was equipped with double shoot Atom jet openers, which made it possible to seed and apply fertilizers at the same time. Based on the soil tests carried out before seeding, all plots received equivalent amounts of fertilizer recommendations as shown in Table 3. At seedling stage, plots were sprayed with 1.65 L ha^{-1} Assert A + 2.00 L ha^{-1} Curtail M in 2010 only.

Table 3. Rates of different fertilizer nutrients applied (kg ha^{-1}) in the four years*

Year	N	P	K	S
2009	77	22	56	0
2010	67	10	14	0
2011	56	15	18	34
2012	100	11	17	30

Note. *Combinations of seed row placed (11-52-0) and side banded (46-0-0, 0-0-60, 20-0-0-24) fertilizers were used to apply these nutrient amounts.

2.4 Triticale Growth and Forage Yield Measurements

Each year, the plant stand was visually inspected after 3-4 weeks of seeding to assess adequacy of crop emergence. Each variety was harvested for at late milk stage (Zadok et al., 1974), between late July and early August each year. Prior to harvest, 3 plants per plot were randomly selected and their primary tiller heights measured from ground to top of heads. Also, each plot was examined for plant lodging and any > 50 cm gaps in the crop rows to determine the actual harvest area per plot. For each plot, the above ground parts of plants were harvested and weighed fresh. About 0.5 kg of the fresh harvest was sub-sampled and dried at 50 °C to constant weight to determine the moisture content, silage yield (SY, at 65%), forage dry matter yield (DMY) and nutritive analyses.

2.5 Laboratory Determined Forage Nutritive Values

For forage nutritive indicators (determined using wet chemistry), two dry samples per variety (sample 1 – composite from replications 1 & 2 and sample 2 – composite from replications 3 & 4) were analysed. The dried ground tissue was digested with aqua regia on a hot block digester and the digest analysed by ICP-OES (Western

States Laboratory Proficiency Testing Program, 1997). The forage samples were analyzed for acid detergent fiber-crude protein (ADF-CP), acid detergent fiber (ADF), neutral detergent fiber (NDF)), macro minerals (N, Ca, P, Mg, P, Na, S) and micro minerals (Cu, Mn, Z, Fe). Nitrogen content was measured by Dumas Method (dried, ground tissue combusted with oxygen and analysed by thermal conductivity). Crude protein (CP) was calculated as N × 6.25. The undegradable (insoluble) intake protein (UIP) was determined using NIR. The laboratory feed test results included calculated values of soluble (degradable) protein (Sol-CP) and various forms of energy; total digestible nutrients (TDN), net energy for lactation (NE_L), net energy for maintenance (NE_M), net energy for gain (NE_G)), relative feed value (RFV) and non-fiber carbohydrate (NFC).

2.6 Estimated Forage Nutritive Values

Additional forage nutritive indicators were estimated using laboratory determined values and previously developed equations, as earlier used by Gill et al. (2013a, 2013b). These included digestible feed energy (DFE, MCal kg^{-1}; Bull 1981), dry matter intake (DMI, % of body weight; Undersander & Moore, 2002), digestible crude protein (DCP, % DM; Demarguilly & Weiss, 1970) and dry matter digestibility (DDM, % DM; Undersander & Moore, 2002) The crude protein yield and tetany ratio were estimated from the following equations:

$$\text{Crude protein yield (CPY, kg CPY ha}^{-1}) = CP \times DMY \quad (1)$$

$$\text{Tetany ratio} = K/(Mg + Ca) \quad (2)$$

3. Results

3.1 Crop Growth and Yield

Visual assessment at four weeks after seeding showed very good stand establishments for all varieties in each growing season. There was no lodging of any variety during the 4 growing seasons.

Variety by growing season interaction was significant for plant height, SY and DMY (interaction data not presented). Compared to other varieties, the plant height was significantly lower for Tyndal and AC Ultima (83 and 86 cm) in 2010, and it was higher for Bunker in 2011 (145 cm). Both the SY and DMY were lower for Bunker in 2010 (16 t SY ha^{-1} and 5.60 t DMY ha^{-1}), while they were higher for Bunker in 2012 (30 t SY ha^{-1} & 10.60 t DMY ha^{-1}) than other varieties.

In comparison to Taza, the mean plant height was significantly higher for Bunker and it was significantly lower for the AC Ultima, Pronghorn and Tyndal (Table 4). Mean plant height was significantly higher in 2011 and significantly lower in 2010 than the other growing seasons (Table 4).

Differences in the mean (across 4 years) SY and DMY of tested varieties were not significant (Table 4). Significantly lower yields (SY and DMY) were observed in 2010 than in other 3 years.

