Forage Breeding in Canada

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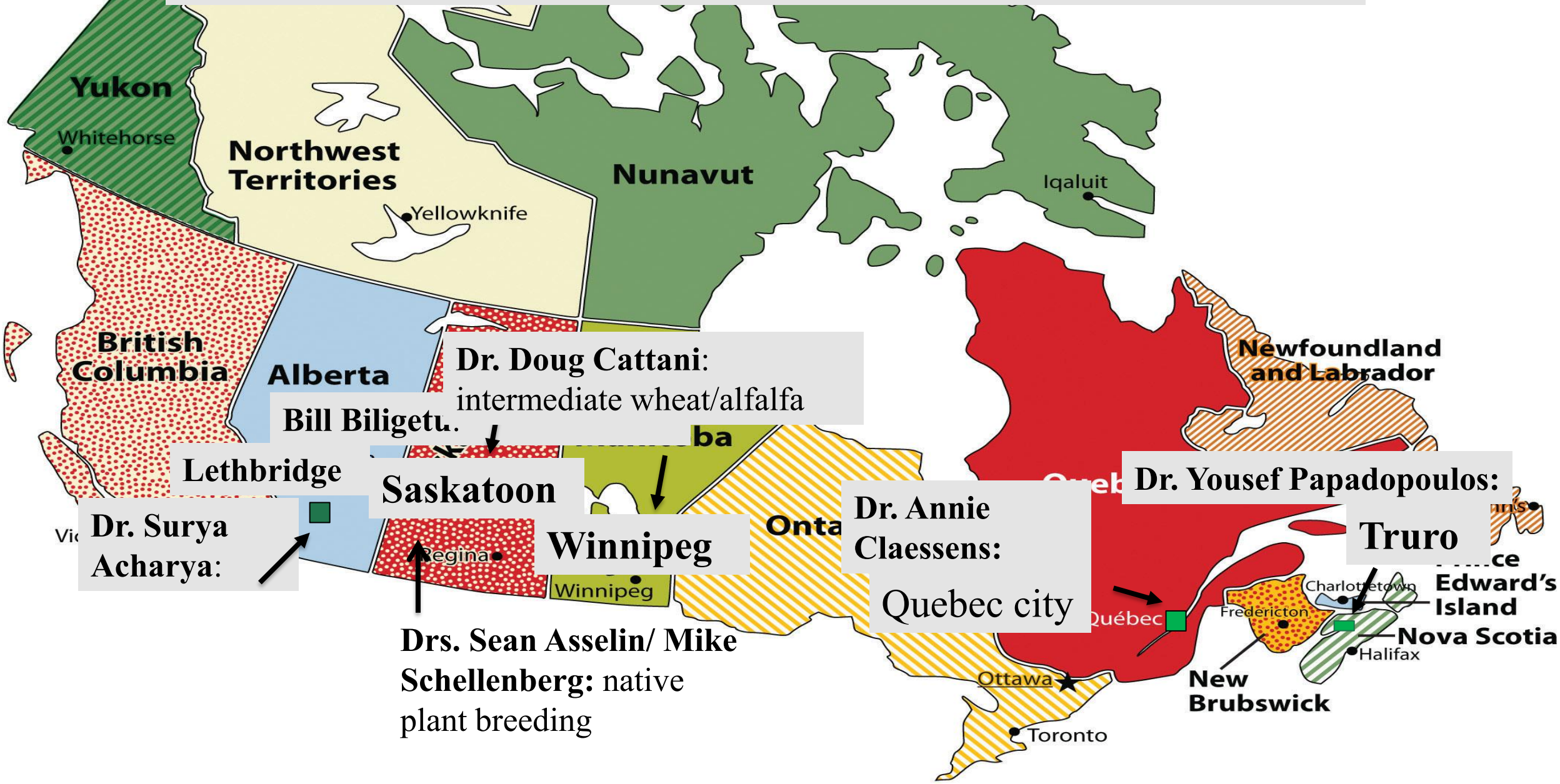
UNIVERSITY OF SASKATCHEWAN

Outline

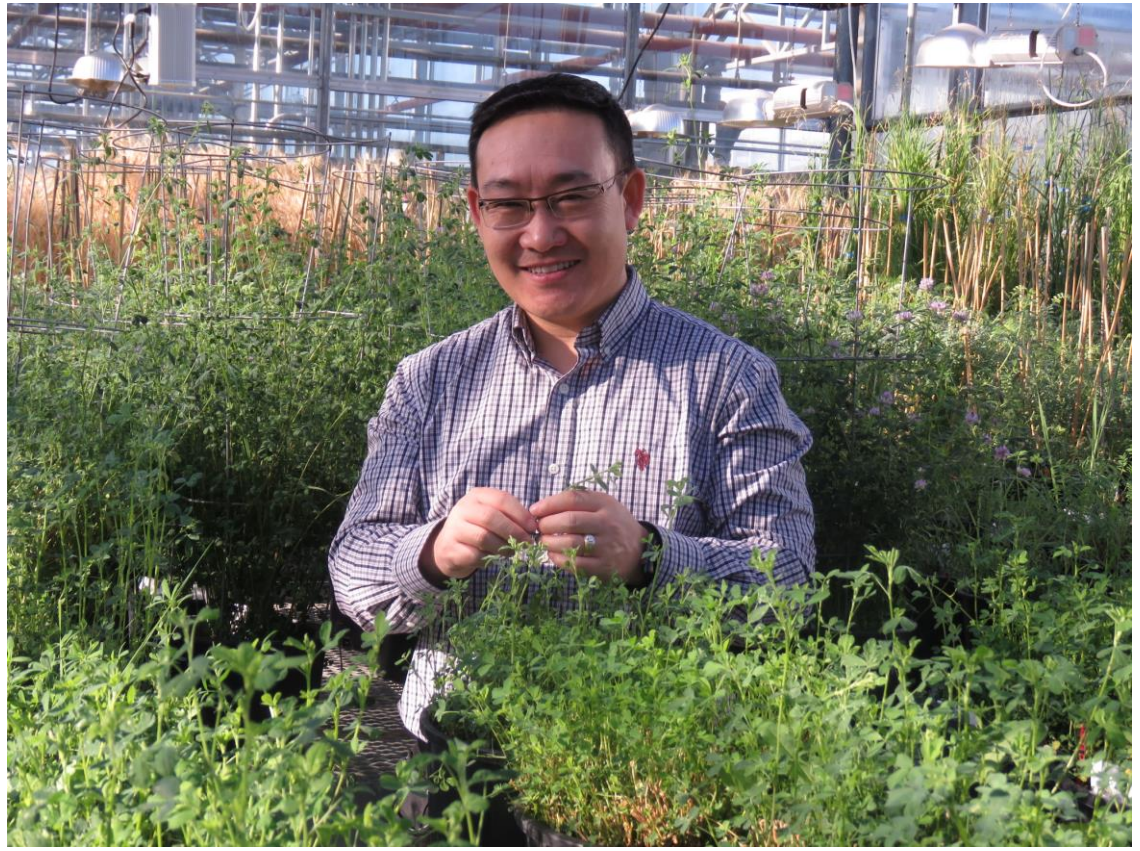
- Canadian forage breeding programs (with focus on Saskatoon program)
- New forage variety update
- Future perspectives of forage breeding

