New Forage Options for Western Canada

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■ Take Home Message

- Lethbridge forage program deals with improvement of traditional crops (alfalfa, cicer milkvetch, sainfoin and orchardgrass) and non-traditional crops (fenugreek and PC rye).
- Genetic improvement in forage and seed yield, establishment and persistence of these crops in mixed stands and under grazing are being attempted.
- Agronomic packages to maximize productivity and to optimize forage quality and establishment are being developed.
- Other uses for these crops (health benefit of fenugreek) are also being explored.

The Agriculture and Agri-Food Canada (AAFC) forage breeding activities were amalgamated into one National Forage Development Study. This study includes five AAFC breeders, with one breeder, Dr. Grant McLeod, exclusively spending time on breeding activity related to native grass "ecovar" development. The forage breeding activities at Lethbridge, AB; Charlottetown, PEI; Saint Foy, QC; Saskatoon, SK; Swift Current, SK are led by Surya Acharya, Yousef Papadopoulos, Real Michaud, Bruce Coulman, and Grant McLeod, respectively. Dr. Coulman has recently moved to the University of Saskatchewan as Head of the Plant Science Department and will continue his forage breeding work at Saskatoon with the technical help from AAFC Research Centre. Breeding programs outside AAFC also develop forage cultivars for Canada. They include some private breeding companies in USA and Canadian Universities and provincial government institutions.

The objective of AAFC breeding programs in forage crops is to develop forage crops and cultivars to improve productivity, nutritive value, persistence, novel uses and stress tolerance for the Canadian livestock, forage and conservation industries. In the past, our emphasis was improvement in productivity, stand longevity and ease of establishment. Cultivars developed earlier were mainly for monoculture production and were primarily for hay

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production. Presently, the AAFC breeding programs are aiming towards development of cultivars with ability to grow in mixed stands with grasses and other legumes for grazing purposes.

The Lethbridge program focuses on traditional forage crops (TFC) such as alfalfa (*Medicago* sativa) and bloat-free forage legumes such as cicer milkvetch (*Astragalus cicer*), sainfoin (*Onobrychis viciaefolia*) and orchardgrass (*Dactylis glomerata*). This breeding program has also developed two non-traditional forage crops fenugreek (*Trigonella foenum-graecum*) and perennial cereal rye (PC rye) (*Secale cereale*).

■ Alfalfa Improvement

Alfalfa is the “queen of the forages"; widely adapted, easy to establish and produces high dry matter yield and forage quality. However, alfalfa can cause bloat, can not survive in mixed stands and has no tolerance for acid or saline soils. Old cultivars were susceptible to verticillium wilt (VW) caused by *Verticillium albo-atrum* in areas with high moisture. Lethbridge Research Centre (LRC) breeding program has produced high yielding AC Blue J and AC Longview alfalfa cultivars with high levels of VW and bacterial wilt resistance for western Canada. At present our emphasis is on production of cultivars with improved:

- forage yield and tolerance to acidic and saline soils
- persistence (6-8 yrs) under grazing
- persistence in mixed stands with grass and other legumes

We have produced new populations by inter-crossing plants selected for the above characteristics and now we have enough seed of these populations to go for multi-location testing. Our challenge is to prove their superiority in these important characteristics and not just for forage yield. At present, we do not have an adequate and proven method for testing for these characteristics.

Although alfalfa is the most extensively utilized forage in the country and western Canada, forage producers have used other forage legumes. Improved cultivars and management practices of these forages may provide unique benefit in particular areas or management situations.

■ Sainfoin Improvement

Research at LRC has indicated that sainfoin (*Onobrychis viciaefolia* Scop.), a bloat free legume when mixed with alfalfa can prevent bloat in grazing cattle. This crop also has the following properties:

- More drought and cold tolerant than alfalfa, but is best adapted to Brown and Dark Brown soil zones and grows on soils high in alkalinity
- Excellent quality and palatability, contains condensed tannins (CT) and so reduces bloat of alfalfa pastures if present even at low proportions. CT also helps milk production by increasing absorption of essential amino acids from the small intestine (Min *et al*. 2003)
- Requires well drained soil and has a low tolerance to flooding or high water table
- Sainfoin cultivars available in Canada produce less biomass than alfalfa and stand vigor decreases when cut frequent or cutting in the year of seeding
- The cultivars developed for pure culture production, do not survive in mixed stands with alfalfa and hence are not reliable for reducing bloat in alfalfa pastures.