Table 4. For the triticale varieties and years, mean plant height, 65% moisture silage yield (SY), dry matter yield (DMY) and crude protein yield (CPY); and crude protein (CP), soluble protein (Sol-CP), undegradable intake protein (UIP), and acid detergent fiber-crude protein (ADF-CP) contents in dry forage

Variety/Year	Plant height (cm)	Silage Yield (t ha^{-1})	DM Yield (t ha^{-1})	CP (%)	Sol-CP (%)	UIP (%)	ADF-CP (%)	CPY (kg ha^{-1})
Means across the 2009-2012 years								
AC Ultima	107c	23.3a	8.14 a	8.01 a	54.8 a	23.6 a	0.42 b	654 a
Bunker	123a	24.4 a	8.53 a	7.94 a	54.8 a	22.6 a	0.48 b	660 a
Pronghorn	109c	24.0 a	8.39 a	8.05 a	52.3 a	24.1 a	0.47 b	649 a
Taza	115d	24.3 a	8.51 a	8.32 a	47.9 b	24.2 a	0.71a	704 a
Tyndal	106c	23.4 a	8.18 a	8.00 a	53.5 a	24.3 a	0.44 b	635 a
$LSD_{0.05}$^{z}	3.26	1.68	0.59	0.90	4.23	1.91	0.09	123
Means across the triticale varieties								
2009	113 b	25.5 a	8.91 a	7.16 c	59.8 a	26.0 b	0.30 c	602 c
2010	85 c	16.8 c	5.88 c	8.10ab	65.4 a	17.4 d	0.10 d	478 d
2011	127 a	25.1 b	8.78 b	7.90 b	46.9 b	22.0 c	0.46 b	666 b
2012	116b	26.8 a	9.40 a	8.45 a	43.1 b	28.5 a	0.94 a	829 a
$LSD_{0.05}$^{z}	4.87	1.63	0.56	0.41	9.52	2.21	0.06	48
Overall mean	112	23.8	8.33	8.04	52.9	23.7	0.48	655
CV, %^{Y}	2.90	7.01	7.01	8.98	5.28	5.32	14.8	12.1

Note. ^{Z}: $LSD_{0.05}$, least significant difference at $P < 0.05$; ^{Y}: CV, coefficient of variation.

3.2 Forage Nutritive Value Indicators

3.2.1 Protein Fractions and Yield

The forage crude protein (CP) and protein fractions as well as calculated crude protein yield (CPY) did not show significant variety by growing season interaction effects.

Varieties did not have any significant ($P > 0.05$) effects on the mean forage CP, UIP and CPY (Table 4). But the Sol-CP and ADF-CP protein fractions were significantly ($P < 0.05$) influenced by varieties. Taza (47.9%) had significantly lower Sol-CP than other varieties, with no significant differences between the Bunker, Tyndal, AC Ultima and Pronghorn (52.3 to 54.8). On the other hand, Taza (0.71%) had significantly higher ADF-CP value, and there were no significant differences between the ADF-CP values of other varieties (0.42 to 0.48%).

Forage CP content, protein fractions contents and CPY were significantly affected by growing seasons (Table 4). The CP content varied from 7.16% in 2009 to 8.45% in 2012. The CP content was significantly lower in 2009 than in other years and was also significantly lower in 2011 than in 2012. Forage CPY, UIP and ADF-CP, all were significantly higher in 2012 and lower in 2010 than in other years. On the other side, forage Sol-CP was significantly higher in 2010 than in 2011 and 2012.

3.2.2 Macro Minerals, Ca:P Ratio and Tetany Ratio

None of the measured macro-mineral contents as well as the calculated Ca:P and tetany ratios showed significant variety × growing season interaction effects.

Across the years mean forage K, Na and S contents did not differ significantly ($P > 0.05$) between varieties (Table 5). However, the varieties showed significant differences for Ca, P and Mg contents as well as Ca:P and tetany ratios. AC Ultima and Taza had the lowest Ca content (0.21%), while Bunker had the highest Ca content (0.29%). Bunker had significantly greater Ca content than other varieties, except Tyndal. Taza had higher P content than Bunker while differences between other varieties were not significant. The Ca:P ratio was lowest for Taza and highest for Bunker. The Ca:P ratio of Bunker was significantly greater than other varieties, except Pronghorn. Forage Mg content varied from 0.10% for both Pronghorn and Taza to 0.13% for Bunker. Bunker and AC Ultima had significantly higher Mg content than other varieties. Both Pronghorn and Taza had significantly higher tetany ratio than Bunker, while differences in tetany ratios between the AC Ultima, Bunker and Tyndal were not significant.

Growing seasons did not affect (P > 0.05) forage Ca content (Table 5). Forage P, K and S contents and tetany ratio were all significantly influenced by growing seasons. The P and K contents and tetany ratio were consistently lowest in 2010 and highest in 2011. Forage S content was lower in 2009 and 2011 than in 2010 and 2012. The Na content was lower in 2009 than in other years. The Ca:P ratio was higher in 2010 than in other years.