Forage breeding in Canada



UofS Forage Breeding Program-Saskatoon

Dr. Bruce Coulman



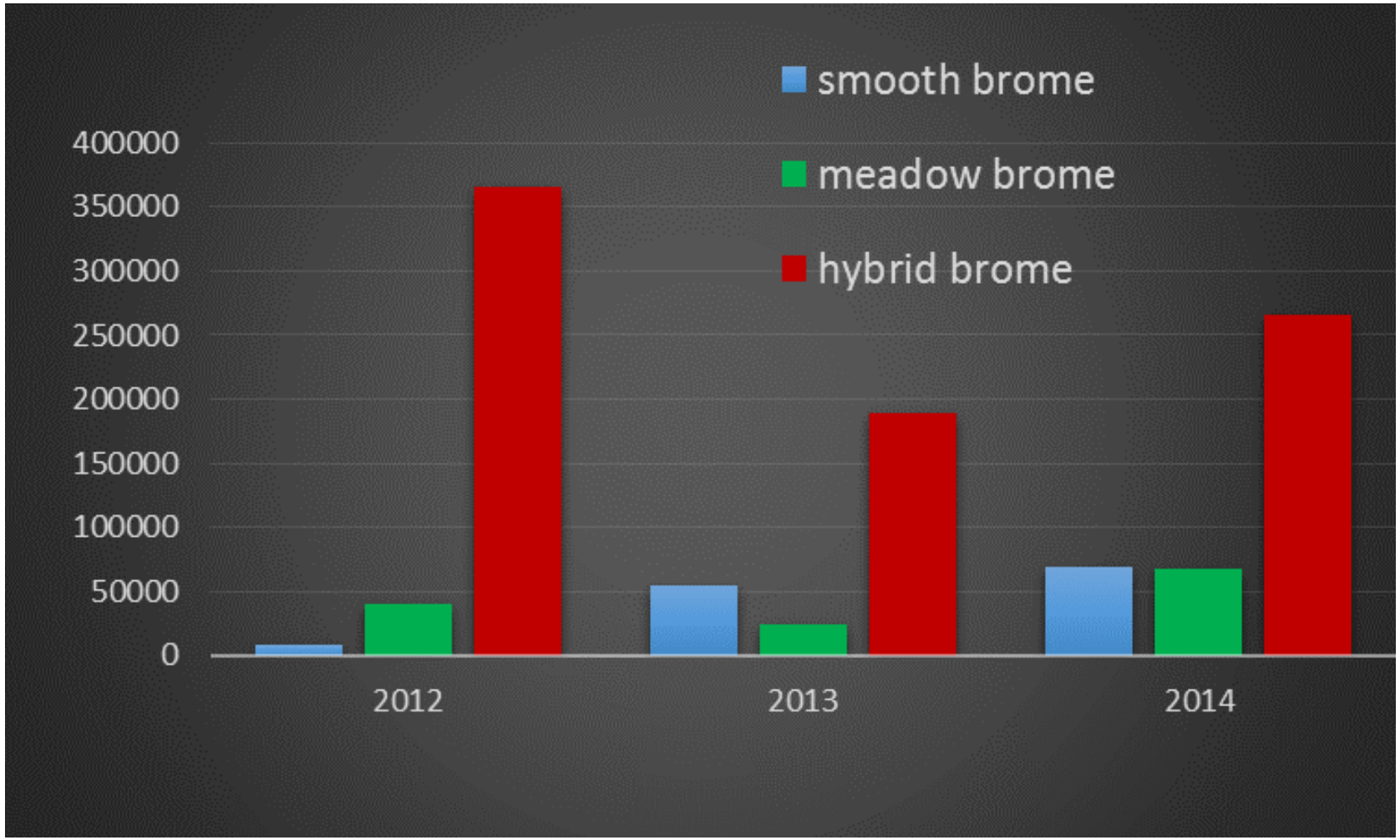
Bill Biligetu

Saskatoon grass breeding

Hybrid bromegrass

- Meadow brome X smooth brome
- Dual purpose type of grass
  - First cross 1978
- AC Knowles (2000) AC Success (2003)
- Current breeding goal:
  a) Improved seed yields
  b) NDF digestibility

Seed delivery ($) of meadow, hybrid and smooth brome 2012-2014 (source: SFSDC)



Saskatoon grass breeding

- **Meadow brome**
  a) Important pasture grass in western Canada
  b) AAC Maximus (2018) – improved seed/biomass yield
  c) Improved fall regrowth

Saskatoon grass breeding

Crested wheatgrass

Diploid (2X)

Tetraploid (4X)

Hexaploid (6X)

Crested wheatgrass

Value: drought tolerance, early greenness

Breeding goal: Late maturity

April 21 2015

Alfalfa CWG

Seed head development

Late maturity in crested wheatgrass

Hybrid wheatgrass

- Natural hybrid
- Choice for saline soil
- Complete well with foxtail barley
- ‘Hoffman’& ‘NewHy’ (1989) by USDA, Logon Utah
- ‘AC Saltlander’ (2004) AAFC, Swift Current
  - Cost of seeds is high
- **S9615** selected for higher seed yield

  - greenhouse/farm sites

Hybrid wheatgrass

- Improved seed yield

S9615 > AC Saltlander (EC=16dS/m)

Strongfield SK 2019

EC=9.8 dS/m

Intermediate wheatgrass

- A few new breeding lines recent years

Other grasses

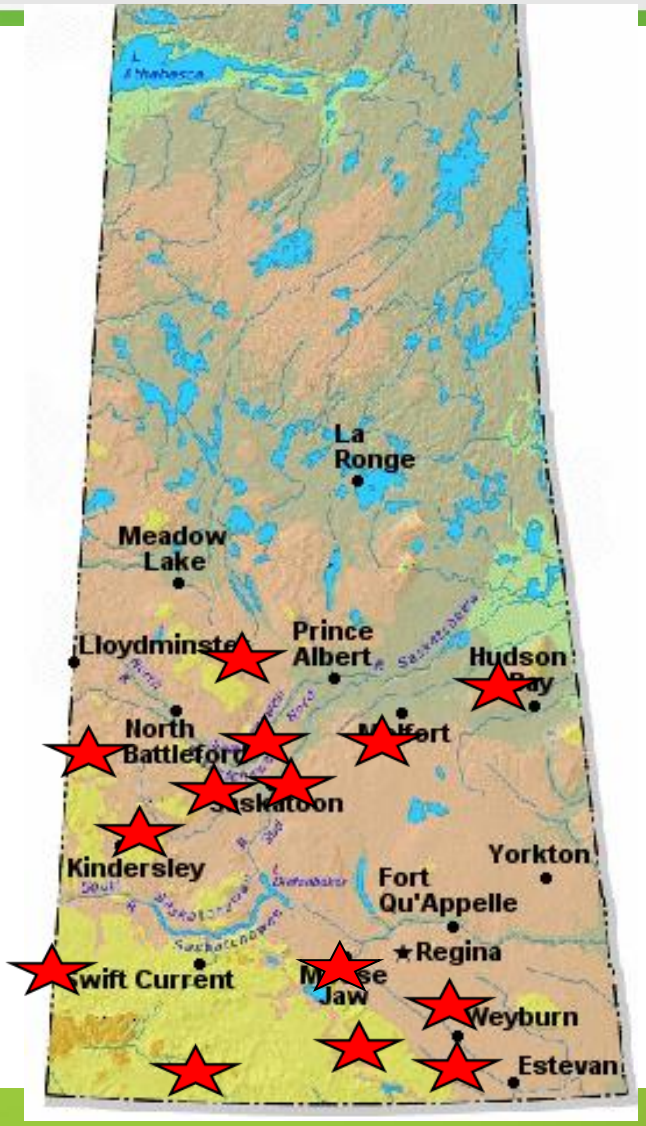
- **Orchardgrass**
- **Tall fescue**
- **Timothy**
- UofS
- USDA –Logan, UT
- AAFC Quebec
- AAFC Swift Current
- AAFC Beaverlodge
- Measurement (survival, yield, nutritive value)