The LRC program has initiated selection to improve the forage yield and persistence of sainfoin in mixed stands with alfalfa and in monoculture. Two of the new introductions are performing well in southern Alberta (Fig. 1). New cultivars developed using selected plants from the competition nurseries are expected to persist longer (Fig. 2) and contribute more to the mixtures than the old cultivars.

■ Cicer Milkvetch Improvement

Cicer milkvetch (*Astragalus cicer*) has good potential, especially for grazing. This crop is long-lived, has no serious diseases or insect pests and pocket gophers leave it alone. The cicer milkvetch component of a mixed pasture tends to increase as the stand ages; also, the plants stay green throughout the growing season providing high quality forage even when bearing mature pods. Unlike alfalfa, cicer milkvetch stems are hollow and relatively tender when mature. Because of this, in pure stands the crop does not lend itself to hay making, as the swaths take too long to dry. However, cattle readily graze on it and the crop was found to be more palatable to sheep than alfalfa, especially in the mature stages (Acharya et al. 2005).

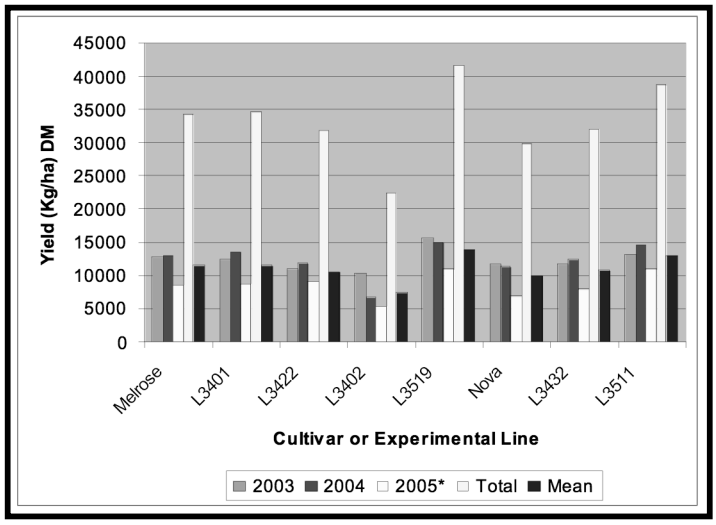

Fig. 1. Mean dry matter (DM) yield of eight sainfoin populations established in 2002 at LRC under irrigation when grown in monoculture.

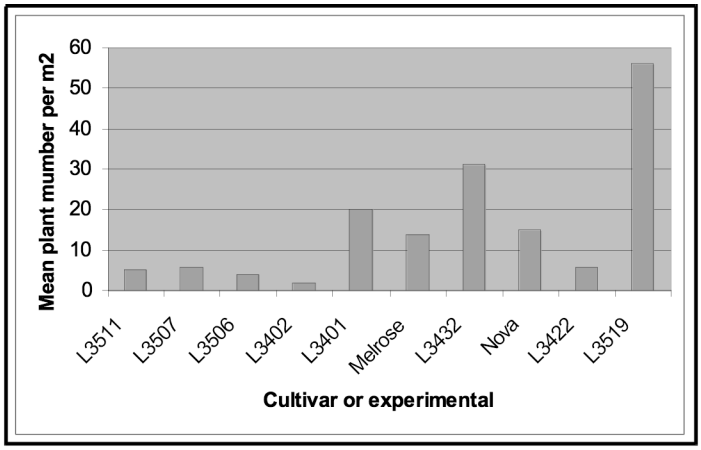

Fig. 2. Mean sainfoin plant count of different populations in 2003 1st cut samples on 2001 established competition test.

The biggest weakness of cicer milkvetch is that the old cultivar, Oxley, is very slow to establish. As a result, cicer milkvetch was not used to its potential. A rapidly establishing cicer milkvetch cultivar AC Oxley II (Acharya 2001) was developed and released to overcome this difficulty. This new cultivar produces 23% higher forage yield than Oxley under dryland conditions and

11% higher under irrigation in western Canada. This cultivar, released jointly to Prairie Seeds Ltd., Nisku, AB and Newfield Seeds Inc., Nipawin, SK yielded about 6 tonne of DM ha^{-1} on dryland (mean of 26 location x years) and about 9 tonne of DM ha^{-1} under irrigation (mean of 8 L x Y). The LRC program has developed improved cicer milkvetch synthetics and these are now being tested in western Canada (Fig. 3).