Table 5. Macro minerals, Ca:P ratio and tetany ratio of dry forage for the triticale varieties and years

Variety/Year	Ca (%)	P (%)	Ca:P (ratio)	K (%)	Mg (%)	Na (%)	S (%)	Tetany (ratio)
Means across the 2009-2012 years								
AC Ultima	0.21 b	0.13ab	1.66 b	1.27 a	0.12 a	0.02 a	0.12 a	3.93ab
Bunker	0.29 a	0.12 b	2.78 a	1.25 a	0.13 a	0.02 a	0.13 a	3.24 b
Pronghorn	0.22 b	0.13ab	1.94ab	1.36 a	0.10 b	0.02 a	0.12 a	4.33 a
Taza	0.21 b	0.16 a	1.41 b	1.37 a	0.10 b	0.02 a	0.12 a	4.34 a
Tyndal	0.24ab	0.14 b	1.83 b	1.33 a	0.11 b	0.01 a	0.12 a	3.82ab
LSD0.05^{Z}	0.07	0.03	0.92	0.16	0.01	0.01	0.02	0.79
Means across the triticale varieties								
2009	0.22 a	0.13 b	1.70 b	1.24ab	0.09 c	0.01 b	0.10 b	4.04 a
2010	0.27 a	0.09 c	3.39 a	1.12 b	0.15 a	0.02 a	0.14 a	2.89 b
2011	0.24 a	0.16 a	1.49 b	1.40 a	0.09 c	0.02 a	0.11 b	4.30 a
2012	0.22 a	0.14 b	1.57 b	1.42 a	0.13b	0.02 a	0.15 a	4.15 a
LSD0.05^{Z}	0.08	0.01	1.56	0.23	0.01	0.003	0.01	0.84
Overall mean	0.24	0.13	2.04	1.31	0.11	0.12	0.12	3.89
CV, %^{Y}	20.9	15.7	21.3	8.21	9.06	21.0	9.52	13.6

Note. ^{Z}: $LSD_{0.05}$, least significant difference at P < 0.05; ^{Y}: CV, coefficient of variation.

3.2.3 Micro Minerals

Of the measured micro minerals, only forage Fe content showed significant variety × growing season interaction effects (interaction data not presented). Compared to other varieties, the Fe content was significantly lower for Bunker (363 ppm) in 2009, and it was significantly higher for Bunker and AC Ultima (656 and 627 ppm) in 2010.

For the mean micro mineral contents, only Fe and Mn were significantly affected by varieties (Table 6). Taza had significantly lower Fe content than other varieties. Bunker had significantly greater Mn content than other varieties.

Growing years did not influence (P > 0.05) forage Cu and Fe contents. But growing years showed significant effect on forage Mn and Zn contents. In 2012, the forage Mn content was significantly lower than in 2010 but it was significantly higher than in 2009 and 2011. Significantly higher Zn content was observed in 2010 than in other years.

Table 6. Micro mineral contents of dry forage for the oat varieties and years

Variety/Year	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Means across the 2009-2012 years				
AC Ultima	5.52 a	226 a	51.8ab	31.5 a
Bunker	6.20 a	218 a	62.3 a	31.3 a
Pronghorn	5.95 a	177 a	50.2 b	27.4 a
Taza	5.57 a	71 b	46.7 b	30.8 a
Tyndal	5.48 a	173 a	53.6ab	26.0 a
$LSD_{0.05}^{Z}$	1.18	59	11.6	6.04
Means across the triticale varieties				
2009	7.63 a	80 a	25.5 c	24.4 b
2010	5.42 a	532 a	96.1 a	35.7 a
2011	5.18 a	69 a	34.0 c	28.9 b
2012	5.15 a	105 a	61.3 b	28.4 b
$LSD_{0.05}^{Z}$	2.76	464	26.1	5.95
Overall mean	5.77	184	53.6	29.3
CV, %^{Y}	13.5	21.4	13.2	13.2

Note. ^{Z}: $LSD_{0.05}$, least significant difference at $P < 0.05$; ^{Y}: CV, coefficient of variation.

3.2.4 Detergent Fiber and Non Fiber Contents and Relative Feed Value

Detergent fiber contents measured as ADF and NDF, as well as non fiber carbohydrate (NFC) and RFV were not significantly ($P > 0.05$) affected by variety × growing season interactions.

The forage ADF, NDF, and RFV were not significantly different ($P > 0.05$) among varieties (Table 7). But the NFC was greater for AC Ultima than Taza and Tyndal.

Forage ADF, NDF, NFC and RFV were influenced by growing years ($P < 0.05$). The ADF content was significantly greater in 2009 and 2011 than in 2010. Forage NDF content was significantly lower in 2010 than other growing seasons. Both the NFC and RFV were significantly higher in 2010 than other growing seasons.