Saskatoon 2019

Swift Current 2019

Saskatoon program- Development of grazing tolerant alfalfa

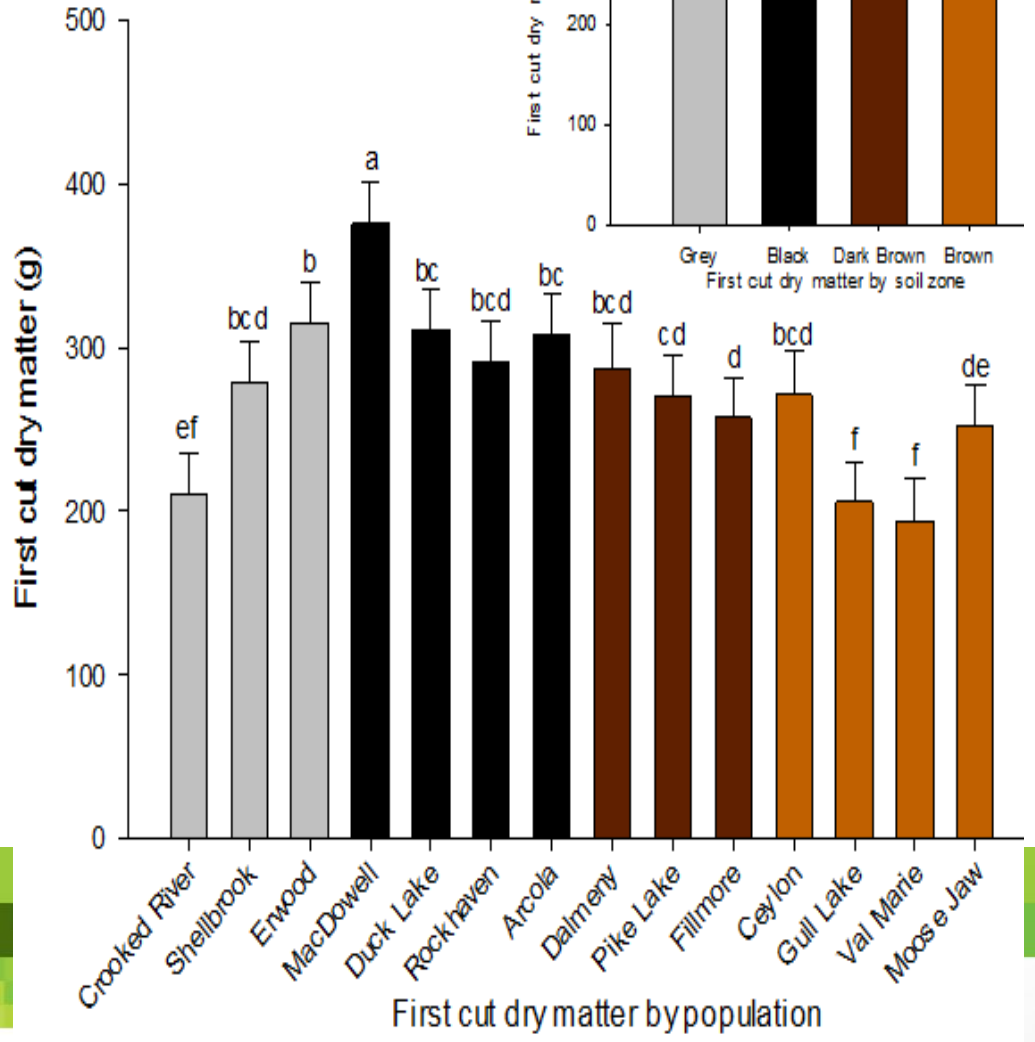
- **Alfalfa stand 25+yr long grazing history**
- **4 Soil zones**
- **14 sites**
- **30 plants/site**



