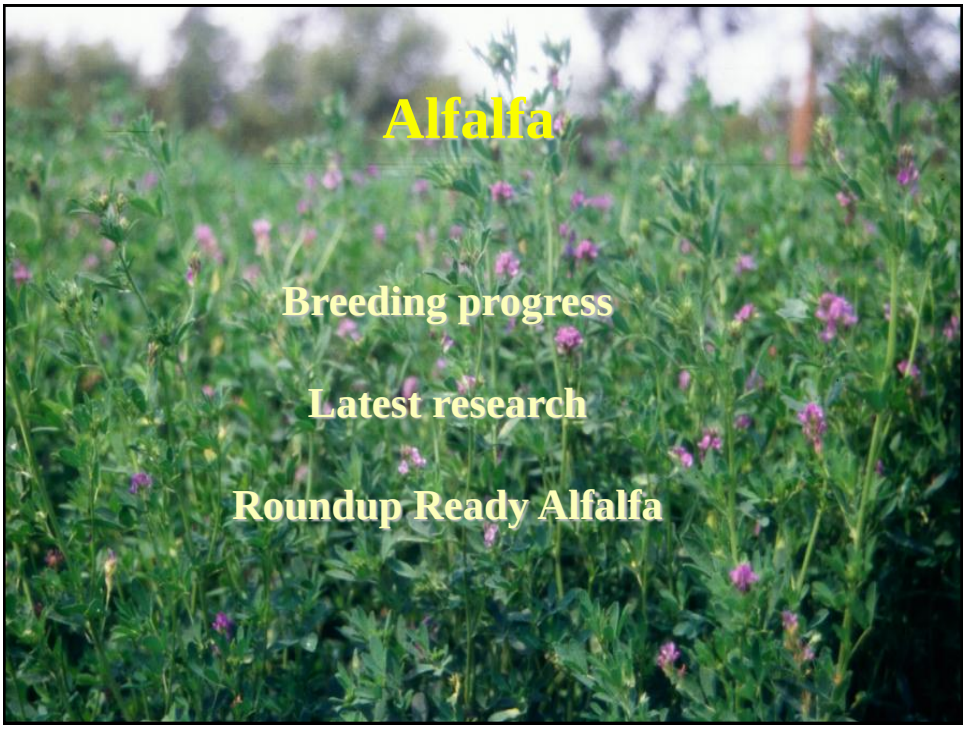
New Developments in Forage Breeding

Bruce Coulman
University of Saskatchewan

Forage crop breeding in Canada

- **Tame**
  - **U. of S./AAFC Saskatoon (Bruce Coulman)**
  - **AAFC Lethbridge (Surya Acharya)**
  - **AAFC Ste-Foy (Annie Claasens)**
  - **AAFC Kentville (Y. Papadopoulos)**
- **Native**
  - **AAFC Swift Current (Mike Schellenberg)**
  - **Alberta Res Vegreville (Jay Woosaree)**
- **Western Forage Testing System (WFTest)**
  - **11 sites in three prairie provinces**



North American Alfalfa Breeding Programs

- Canada
  - AAFC Lethbridge and Ste-Foy
  - University of Guelph - genetics
- U.S.
  - Private companies
    - Largest breeding effort
  - Universities and USDA
  - Private, non-profit – Noble Foundation

Improvements from "Conventional" Alfalfa Breeding Programs

- New varieties of all dormancy classes
- Multiple disease resistance
- Grazing tolerance
- Leafhopper resistance
- Slightly lower fiber content
- Increased forage yield
- Improved winter hardiness
- Salt tolerance

Canadian Alfalfa Breeding Programs: Lethbridge

- Continued selection for resistance to diseases
  - Latest release in AC Dalton (2007)
    - Well adapted to irrigated areas and in B.C.
- Tolerance to acid and saline soils
  - Release of AC Bridgeview (2010)

Canadian Alfalfa Breeding Programs: Ste-Foy

- The most important alfalfa breeding and research program in Canada
  - A team of scientists – breeder, physiologists, animal nutritionist, molecular geneticist
- Persistence and winter survival
  - Selection for cold tolerance in laboratory
  - Selection for disease resistance
  - Selection for persistence in the field
  - Selection based on molecular markers related to cold tolerance.