Table 7. Acid detergent fiber (ADF), neutral detergent fiber (NDF), non fiber carbohydrate (NFC) and relative feed value (RFV) of dry forage as influenced by triticale varieties and years

Variety/Year	ADF (%)	NDF (%)	NFC (%)	RFV (%)
Means across the 2009-2012 years				
AC Ultima	31.9 a	49.5 a	31.1 a	121 a
Bunker	33.6 a	51.2 a	29.5ab	115 a
Pronghorn	34.1 a	51.2 a	28.8ab	113 a
Taza	33.5 a	52.1 a	27.9 b	112 a
Tyndal	34.3 a	52.9 a	27.9 b	111 a
$LSD_{0.05}^{z}$	3.36 a	3.46	2.96	12
Means across the triticale varieties				
2009	35.2 a	52.6 a	28.6 b	108 c
2010	30.1 b	47.5 b	33.3 a	130 a
2011	35.2 a	54.1 a	26.5 b	106 c
2012	32.9ab	51.1 a	28.9 b	115 b
$LSD_{0.05}^{Z}$	3.81	3.25 a	4.05	5
Overall mean	33.4	51.4	29.2	114
CV, %^{Y}	6.63	4.39	6.75	6.94

Note. ^{Z}: $LSD_{0.05}$, least significant difference at $P < 0.05$; ^{Y}: CV, coefficient of variation.

3.2.5 TDN and Other Forms of Energy

The ANOVA indicated no significant ($P > 0.05$) variety × growing season interactions (interactions data not presented) and variety effects on TDN and other forms of energy measured (Table 8). The TDN, NE_L, NE_M and NE_G were significantly greater in 2010 than in 2009 and 2011. Compared to 2010, the ME value was significantly higher for 2012 and significantly lower for 2009 and 2011.

Table 8. Total digestible nutrients (TDN), net energy for lactation (NE_L), net energy for maintenance (NE_M), net energy for gain (NE_G) and metabolizable energy (ME) of dry forage for the triticale varieties and years

Variety/Year	TDN (%)	NE_L (Mcal kg^{-1})	NE_M (Mcal kg^{-1})	NE_G (Mcal kg^{-1})	ME (Mcal kg^{-1})
Means across the 2009-2012 years					
AC Ultima	64.1 a	1.45 a	1.57 a	0.85 a	2.33 a
Bunker	62.8 a	1.43 a	1.54 a	0.81 a	2.28 a
Pronghorn	62.4 a	1.41 a	1.52 a	0.8 a	2.26 a
Taza	62.8 a	1.43 a	1.54 a	0.82 a	2.28 a
Tyndal	62.1 a	1.41 a	1.51 a	0.80 a	2.26 a
$LSD_{0.05}$ [Z]	2.46	0.07	0.07	0.07	0.10
Means across the triticale varieties					
2009	61.3 b	1.39 b	1.49 b	0.77 b	2.22 c
2010	65.7 a	1.50 a	1.62 a	0.89 a	2.39 b
2011	61.5 b	1.39 b	1.50 b	0.78 b	2.25 b
2012	63.2ab	1.43ab	1.55ab	0.83ab	2.81 a
$LSD_{0.05}$	3.26	0.07	0.09	0.09	0.10
Overall mean	62.9	1.43	1.54	0.82	2.28
CV, % [Y]	2.75	3.02	3.06	5.85	2.61

Note. [Z]: $LSD_{0.05}$, least significant difference at $P < 0.05$; [Y]: CV, coefficient of variation.

3.2.6 Estimated Digestibility and Intake

Of the estimated feed digestibility and intake parameters, none was affected by varieties (Table 9). Growing season affected the DFE, DCP, DDM and DMI. Compared to 2010 and 2011, the DCP was significantly higher in 2012 and lower in 2009. The DFE and DDM were significantly greater in 2010 than in 2009 and 2011. The DMI was significantly greater in 20110 than in all other years.

Table 9. Digestible feed energy (DFE), digestible crude protein (DCP), digestible dry matter (DDM), and dry matter intake (DMI) of dry forage for the triticale varieties and years

Variety/Year	DFE (Mcal kg^{-1})	DCP (%DM)	DDM (%DM)	DMI (%DM)
Means across the 2009-2012 years				
AC Ultima	2.81 a	3.89 a	64.1 a	2.43 a
Bunker	2.76 a	3.87 a	62.8 a	2.35 a
Pronghorn	2.74 a	3.92 a	62.3 a	2.32 a
Taza	2.76 a	4.39 a	62.8 a	2.30 a
Tyndal	2.73 a	3.83 a	62.2 a	2.27
$LSD_{0.05}^{Z}$	0.12	1.30	2.45	0.16
Means across the triticale varieties				
2009	2.70 b	3.13 c	61.2 b	2.27 b
2010	2.89 a	4.00 b	65.7 a	2.56 a
2011	2.71 b	3.82 b	61.5 b	2.22 b
2012	2.78ab	4.65 a	63.2ab	2.35 b
$LSD_{0.05}^{Z}$	0.13	0.42	2.96	0.16
Overall mean	2.77	3.94	62.9	2.34
CV, $\%^{Y}$	2.61	20.5	2.61	4.51

Note. ^{Z}: $LSD_{0.05}$, least significant difference at $P < 0.05$; ^{Y}: CV, coefficient of variation.