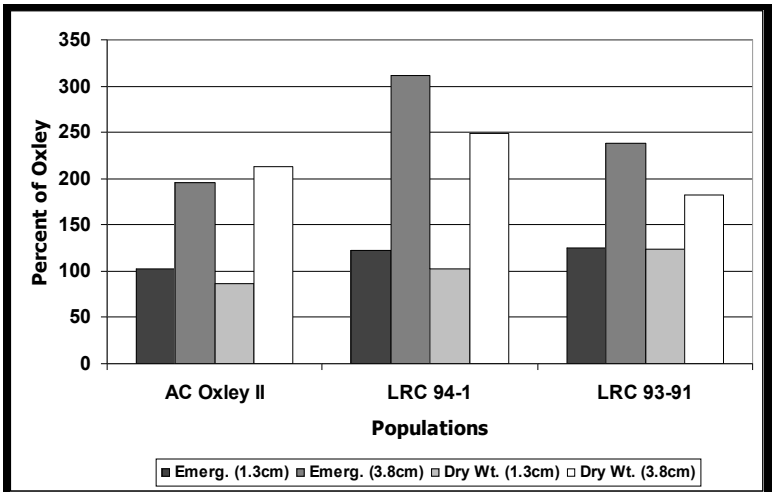

Fig. 3. Mean emergence and dry weight of three experimental cicer milkvetch populations as percent of Oxley when seeded at 1.3 and 3.8 cm depth in LRC greenhouse. LSD (at *P = 0.05*) for emergence and dry weight were 1.65 and 0.08, respectively.

■ Orchardgrass Improvement

LRC program includes improvement in orchardgrass (*Dactylis glomerata*). Orchardgrass is known to have the following attributes:

- Produces high quality forage
- Is capable of producing high forage yield in western Canada
- Responds well to irrigation
- Responds well to heavy application of manure and prevents nutrient leaching

However, the cultivars available in western Canada show:

- Poor stand persistence

- Susceptibility to winter injury due to lack of dormancy
- Adequate forage production only in areas with high moisture

The LRC program started with the objective of developing cultivars with improved winterhardiness, forage yield and quality for BC and irrigated areas of western Canada. Over the past five years this effort has produced three new synthetics one each with improved:

- winterhardiness and forage yield (Table 1, 2 and 3),
- winterhardiness and dry matter digestibility, and
- winterhardiness, forage yield and dry matter digestibility.

Table 1. Forage yield of Kayak and Kay under dryland conditions across western Canada including BC.

Dryland locations	Year of establishment	Harvest Years	Forage yield (kg DM ha^{-1})	
			Kayak	Kay
Lethbridge AB	1998	3	6008	6338
Lacombe AB	1998	3	6923	5688
Vegerville AB	1998	2	5859	5985
Netherhill SK	1998	2	3199	3459
Swift Current SK	1998	2	2261	2454
Saskatoon SK	1998	3	4462	4319
Canora SK	1998	3	5959	6062
Nipawin SK	1998	2	5048	4395
Neepawa MB	1998	3	9480	9921
Fort Kent AB	1998	3	4420	4380
Dawson Creek BC	2000	2	3738	3609
Average over 28 location years			6341	6126
Percent of Kay			104	100

In collaboration with Dr. S. Bittman of AAFC Agassiz, BC produced Cheam-VR, Chilliwack-VR, Haida-VR, Cock's Foot Mottle Virus resistant cultivars and these were released in 2005 to Terralink Horticulture of Abbotsford, BC.

Table 2. Forage yield of Kayak and Kay under Irrigated conditions across western Canada.