Canadian Alfalfa Breeding Programs: Ste-Foy

- Improved forage quality
  - Increase total non structural carbohydrate (sugar+starch)
    - Increase energy, digestibility
    - Population with higher TNC produced and will continue selection
  - Increase bypass protein
    - Improve protein utilization

Roundup Ready Alfalfa

- Developed by Forage Genetics International (FGI) and Monsanto
- Gene from bacteria introduced into alfalfa which gives tolerance to glyphosate
  - Same gene used in corn, soybean, canola
- U.S. regulatory approval – June, 2005
- Canadian regulatory approval – Sept., 2005
  - CFIA and Heath Canada
  - novel plant safe for food, feed and environment

Roundup Ready® Alfalfa in the U.S.

- Planted in U.S. in fall, 2005 and spring and fall, 2006
- 2.5 million lbs seed planted in 2006
  - 5% of total U.S. market
  - 50% of market in Kansas
- Were predicting 20-25% of market in 2008
- $125-$150 technology use fee per 50lb bag
- Varieties available in fall dormancies 3-8

Roundup Ready® Alfalfa in the U.S.

- California U.S. District Court decision on Feb. 13, 2007
  - Court ruled that the US Animal and Plant Health Inspection Service (APHIS) should have prepared an environmental impact statement rather than an environmental assessment
    - Violated the National Environmental Policy Act
- Further sales of RR alfalfa were prohibited

Roundup Ready® Alfalfa in the U.S.

- APHIS provided provisions for RR alfalfa already planted
  - Procedures for cleaning forage and seed harvesting equipment used for RR alfalfa
  - Provisions for segregating and labelling RR hay and seed
- APHIS prepared Environmental Impact Statement and released final version in late 2010
- RR Ready alfalfa re-granted non-regulated status in Feb, 2011
  - Plantings resumed in spring, 2011

Roundup Ready Alfalfa in Canada

- Although approved for cultivation and production, RR Ready alfalfa is not grown in Canada
- Roundup ® not currently approved for use on alfalfa
  - Trials have been done to obtain minor use label
- RR Ready varieties currently not registered for sale in Canada
  - Field trials underway in 2011 in Ontario and Quebec
- No apparent present interest in using in western Canada
  - Alfalfa most often seeded in mixtures with grasses

Assessing the Potential Impact of Roundup Ready® Alfalfa on Canada's Forage Industry

Workshop – Saskatoon Dec. 2011

Douglas Yungblut, Ph.D., P.Ag.
Jacques Jalbert, M.Sc., Agr.

http://www.canadianfga.ca/research-projects/completed-projects/

Canadian Forage & Grassland Association
Association Canadienne pour les Plantes Fourragères

Sask Forage Council

Alfalfa research: Reduction of lignin

- Indigestible component that also makes cellulose less digestible
- Reduced lignin increases forage digestibility and provides more available sugars
- Reduced lignin (20-30%) lines available through "knocking out" activity of certain enzymes involved in lignin biosynthesis
  - Produced by Noble Foundation and Forage Genetics International
  - Preliminary feeding trials show improved animal performance with these lines
- Commercial release in 2014?

Alfalfa research: Bloat reduction and bypass protein

- AAFC Saskatoon
- First lines which express condensed tannins in leaves
  - Very low concentrations
- Digestibility experiments – Lethbridge
  - Lower initial rate of overall digestion
  - Lower initial rate of nitrogen digestion
- Now being evaluated more by comprehensively at U. of S. by graduate student
- Concentrations of tannins must be increased to have significant beneficial effects