3.2.7 Pearson's Correlation Coefficients

Of the pairs of parameters correlated, the following pairs of parameters showed positive and significant correlations:

DMY & plant height (r = 0.76, *P* = 0.001, n = 72)

DMY & K content (r = 0.596, *P* = 0.01, n = 72)

DMY & NDF (r = 0.541, *P* = 0.001, n = 72)

ADF & NDF (r = 0.852, *P* = 0.001, n = 72)

4. Discussion and Implications

4.1 Crop Growth and Yield

In Western Canada, the feed cost can be up to 50-75% of the total cost of beef production. Using cereals such as barley, oats and triticale in these operations can provide good forage as well as play significant role in extending the grazing season through swath grazing, bale grazing and bale processing. In the present study, spring triticale varieties were evaluated for forage production in the north western (Peace River region) Alberta, Canada. The forage nutritive values of triticale varieties and their implications in ruminant nutrition are discussed. In particular, the forage nutritive values of spring triticale varieties are discussed for use in the beef cattle production systems, based on their nutritive value following the National Research Council (NRC, 2000) suggested nutrient requirements for beef cattle (Table 10).

Table 10. Suggested nutrients requirements for beef cows from NRC (2000)

Nutrient	Requirement		
	Growing & finishing calves	Dry Gestating cows (544 kg)	Lactating cows (544 kg)
CP, %	12-13	7-9^{Z}	10-12
Ca, %	0.31	0.18	0.42
P, %	0.21	0.16	0.26
Mg, %	0.10	0.12	0.20
K, %	0.60	0.60	0.70
Na, %	0.06-0.08	0.06-0.08	0.10
S, %	0.15	0.15	0.15
Cu, ppm	10	10	10
Zn, ppm	30	30	30
Fe, ppm	50	50	50
Mn, ppm	20	40	40
NE_M, MCal kg^{-1}	1.08-2.29	0.97-1.10	1.19-1.28
NE_G, MCal kg^{-1}	0.53-1.37	NA^{Y}	NA
TDN, %	65-70^{X}	55-60^{W}	65

Note. ^{Z}: 7% for middle 1/3 of pregnancy, 9% for late 1/3 of pregnancy; ^{Y}: NA, not available; ^{X}: 55% for middle 1/3 of pregnancy, 60% for late 1/3 of pregnancy; ^{W}: for 6-10 months old growing bulls.

Both the silage (SY) and forage DM (DMY) yields were similar for all triticale varieties tested. The lack of any significant differences in both SY and DMY among the spring triticale varieties indicates that all varieties are equally suited for the purpose of forage production and inclusion as forage for beef cattle operations in the region. In the present study, the DMY varied from 8.14 to 8.53 t ha^{-1} (mean = 8.33 t ha^{-1}) and SY ranged from 23.3 to 24.3 t ha^{-1} (mean = 23.8 t ha^{-1}). Compared to results from Gill et al. (2013a, 2013b) on other cool season cereal crops in the same environment, overall DMY mean for the examined spring triticale varieties (8.33 t ha^{-1}) compared well with forage DMY reported for barley (8.05 t ha^{-1}) varieties, while they out yielded the oat varieties by as much 2.20 t ha^{-1}. Both barley and oats are the two most common cool season cereals grown in the region for green feed, silage, grazing and swath grazing. The higher forage DMY as well as forage protein (CP) and energy (TDN) of triticale varieties (8.05 t ha^{-1} DMY, 8.04% CP, 62.9% TDN) tested here over those of oat varieties (6.13 t ha^{-1} DMY, 7.21% CP, 59.0% TDN) reported by Gill et al. (2013b) would further increase the adoption of triticale by beef cattle producers. These attributes observed for triticale in the present study probably explain a gradual increase in the use of triticale monocrop or in mixtures with oat and forage pea as swath grazing for extending the fall grazing season, hay or silage for back grounding calves in the Peace River region of Alberta (Omokanye, 2014).

The forage DM yields obtained in this study were higher than those for triticale in the southern High Plains, USA (Lauriault & Kirksey, 2004). Mut et al. (2006) reported far higher DMY in Bangladesh (11-15 t ha^{-1} DMY) than in the present study. The large differences in DMY between in this study and those of Mut et al. (2006) could have resulted from differences in the following: seasonal growing conditions, crop management practices, seed rates and cultivars. For instance, Mut et al. (2006) used higher seed rate (500 seeds m^{-2}) than in the present study (263 seeds m^{-2}).

The genetic make-up of the tested varieties was probably responsible for the differences in plant height among varieties in this study. Though Bunker variety significantly grew taller, followed by Taza, but the forage yield advantage associated to taller plants was not significant. However, the significant correlation recorded for plant heights and DMY ($r = 0.7$, $P = 0.001$, $n = 72$), seemed to indicate that plant height could have been an important agronomic trait in triticale breeding and selection programs for forage production. However, the triticale varieties tested in the present study did not significantly differ in SY or DMY, but the results seemed to show that taller varieties may have a tendency to yield slightly more than the shorter varieties. It is important to point out that with the plant height recorded in the present study (up to 123-127 cm), no plant lodging occurred with all varieties in any particular year. This shows that all varieties have excellent lodging resistance.