Irrigated locations	Year of establishment	Harvest Years	Forage yield (kg DM ha^{-1})	
			Kayak	Kay
Lethbridge AB	1997	4	6007	5407
Bow Island AB	1998	3	13039	12681
Lethbridge AB	1998	3	9856	9208
Outlook SK	1998	3	8905	9593
Kersley BC	2000	2	9599	8778
Kamloops BC	2000	2	15880	14277
Average over 17 location years			9373	8988
Percent of Kay			104	100

Table 3. Cold tolerance of Kayak and Kay as determined through LT50 tests using Probit analysis.

Locations	Establishment Year	Harvest Years	LT50	
			Kayak	Kay
Lethbridge AB*	1999	1	-15.37	-14.97
St. Foy, QC**	2005	1	-8.6	-8.3

* Test conducted indoors with plants picked up from the field in January.

** Tests conducted indoors with potted plants grown in the controlled environmental chamber.

Fenugreek Improvement

One of the non-traditional forage crops (NTFC) we work on at LRC is fenugreek. In collaboration with researchers from Alberta Agriculture, Food and Rural Development, the LRC program has developed a fenugreek (*Trigonella foenum-graecum*) cultivar 'Tristar'. This cultivar was released to Agricore United and Newfield Seeds in 2004 for multiplication and distribution in Canada. Commercial seed for this cultivar will be available in 2006 fall. Tristar is an annual legume cultivar that can be used in short term rotations, is adapted to dryland conditions of western Canada and has the following important features:

- Produces high forage yield, about 6000 kg ha^{-1} in western Canada (mean of 24 L x Y)
- Produces high quality forage irrespective of maturity (Table 4 and Fig. 4)
- Dryland crop, but responds well to minimal irrigation
- Suitable for silage, hay making can be difficult due to heavy swath

- Bloat free forage; contains steroidal sapogenins, not present in alfalfa, and other compounds known for their medicinal qualities
- Fenugreek seed in dairy cattle diet improved functional fatty acid profile in the milk, reduced blood cholesterol concentration and produced lower concentrations in milk without altering milk flavour or taste (Shah and Mir 2004).

Fenugreek contains natural growth promoting compounds such as diosgenin (Table 4), which increases livestock growth rates and so use of hormone implants can potentially be reduced if fenugreek is included in the cattle diet. These characteristics make fenugreek an interesting crop for the cattle industry.

Table 4. Mean nutrient composition, diosgenin (dios) and IVDMD of fenugreek at different growth stages and alfalfa (% of DM)

	Age of plants (wk)			Alfalfa
	9	15	19	(early bloom)
CP	25	20	16	18
NDF	29	37	39	44
ADF	25	31	34	36
Lignin	5	6	6	8
Ash	13	10	9	9
IVDMD	64	67	66	59
Dios	.15	.06	.06	ND

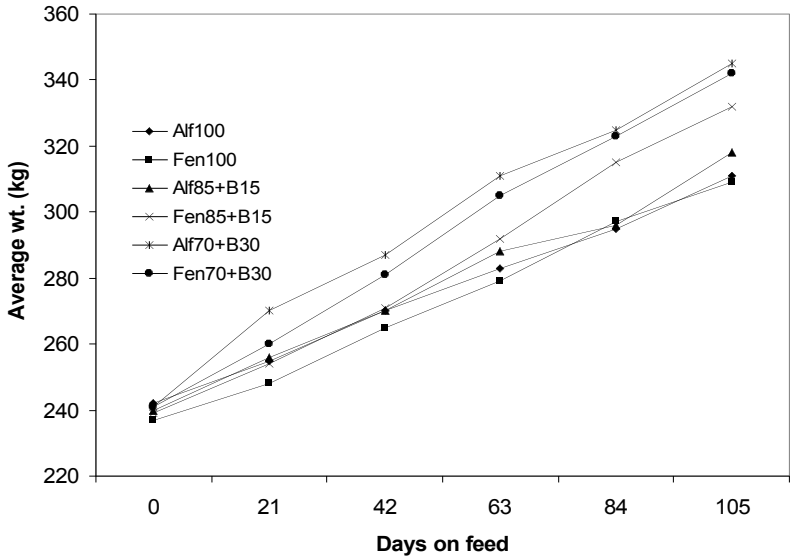

Fig. 4. Effect of feeding prime cut alfalfa and mature fenugreek silage on growth weight of backgrounding steers.