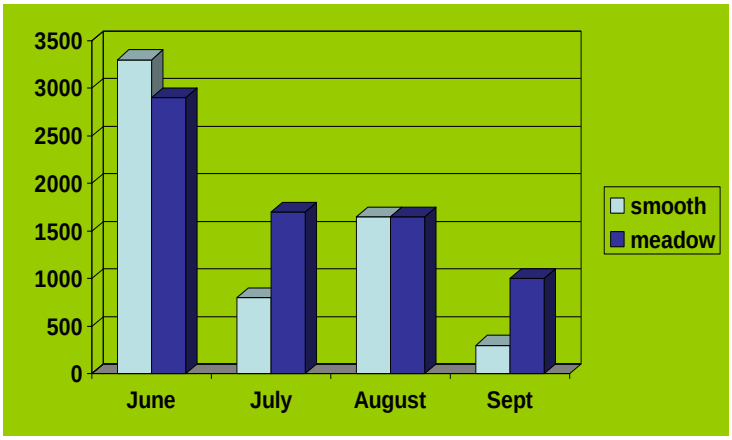
Perennial Grass Breeding Saskatoon

- Meadow bromegrass
- Hybrid bromegrass
- Crested wheatgrass
- Orchardgrass
- Timothy

Smooth bromegrass
(Bromus inermis)

Meadow bromegra
(Bromus riparius)

Bromegrass yields (kg/ha DM) at four harvests in Lacombe, Ab



Knowles et al. 1992

Meadow bromegrass breeding

- Improved seed and forage yield
  - Release of Armada in 2008
- Improved vigor and greenness in fall
  - Release of Admiral in 2009
- Expand genetic base
  - 72 accessions from world genebanks

Hybrid bromegrass breeding (Saskatoon)

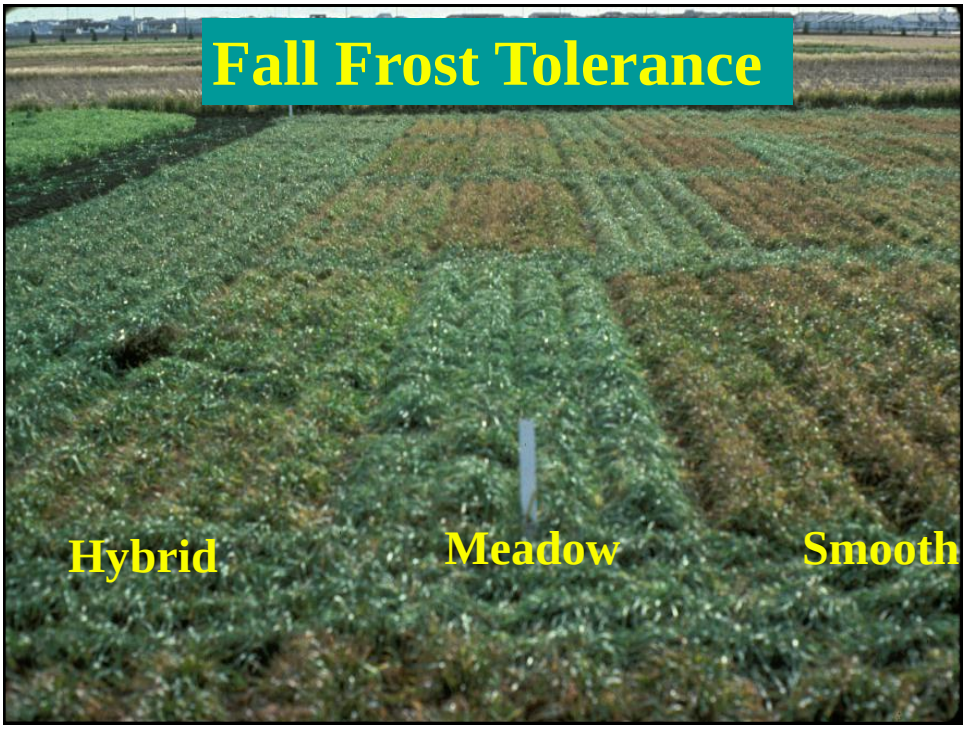
- Meadow X smooth bromegrass hybrid populations
  - Original crosses made in late 1970s
- Dual purpose type of grass
  - High first cut yield like smooth
  - Fast regrowth like meadow brome

Hybrid bromegrass *(B. riparius X B. inermis)*

Characteristics of hybrid bromegrasses

- Are hybrid populations, not hybrid cultivars
  - Seed production is same as for parental species
- Intermediate to the parental species in many characteristics
- Chromosome numbers variable – most 56, some plants 62 or 63
- Good hay production and regrowth
- Pubescent leaves and stems like meadow brome
- Reduced creeping habit like meadow brome