Plant height and forage DMY were lower in 2010 than in 2009, 2011 and 2012, apparently because the spring soil moisture plus rainfall in 2010 was 102 to 190 mm less than those in other years.

4.2 Forage Nutritive Value Indicators

Matching the nutrient requirements of beef cattle and the nutrients supplied by triticale varieties would help identify nutritional sufficiencies and inadequacies. The CP content of forage is one of the most important criteria for forage quality evaluation (Assefa & Ledin, 2001). The protein requirements of cattle vary with stage of production, size of the animal, and expected performance. Considering the protein requirements for beef cows from the second trimester to post calving (NRC, 2000; AARD, 2004), all spring triticale varieties tested here were able to adequately meet the recommended value of 7% CP requirement for mature pregnant beef cows in the mid-pregnancy (second-trimester) stage (Table 4). However, the varieties examined here were short of meeting the 9% CP requirements of cows in the late pregnancy (third trimester) stage as well as 11% CP needed by lactating cows. It is evident that using the tested triticale varieties for silage or swath grazing would need additional sources of protein when fed to a mature cow in the third trimester pregnancy stage as well to a nursing cow. The protein supplementation could be in form of legume hay with high CP or protein blocks, which are normally designed to be fed free-choice. Looking at other studies involving cool season spring oat and barley varieties in the same environments as the present study, the triticale varieties examined here (8.04% CP) had higher CP values than reported for oat (7.21%) varieties (Gill et al., 2013b), but much lower than the CP values for barley (9.63%) varieties (Gill et al., 2013a).

Examining the mineral contents of forage crops is important in selecting the correct mineral supplement for a beef cattle feeding program. Of the 10 minerals tested in the present study, only Ca, Mg, Fe and Zn showed differences among triticale varieties. All varieties, however, met the Ca, K, Fe and Mn requirements for dry gestating cows in the 2nd and 3rd trimester stages (Tables 5, 6 and 10). Only AC Ultima, Bunker and Taza varieties had adequate value for Zn requirement of a dry gestating cow. None of the varieties had enough Na, S and Cu needed by a dry gestating (pregnant) mature cow. Only Taza variety met the P requirement, while only AC Ultima and Bunker met the Mg requirements for a pregnant cow in the second and third trimester pregnancy stages. The low forage P content obtained for the triticale varieties tested here (except for Taza) is not unusual. Deficiency of P is very prevalent in forages throughout the world, which are the primary feed for ruminants and are considered a poor source of P. Deficiency of P can lead to many problems including reduced growth and feed efficiency, decreased appetite, reduced reproduction efficiency, decreased milk production, and weak or fragile (rickety) bones (Harty, 2014).

Of the macro (Na, Ca, P, Mg, P, Na, S) and micro (Cu, Mn, Z, Fe) minerals examined in this study, only K (which is on a high side), Fe and Mn requirements for a lactating mature cow (nursing cow) can be sufficiently met by all triticale varieties.

Tetany is not limited to spring only, and it can also occur in winter. A combination of K, Ca and Mg make up the tetany ratio. Tetany is associated with Mg deficiency in the blood of animals. Loredo et al. (1983) warned that high K concentration could cause Mg deficiency. The threshold for risk of grass tetany increases at K/(Ca + Mg) ratio of 2.2 or higher (Elkins et al., 1977). According to a ration balancing software Cowbytes (AARD, 2004), tetany ratio should not exceed 2.2. In the present study, tetany ratio were >3.2 for all varieties. Another criterion is also used to evaluate tetany danger of forage Mg for lactating or pregnant beef cows (Bohman et al., 1980): tetany prone (< 0.12% Mg), marginal (0.12 to 0.18% Mg) and adequate-non tetany state (> 0.18% Mg). In the present study, considering the Mg results, 2 varieties (AC Ultima and Bunker) were in the marginal level and other varieties were in the tetany prone range.

It is evident from the present study that P, Mg, Na, S, and Cu supplementation may be needed when feeding a mature cow the forage from the tested triticale varieties grown in the Peace River region.

The difference between the growing years for Fe was very high in the present study. The low soil pH at the Valleyview (2010) than other sites (Table 2) may have enhanced the availability and plant uptake of Fe, and also somewhat of Mn and Zn. Apparently, combination of increased uptake from low pH soil and lower forage yield in 2010 resulted in higher Fe, Mn and Zn values.

The RFV is an index that is used to predict the intake and energy value of the forages and it is derived from the DDM and DMI. The triticale varieties tested in the present study did not differ in RFV. Using the quick guide to forage allocation by cattle class described by Schroeder (1996), the Bunker, Pronghorn, Taza and Tyndal were well within the suggested RFVs for beef cows (90-115 RFV). The AC Ultima had higher RFV value than other varieties and above the normal range, an indication that AC Ultima is of higher grade than other varieties. The ADF values are important because they inversely relate to the ability of an animal to digest the forage. As ADF increases, digestibility of forage usually decreases. The NDF values are important in ration formulation because they reflect the amount of forage the animal can consume. Like ADF, as NDF percentages increase, forage DM intake will generally decrease. With the lower ADF and NDF values obtained for the AC Ultima, there may be a tendency that when all the varieties are presented side by side to cows in a preference study AC Ultima forage would likely be preferred and consumed more.