■ Perennial Cereal Rye Improvement

The other non-traditional forage crop (NTFC) we work on at LRC is perennial cereal rye (PC rye) (*Secale cereale*). This crop was developed by crossing *Secale cereale* with a perennial grass *Secale montanum* and then back crossing with *S. cereale* and selecting for perennial types (Reimann-Philipp 1995). Perennial cereal rye was expected to have the following advantages:

- Will use spring moisture and produce a second crop
- Will help conservation of soil
- Can be grown like other cereals
- Reduce silage production cost

The LRC PC rye improvement program started with the objective of developing a cultivar and associated agronomic package for production in western Canada and compare crop performance with barley, traditionally used for silage in this area. Our 15 years of experience with this crop indicates that PC rye:

- Is a winterhardy cereal that can produce more forage than barley

- Requires vernalization and so should be seeded in early fall
- Responds well to irrigation and fertilization
- Competes well with weeds
- Has comparable nutritional quality with barley (Table 5)
- Produces less seed than high yielding fall rye cultivars
- Has relatively limited adaptation to southern Alberta

Table 5. Mean (± SE) forage quality parameters of ACE-1 PC rye and Kodiak fall rye and Duke barley harvested in 2000 and 2001 from dryland plots at Lethbridge, Alberta. The crops were harvested at soft dough stage for quality analyses

	ACE-1	Kodiak	Duke
% DWT[z]	96.76 ∀ 0.35	96.55 ∀ 0.07	97.22 ∀ 0.01
% Ash	6.45 ∀ 0.42	5.76 ∀ 0.24	9.68 ∀ 0.07
% NDF[y]	59.92 ∀ 0.31	58.81 ∀ 0.23	50.52 ∀ 0.24
% ADF[x]	40.09 ∀ 0.25	37.54 ∀ 0.05	31.67 ∀ 0.48
% Lignin	7.25 ∀ 0.40	6.98 ∀ 0.12	5.35 ∀ 0.20
% C[w]	46.31 ∀ 0.29	45.62 ∀ 0.51	44.61 ∀ 0.65
% CP[v]	15.01 ∀ 0.16	15.60 ∀ 0.09	16.68 ∀ 0.91

[z]DWT = Dry Weight.
[y]NDF = Neutral Detergent Fibre.
[x]ADF = Acid Detergent Fibre.
[w]C = Carbon.
[v]CP = Crude Protein.

The first North American PC rye cultivar ACE-1 (Acharya *et al.* 2002) was released to Kenneth Long Seeds Inc. in 2001 and so far the company has sold all the seed they had produced in 2004 and 2005.

Our immediate research challenges for this crop include:

- Increase in area of adaptation, forage quality and yield
- Improvement in seed yield
- Improvement in grazing tolerance
- Improvement in persistence under competition (mixed cropping)

■ Summary:

Forage breeding program at AAFC Lethbridge deals with traditional crops such as alfalfa, cicer milkvetch, sainfoin and orchardgrass and non-traditional crops such as fenugreek and PC rye. This program primarily aims at genetic

improvement in establishment, forage and seed production and persistence of these crops in mixed stands as well as under grazing. The program also develops agronomic packages to maximize productivity, forage quality and longevity of the forage legumes with the ultimate aim of improving efficiency of the livestock industry without adversely affecting the environment. Our collaboration also aims at exploring other uses of these crops. Research on the health benefit of fenugreek is a good example of this activity.

■ References:

Acharya, S. N. 2001. AC Oxley II Cicer Milkvetch. Can. J. Plant Sci. 81:749-751.

Acharya, S. N. 2004. ACE-1 Perennial Cereal Rye. Can. J. Plant Sci. 84:819-822.

Acharya, S.N, Kastelic, J. P., Beauchemin, K. A. and Messenger, D. F. 2005. A review of research progress on cicer milkvetch (*Astragalus cicer* L.). Can. J. Plant Sci. (in press)

Min, B. R., Barry, T. N., Attwood, G. T. and McNabb, W. C. 2003. The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: a review. Animal Feed Science and Technology. 106: 3-19.

Reimann-Philipp, R. 1995. Breeding perennial rye. Plant Breed. Rev. 13: 265-292.

Shah, M. A. and Mir, P. S. 2004. Effect of dietary fenugreek seed on dairy cow performance and milk characteristics. Can J. Anim. Sci. 84: 725-729.