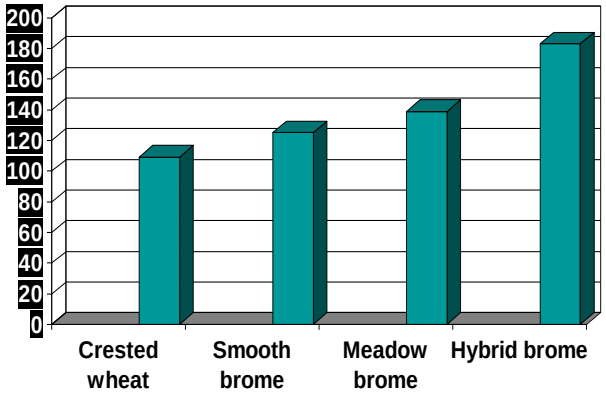

Regrowth After First Cut
Smooth
Hybrid
Meadow
B. Coulman


Fall Frost Tolerance
Hybrid
Meadow
Smooth

Hybrid bromegrass cultivars

- AC Knowles (2000)
  - More "meadow brome" like in appearance
- AC Success (2003)
  - More "smooth-brome like" in appearance
- S9478 (under development)
  - New population bred for wider adaptation

Beef gains (kg/ha) – 2000,01 Termuende, Sk grazing trial



Thompson et al. 2003. Can. J. Anim. Sci. 83:165

Crested wheatgrass breeding at Saskatoon

- *Agropyron cristatum*
  - Most common type
  - 2X, 4X

Parkway

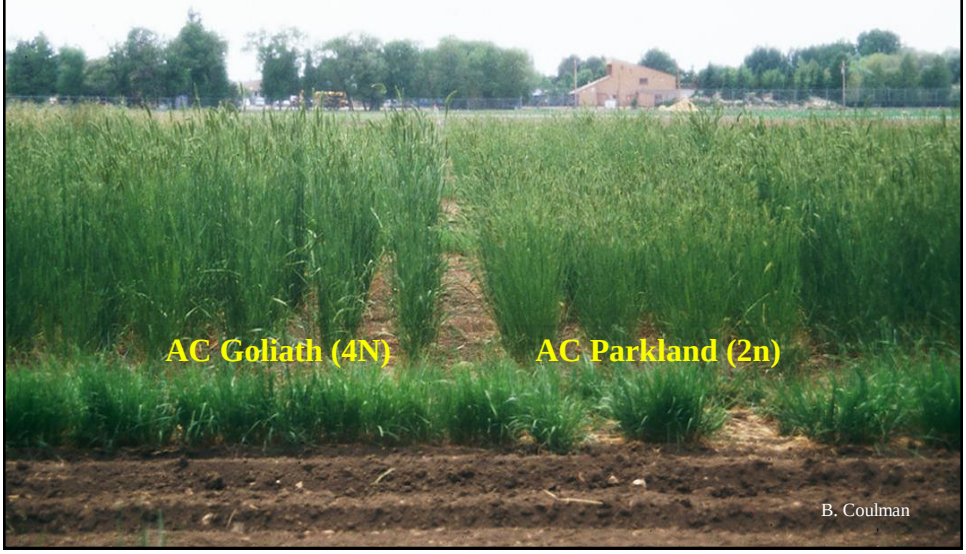
AC Goliath

Kirk

Crested wheatgrass breeding at Saskatoon

- **Release of AC Goliath in 2001**
  - **Tetraploid *Agropyron cristatum***
  - **Tall, large seeded, narrow crowned**
  - **High yields in regional trials**
- **Release of Newkirk in 2010**
  - **Tetraploid A. cristatum**
  - **Not as tall as Goliath but high yields**

Crested wheatgrass (*Agropyron cristatum*)



Timothy breeding at Saskatoon

- Use in western Canada was increasing for compressed hay prior to 2005
  - High Canadian dollar reduced production
- Several high yielding lines were selected for compressed hay market
  - Disease resistant
  - Early cultivars for irrigation
  - Late cultivars for dryland

Orchardgrass breeding at Saskatoon: Recent releases

AC Kootenay (2007)

- very winterhardy
- high yielding

AC Killarney (2007)