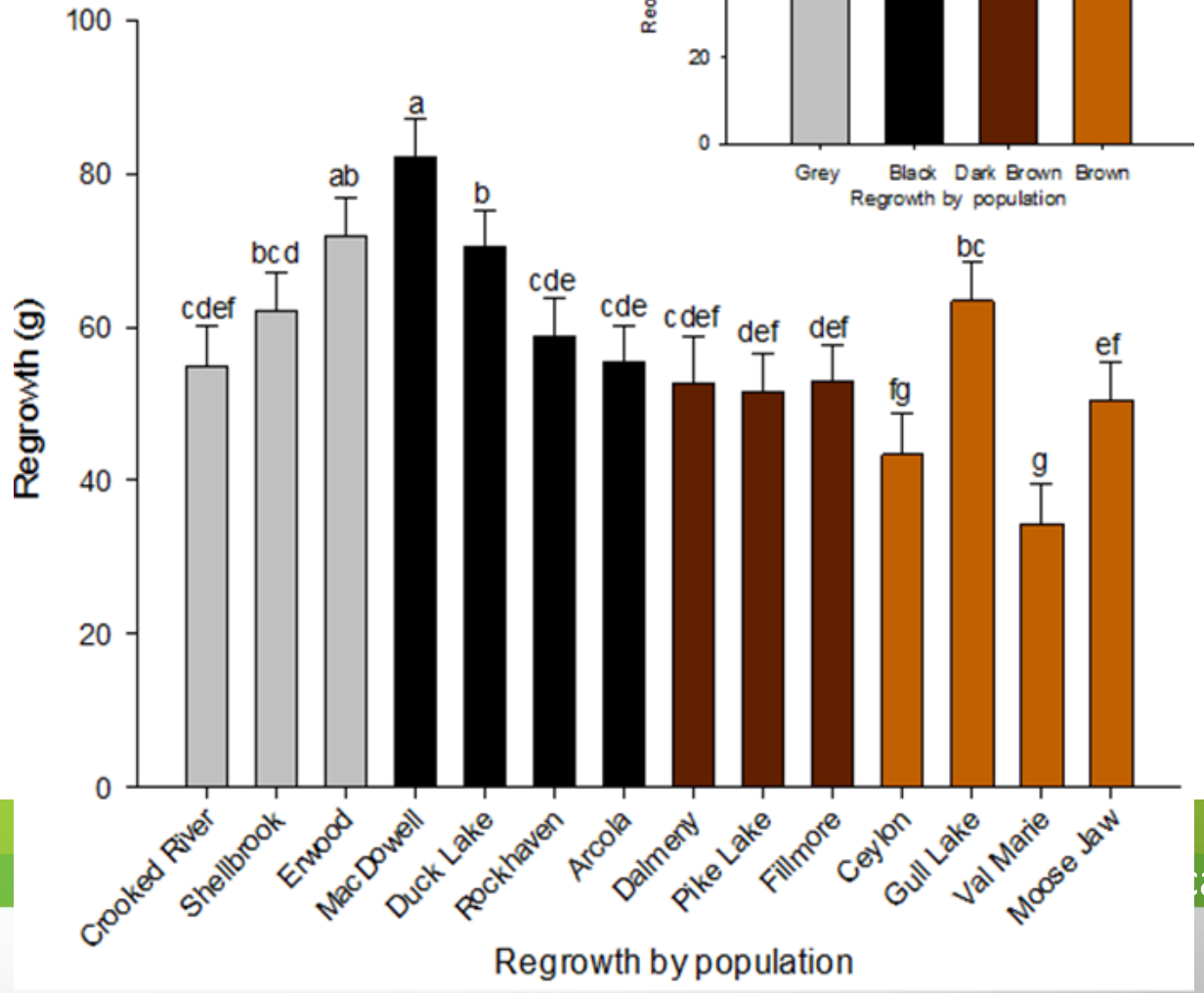
2017 summer

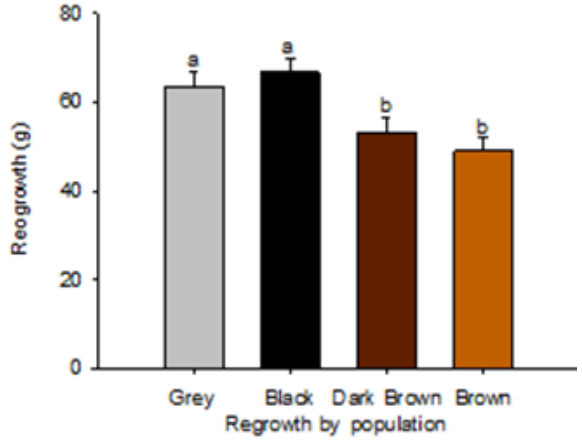
Forage yield

First cut

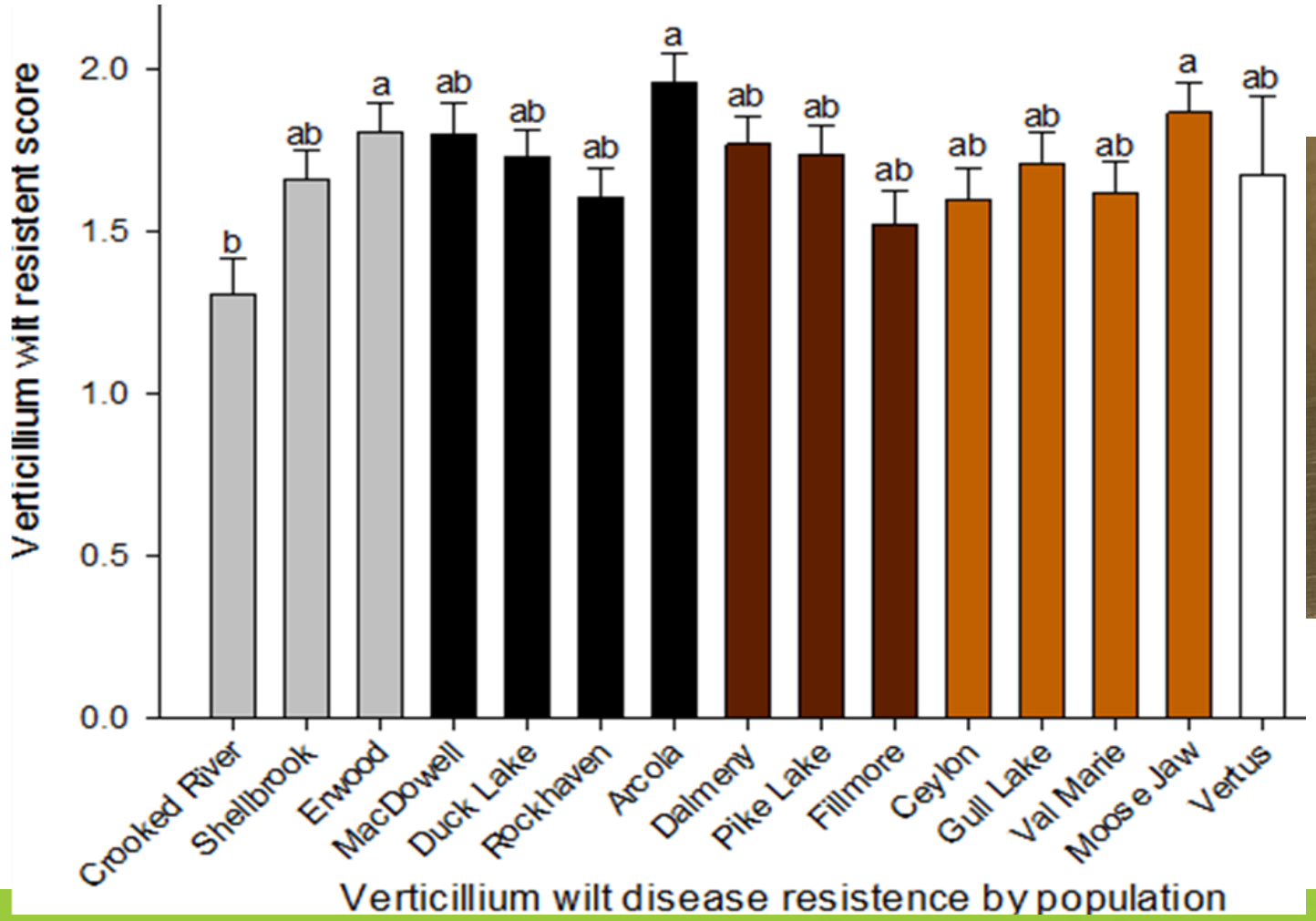


Regrowth





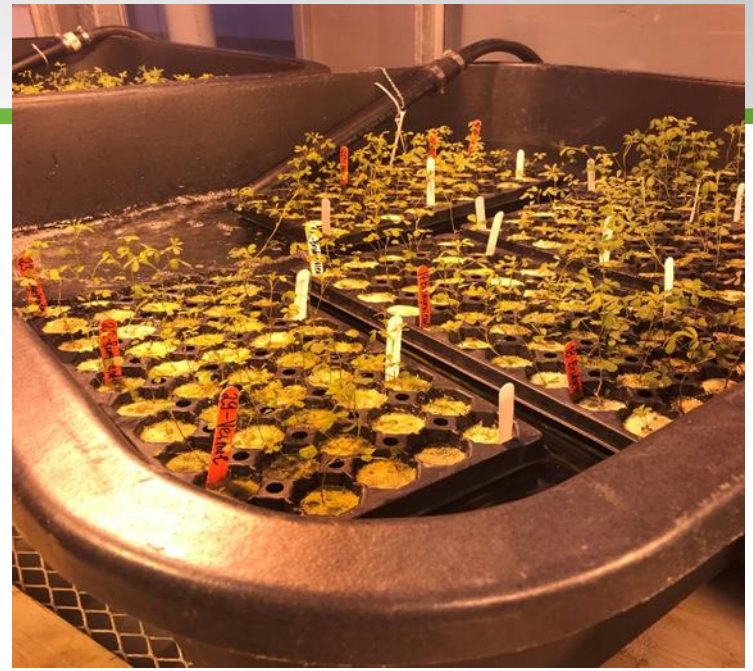
Verticillium wilt disease evaluation

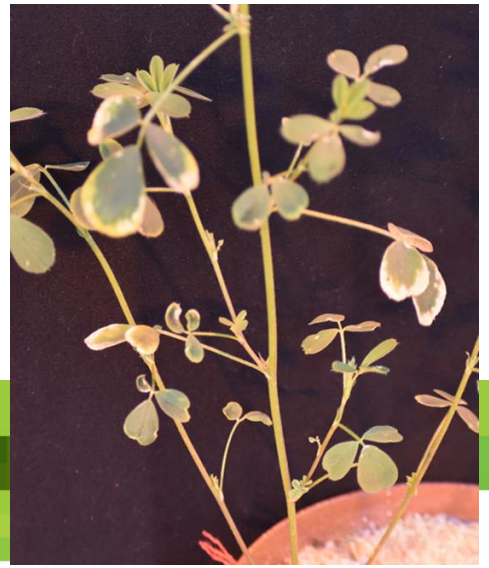


Verticillium wilt spore under 40X microscope

Alfalfa salt tolerance

- Moderate tolerance
- over 50 varieties in USA
- Germination under salt
- Bridgeview
- Halo
- Rugged