The TDN, NE_L, NE_M, NE_G indicate the energy levels of forage/feed and ME values (Table 8). All triticale varieties tested in the present study had adequate amounts of TDN for a mature dry gestating beef cow, which require 55-60% TDN (Table 8 & 10). However, all varieties fell short of the amount of TDN that is required by a mature lactating cow (65% TDN). Thus, feeding any of these varieties to a mature lactating cow would require additional energy source(s) to meet the TDN requirement. All tested triticale varieties had NE_M levels within the range for a mature cow. Looking at the ME values in the present study (2.26 to 2.33 Mcal kg^{-1}), all triticale varieties tested met the daily ME requirements of 2.23 to 2.54 Mcal kg^{-1} for a mature beef cow (NRC, 1984).

The superiority of AC Ultima over other varieties was indicated by the lower ADF and NDF values as well as its higher RFV and TDN value.

For growing and finishing calves, the requirements for Mg, Fe, Mn, and Zn (except for Tyndal) are met by the triticale varieties tested. Both NE_M & NE_G were within the adequate ranges suggested for growing and finishing calves (NRC, 2000; Table 10).

Because forage was harvested in summer, nitrate content was not tested in this study. However, when harvested for swath grazing in late falls or early winter, forage from triticale varieties grown to feed beef cattle should be tested for danger of nitrate toxicity. Then producers can either dilute triticale forage with other feeds or manage harvest time and feed utilization. Testing for nitrate is particularly important as the time of swathing triticale for swath grazing in the Peace River would normally coincide with drop in temperature in fall to occasional freezing temperatures before swathing for swath grazing.

5. Conclusions

Taking into consideration the forage yields (65% moisture silage & dry matter), CP yields, and some observed forage quality attributes, any of the triticale varieties can be grown in the Peace River for the purpose of silage, swath grazing or inclusion in annual crop cocktail mixtures for silage, grazing or green feed. The triticale varieties were not consistent in meeting some of the mineral requirements of growing and finishing beef cattle, dry gestating and lactating cows. Because of these inconsistencies, some form of commercial mineral supplement would be required. Similarly, feeding silage or forage from any of the tested triticale varieties to cows in the third trimester and nursing cows, which require 9 and 11% CP, would need some form of protein supplementation. AC Ultima had higher RFV and TDN values as well as lower ADF and NDF values than other varieties, an indication that AC Ultima tended to have higher grade than other varieties. Overall, use of triticale is suggested as one of the available options for swath grazing to extend the fall grazing, produce silage or dry forage for beef cattle producers in north western Alberta, Canada.

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References

Aasen, A., Baron, V. S., Clayton, G. W., Dick, A. C., & McCartney, D. H. (2004). Swath grazing potential of spring cereals, field pea and mixtures with other species. *Canadian Journal of Plant Science, 84*, 1051-1058. http://dx.doi.org/10.4141/P03-143

Agriculture and Rural Development. (2001). *Triticale*. Alberta Agriculture & Forestry, Agdex 118/20-1. Revised April, 2001. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex127

Agriculture and Rural Development. (2004). *Beef Ration Rules of Thumb*. Agdex 420/52-4. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ agdex9146

Assefa, G., & Ledin, I. (2001). Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. *Anim. Feed Sci. Technol., 92*, 95-111. http://dx.doi.org/10.1016/S0377-8401 (01)00242-5

Baron, V. S., Okine, E., & Campbell, A. (2000). *Optimizing Yield and Quality of Cereal Silage*. Retrieved from http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/frg70/$FILE/foragebeef_caoptimizingyieldqualityofcerealsilage.pdf

Baron, V. S., Raquel R. D., Basarab, J. A., & Campbell, D. (2014). Swath grazing triticale and corn compared to barley and a traditional winter feeding method in central Alberta. *Can J. Plant Sci., 94*, 1125-1137. http://dx.doi.org/10.4141/cjps2013-412

Bohman, V. R., Stuart, D. M., & Hacket, E. L. (1980). *Nevada Hays and Grass Tetany*. Nevada Ag Expt. Sta. Bull. B-46, Univ. of Nevada.

Bull, H. S. (1981). Estimating the nutrient value of corn silage. *Proceedings of 1st Semi-annual Meeting of American Feed Manufacturers Association* (pp. 15-19). American Feed Manufacturers Assoc., Lexington, KY.

Demarguilly, C., & Weiss, P. (1970). *Tableau de la valeur alimentaire des fourrages*. Paris, INRA.

Elkins, C. B., Haaland R. L., & Honeland C. S. (1977). Tetany potential of forage species as affected by soil oxygen. *Proceedings of the XIII International Grassland Congress* (pp. 1505-1507).