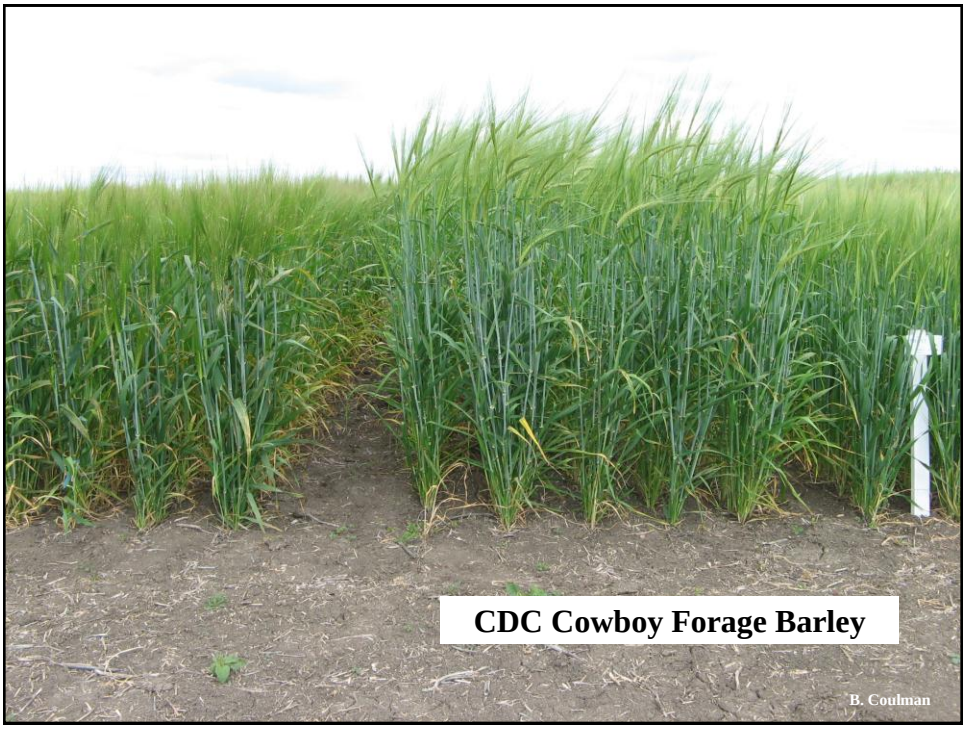
- selected for persistence under grazing