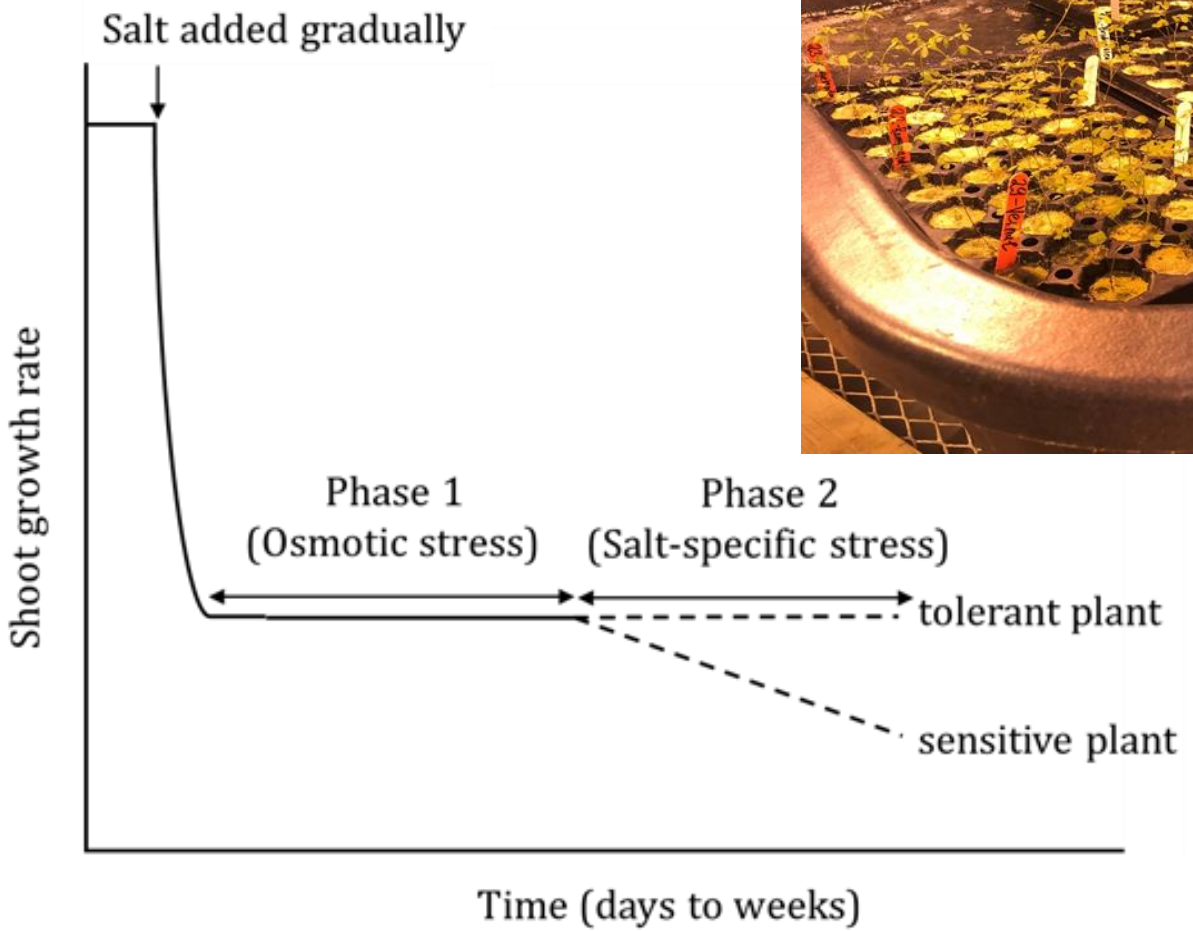


Figure 2. Two-phase growth response to salinity (From Munns, R. 2005. New Phytologist; 167:645–663.)

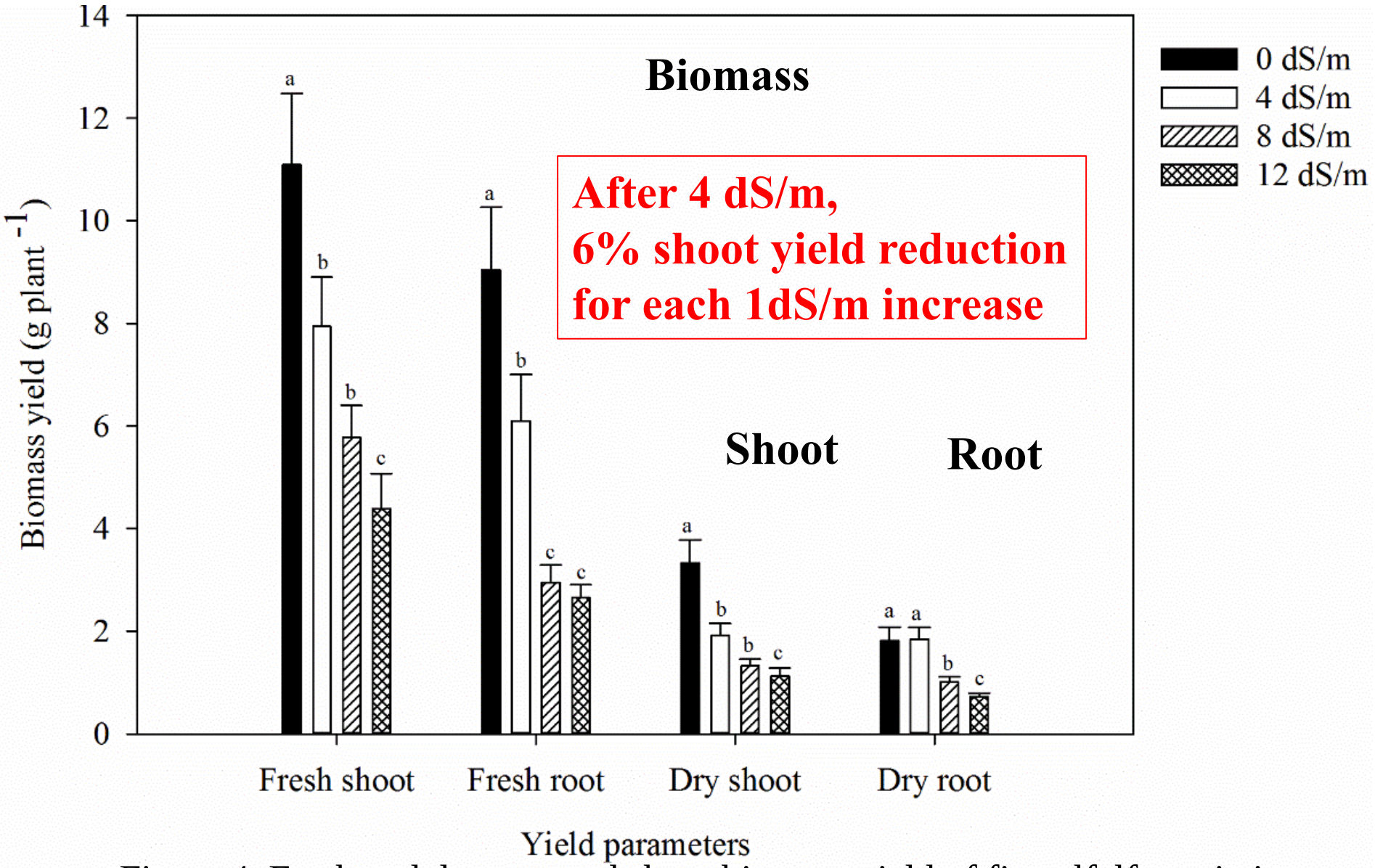


Figure 4. Fresh and dry root and shoot biomass yield of five alfalfa varieties under four gradient of salt stress

Molecular marker development (leaf of tolerant alfalfa)

	Gene ID	Putative function	Nr ID[a]	Log_2FC[b] at HL3[c]	Log_2FC at HL27[d]
Halo leaf tissue	TRINITY_DN17973_c0_g1	No significant hit	-	-6.88	-7.15
	TRINITY_DN25497_c0_g1	14-3-3 protein 9	XP_003596410.1	-6.35	-6.24
	TRINITY_DN3043_c0_g3	salicylate carboxymethyltransferase	XP_003629413.1	-5.49	-6.67
	TRINITY_DN7630_c0_g1	glycine-rich RNA-binding protein GRP1A	XP_003606916.1	-4.57	-4.32
	TRINITY_DN88_c0_g1	chaperone protein dnaJ C76, chloroplastic	XP_003589717.2	-4.39	-4.37
	TRINITY_DN1624_c1_g1	mRNA turnover protein 4 homolog	XP_003593096.1	-3.98	-2.53