Entz, M. H., Baron, V. S., Carr, P., McCaughey, P. M., Smith, S. R., & Cash, D. (2002). Potential of forages to diversify Canadian and American northern great plain cropping systems. *Agron. J., 94*, 240-250. http://dx.doi.org/10.2134/agronj2002.0240

Gill, K. S., Omokanye, A. T., Pettyjohn, J. P., & Elsen, M. (2013a). Evaluation of forage type barley varieties for forage yield and nutritive value in the Peace Region of Alberta. *J. Agric. Sci., 5*, 24-36. http://dx.doi.org/10.5539/jas.v5n2p24

Gill, K. S., Omokanye, A. T., Pettyjohn, J. P., & Elsen, M. (2013b). Agronomic performance and beef cattle nutrition suitability of forage oat varieties grown in the Peace Region of Alberta, Canada. *J. Agric. Sci., 5*, 128-145. http://dx.doi.org/10.5539/jas.v5n7p128

Government of Alberta. (2012). *Agriculture/Peace Country.* Retrieved December 15, 2012, from http://www.albertacanada.com/business/statistics/peace-country-agriculture.aspx

Harty, A. (2014). *Importance of calcium and phosphorus in the ruminant diet*. iGrow: A Service of South Dakota State University Extension. Retrieved from http://igrow.org/livestock/beef/importance-of-calcium-and-phosphorus-in-the-ruminant-diet

Igne, B., Gibson, L. R., Rippke, A., & Hurburg, C. R. (2007). Triticale moisture and protein content prediction by near-infrared spectroscopy. *Cereal Chem., 84*, 328-330. http://dx.doi.org/10.1094/CCHEM-84-4-0328

Isaacs, J. (2013). New triticale varieties offer wheat alternative. *Grainews*. Retrieved October 8, 2013, from http://www.grainews.ca/2013/10/08/new-triticale-varieties-offer-wheat-alternative

Laredo, C. M. A., Ardilla, G. A., & Alveraz, V. J. (1983). Variation in mineral concentrations in grasses in the cattle farming area of the Caribbean. *Revista Instituto Colombiano Agropecuario, 18*, 505-113.

Lauriault, L. M., & Kirksey, R. E. (2004). Yield and nutritive value of irrigated winter cereal forage grass-legume intercrops in the Southern High Plains, USA. *Agron. J., 96*, 352-358. http://dx.doi.org/10.2134/agronj2004.3520

McCartney, D., Basarab, J. A., Okine, E. K., Baron, V. S., & Depalme, A. J. (2004). Alternative fall and winter feeding systems for spring calving beef cows. *Can. J. Ani. Sci., 84*, 511-522. http://dx.doi.org/10.4141/A03-069

Mut, Z., Ayan, L., & Mut, H. (2006). Evaluation of forage yield and quality at two phenological stages of triticale genotypes and other cereals grown under rainfed conditions. *Bangladesh J. Bot., 35*(1), 45-53.

NRC (National Research Council). (2000). *Nutrient Requirements of Beef Cattle* (7th ed., Update 2000). Washington, DC: The National Academies Press.

NRC. (National Research Council). (1984). *Nutrient Requirements of Beef Cattle* (6th ed.). Washington, DC: National Academy Press.

Omokanye, A. T. (2014). *Annuals for forage production*. 2014 Peace Region Forage Agronomy Update, Peace Region Forage Seed Association, British Columbia, Canada, held at Rycroft, Alberta, Canada, Tuesday, March 25, 2014.

Salmon, D. F. (2004). Production of triticale on the Canadian Prairies. *Triticale improvement and production* (pp. 99-102). Retrieved from ftp://ftp.fao.org/docrep/fao/009/y5553e/y5553e02.pdf

SAS Institute, Inc. (1990). *SAS user's guide: Statistics* (Version 6, 4th ed.). SAS Institute Inc., Cary, NC.

Schroeder, J. W. (1996). *Quality Forage for Maximum Production and Return*. North Dakota State University. Retrieved from http://www.ag.ndsu.edu/pubs/ansci/range/ as1117w.htm

Soil and Plant Analysis Council. (1999). *Soil Analysis Handbook of Reference Methods*. Soil and Plant Analysis Council, Inc, Athens, GA.

Soil Classification Working Group. (1998). *The Canadian system of soil classification*. Agriculture and Agri-Food Canada Publication, 1646 (Revised).

Undersander, D., & Moore, J. E. (2002). *Relative forage quality (RFQ) indexing legumes and grasses for forage quality*. University of Wisconsin Extension. Retrieved from http://www.uwex.edu/ces/forage/pubs/rfq.htm

Western States Laboratory Proficiency Testing Program. (1997). *Soil and Plant Analysis Methods* (Version 4). Inductivity Coupled Plasma Emission Spectroscopy: Method 6001 EPA.

Zadok, J. C., Chang, T. T., & Konzak, C. F. (1974). A decimal code for growth stages of cereals. *Weed Res., 14*, 415-421.