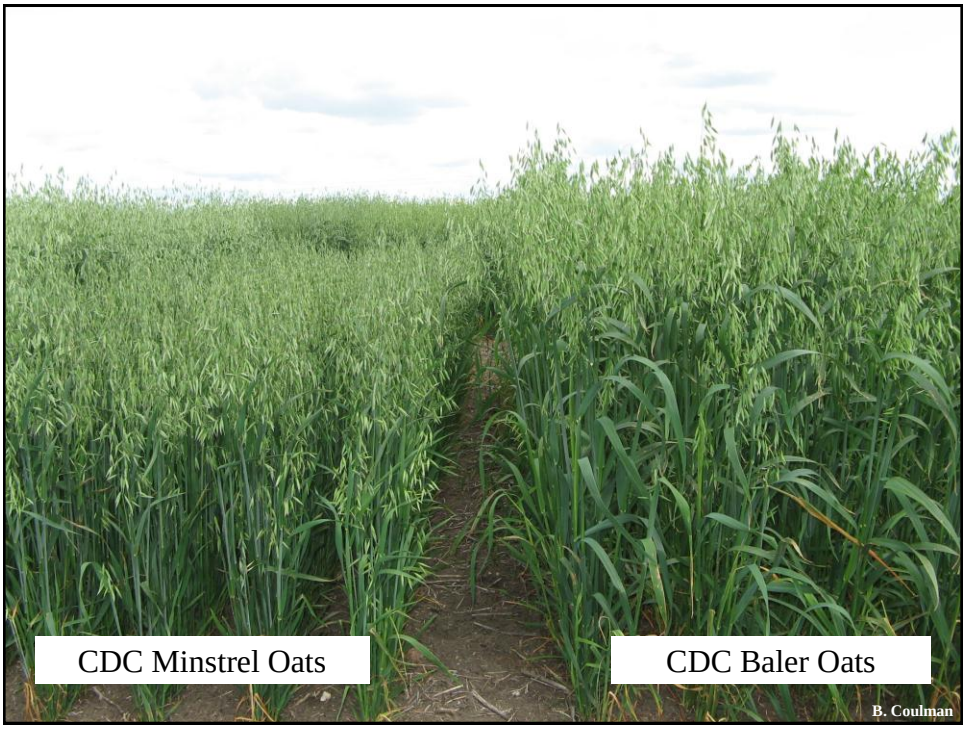
Forage Barley and Oat breeding

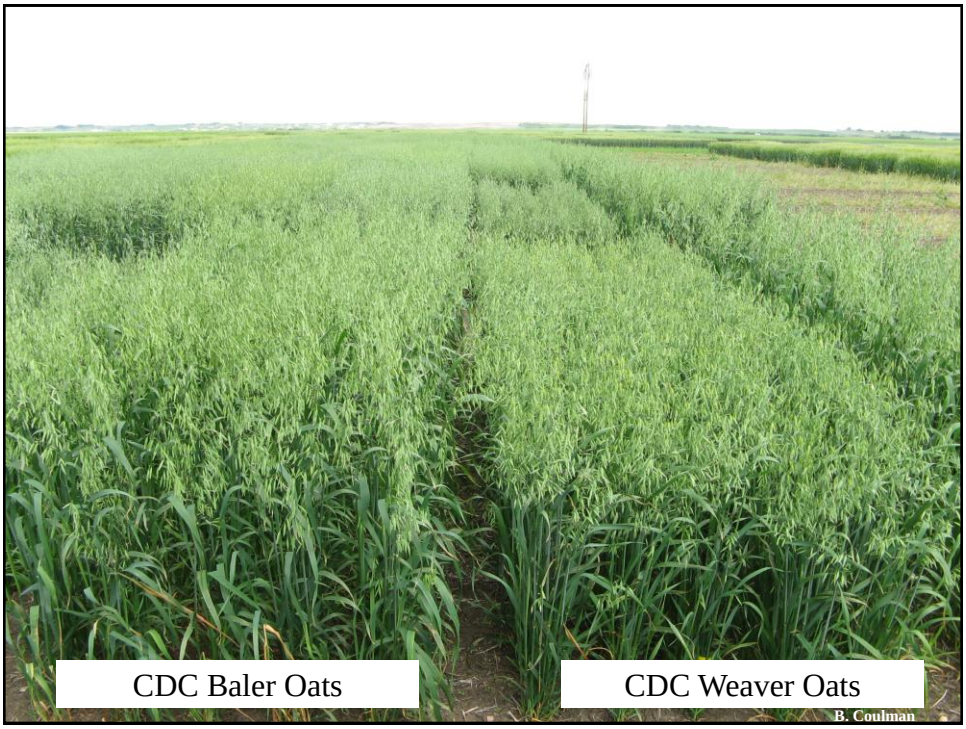
- Grain barley breeders at Brandon, Lacombe and Saskatoon do a small amount of forage barley breeding
- Forage oat and barley program at the University of Saskatchewan
  - Collaboration of Aaron Beattie, Brian Rossnagel and Bruce Coulman
  - Improved yield and quality is the goal for both species.

Recent Releases from Saskatoon Program

- CDC Maverick forage barley (2011)
  - High yielding like CDC Cowboy
  - Has smooth awns
- CDC Haymaker forage oat (2012)
  - Tall, late maturing type like CDC Baler
  - Higher yielding and slightly lower fiber than Baler


CDC Cowboy Forage Barley
B. Coulman


CDC Minstrel Oats
CDC Baler Oats
B. Coulman


CDC Baler Oats
CDC Weaver Oats
B. Coulman


CDC Baler Oats
B. Coulman

Summary and what is the future of forage crop breeding in Canada

- There are presently four tame forage breeding programs releasing new varieties on a regular basis
  - Main focus is feed for livestock production
- Future goals may include selection for biomass/energy production

Summary and what is the future of forage crop breeding in Canada

- New developments such as lower lignin and condensed tannins show promise for improving the forage quality of alfalfa
  - involve transgenic (GMO) technologies