Saskatoon program- Sainfoin breeding progress

- Winter survival
- Forage/seed yields

Saskatoon program- Red clover

Seed yield increase

- Organic growers
- Cover crops
- Green manure

Western Canada – AAFC Lethbridge Research Center

Forage species

Alfalfa
Sainfoin
Cicer milkvetch
Orchardgrass
Fenugreek

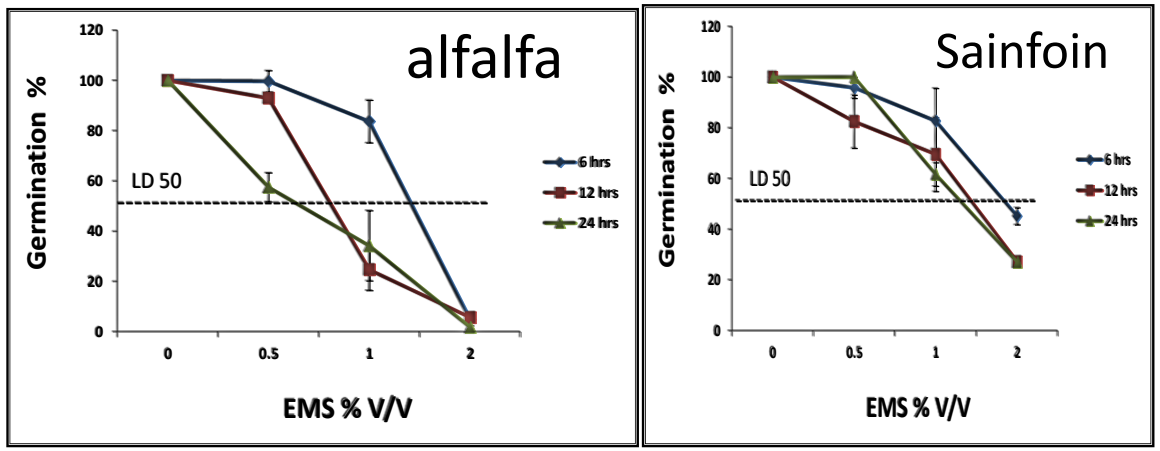
Dr. Surya Acharya

- ♠ Improved leaf lipid content
- ♠ Improved biotic & abiotic stress tolerance
- ♠ Improved ability to establish in existing pasture

AAFC Lethbridge Research Center

Enhancement of total lipid content in vegetative tissues of sainfoin using EMS mediated mutagenesis

- **Treatments included EMS at four concentrations (0, 0.5, 1.0 and 2% v/v) and three seed treatment periods (6, 12 and 24 hr)**
- **Mutagenic effect of EMS on seeds and plants was ascertained** through the altered seed germination, higher proportions of seedling death, stunted plants, and albino or xantha phenotypes compared to controls treated with 0% EMS.



Effect of chemical mutagenesis on seed germination

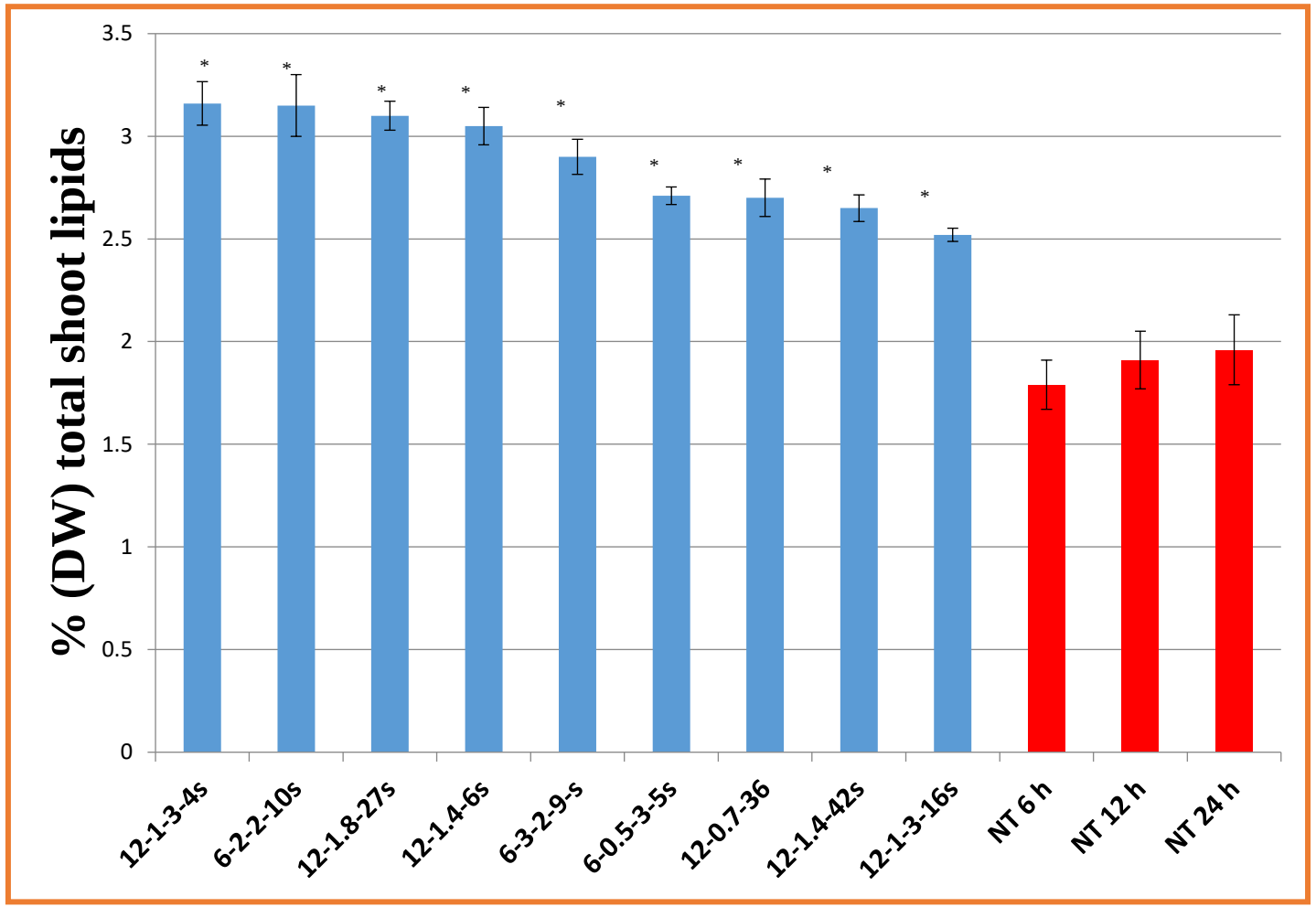
Albino phenotype in alfalfa

Dwarf phenotype in sainfoin

Altered phenotypes of EMS-treated plants

AAFC Lethbridge Research Center

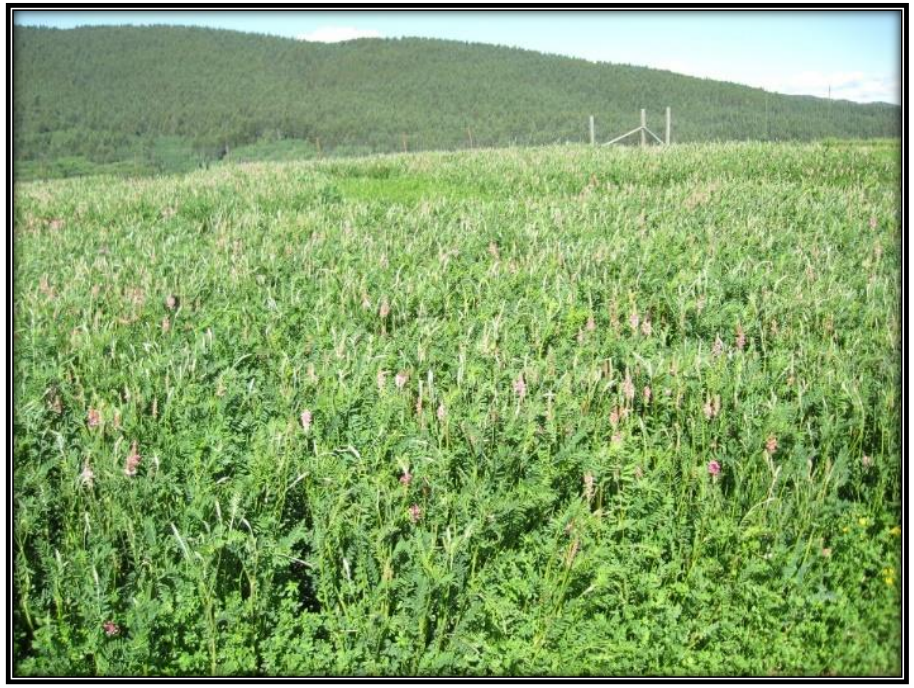
Total shoot lipid content and fatty acid composition of selected sainfoin plants subjected to EMS mutagenesis



AAFC Lethbridge Research Center

Development of acid tolerant sainfoin

- Sainfoin were grown in foothills (pH: 5.5 to 6) and cut three times / year.
- Selected individual plants were cloned and moved to GH after 3 years and intercrossed to produce a new population



AAFC Lethbridge Research Center

Rejuvenation of depleted pastures with bloat-free legumes for high performance cattle grazing

Western Canada : AAFC Swift Current

Native forage Breeding

- Development of native plant genomic resources
- Purple prairie clover, white prairie clover
- Native wheatgrasses
- Winterfat
- Dual-use perennial grain-forage systems

Dr. Sean Asselin

Dr. Mike Schellenberg

Forage Breeding - AAFC Quebec

Research Team

Annie Claessens	Forage breeder
Annick Bertrand	Forage Biochemistry
Solen Rocher	Genomic and genetics
Patrice Audy	Forage pathology

Forage Species

- Alfalfa
- Timothy
- Switchgrass
- Reed canarygrass

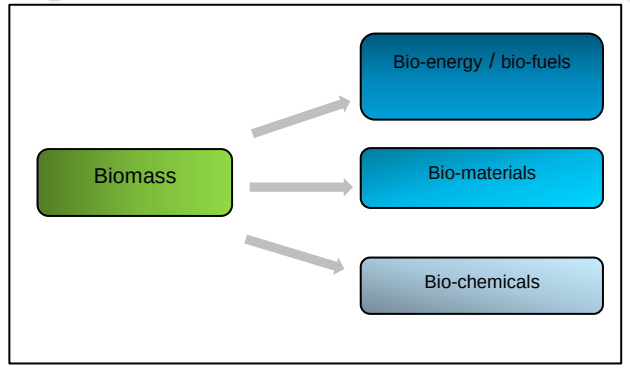
AAFC Québec Forage Breeding Program

Dairy, Beef, and Hay industries

Alfalfa

Timothy

Bioproduct industry



Switchgrass

Reed canarygrass

AAFC Québec Forage Breeding Program

Alfalfa

- High stem sugar content
- Cell wall digestibility
- Cold tolerance and diseases resistance
- Lower fall dormancy/higher cold tolerance to increase total yield

Timothy

- Regrowth
- Rust resistance

Switchgrass

- Cold tolerance and disease resistance
- Dry matter degradability for ethanol production

Atlantic Canada - AAFC Kentville, Nova Scotia

Forage Species:

- Red Clover
- Alsike Clover
- Kura Clover
- Birds foot trefoil
- Orchardgrass
- Alfalfa

Dr. Yousef A. Papadopoulos

AAFC Kentville program

Alfalfa

- Tolerance to spring/fall water logging
- Acid soil tolerance
- High forage yield

Flooding Tolerance

Red Clover

- General adaptation
- Resistance to soil borne root-lesion nematodes

Birdsfoot Trefoil

- Productivity under intensive grazing
- Improved condensed tannins profiles

New cultivar updates

New Cultivars by UofS/AAFC Saskatoon

Hybrid brome - AAC Torque (2018)

15 site-years:

-7% higher yield than AC Knowles
-3% higher than AC Success

Seed available from 2021 seeding

- **Meadow brome**
  a) S9549 Improved regrowth

- **ST1 Timothy**
  - 7% higher biomass yield than ‘Climax’ (15 site –year)
  - 45% higher seed yield than ‘Climax’ (4 site –year)

New Cultivars by AAFC Lethbridge

AAC Mountainview sainfoin (2013)

- Improved regrowth in mixtures with alfalfa

AAC Glenview sainfoin (2016)

- Improved regrowth, high yield

AAC Greenview (2016)

- High forage/seed yields
- Improved winterhardiness

New Cultivars by AAFC Kentvill

AAC Trueman (2017)

- Flooding and grazing tolerance

New Cultivars by AAFC Quebec program

- AAC Nikon alfalfa (2013)
- AAC Prestige Timothy (2014)

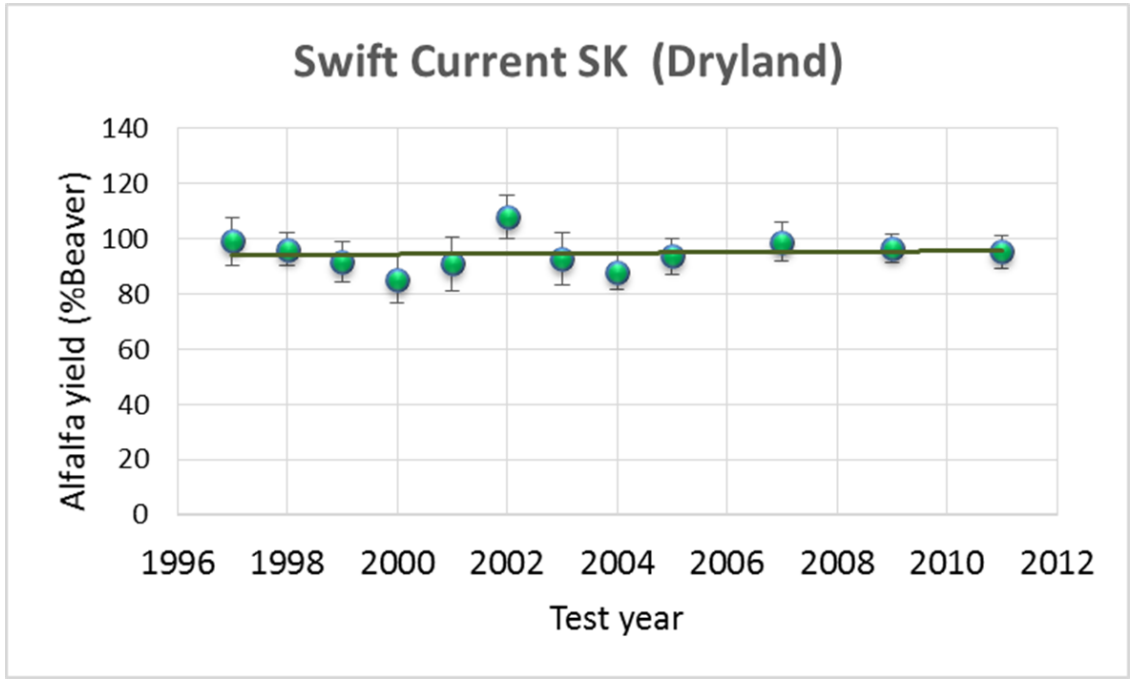
Forage breeding: future perspectives

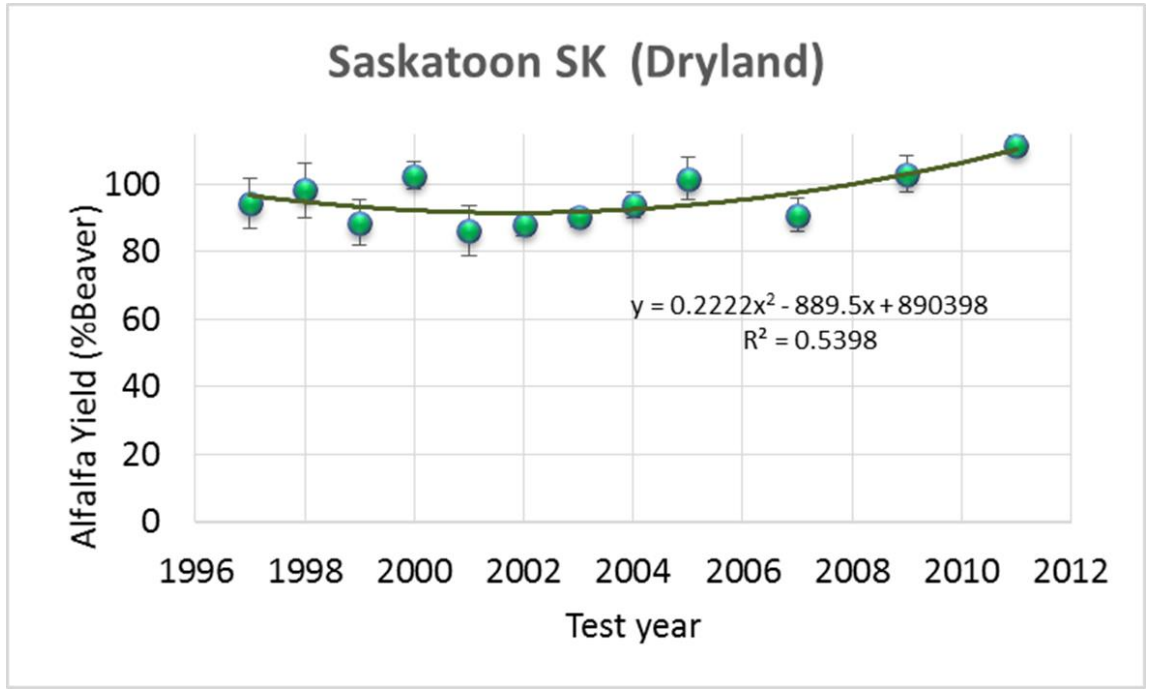
Challenges of forage breeding

- Many species to work on
- Outcrossing nature of perennials
- Limited resources (technical, research funds)

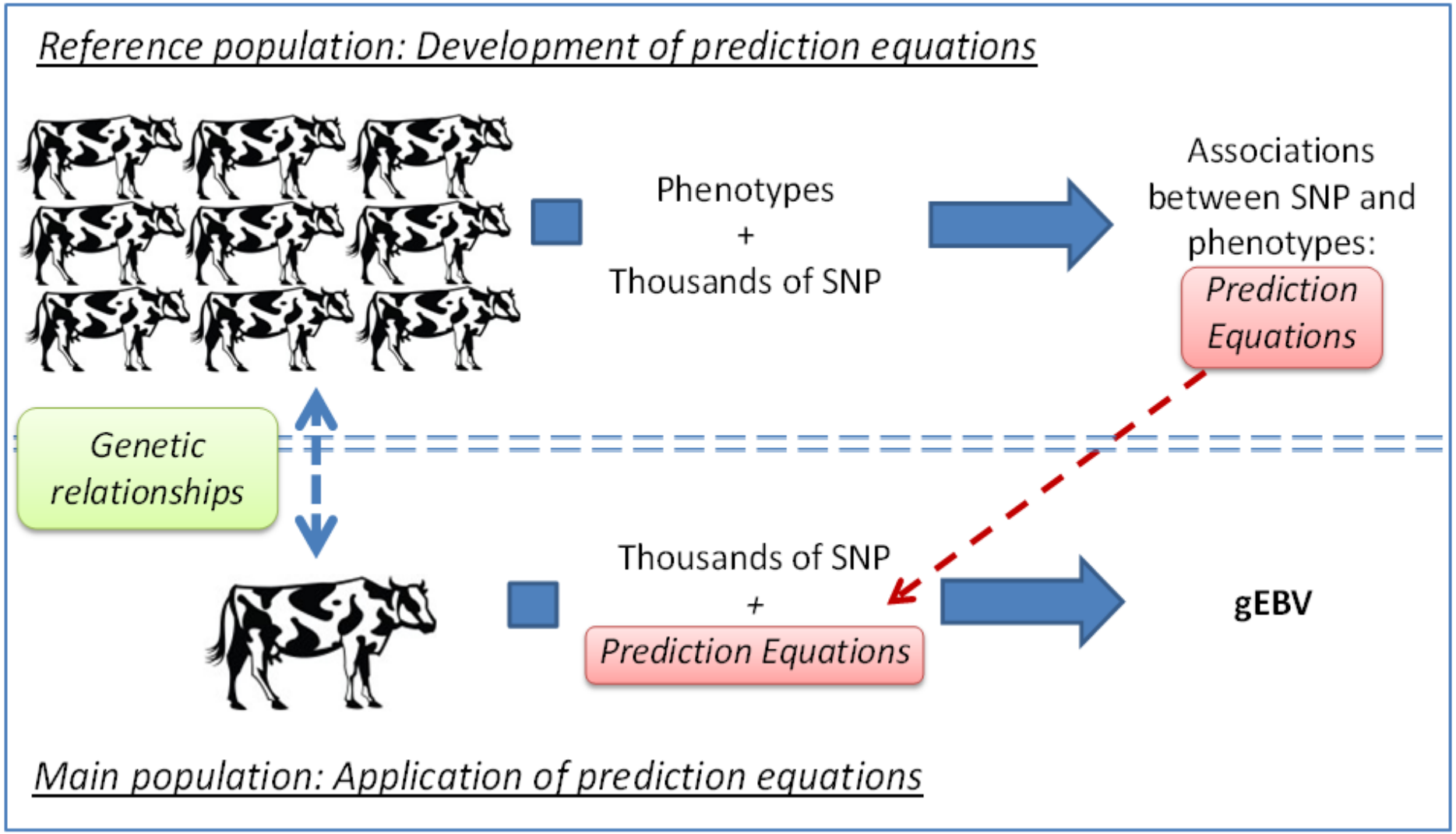
Application of newer technologies

i.e. Genomic selection (GS) to improve forage yield





Genomic selection: Alfalfa



https://wiki.groenkennisnet.nl/display/TAB/Chapter+8.15%3A+Genomic+selection

Application of newer technologies

Drone/multi-spectral (Camera) phenotyping

- Drought stress/ N use efficiency
- Breeding programs
- Easy, fast, accurate (can fly many times during the season)

Adaptation in marginal lands

- Acid tolerance
- Salinity tolerance
- Low soil fertility

High nutritive value

- High fiber digestibility
- Energy dense forage

Target end-use

- i.e. Many forages grow in mixtures
- Select under competition

A multi-disciplinary approach

- Yield
- Nutritive value
- Persistence
- Regrowth
- Maturity

Forage Breeding
Molecular biology
Animal nutrition
Agronomy
Crop physiology

Opportunity

- 33.8 million acres or 39% of the total crop land in Canada
- Diverse Industries
  - Forage seed industry
  - Main feed source for livestock industries
  - Ecological goods and services (soil conservation, carbon sequestration $, pollinator habitat $)


grasses

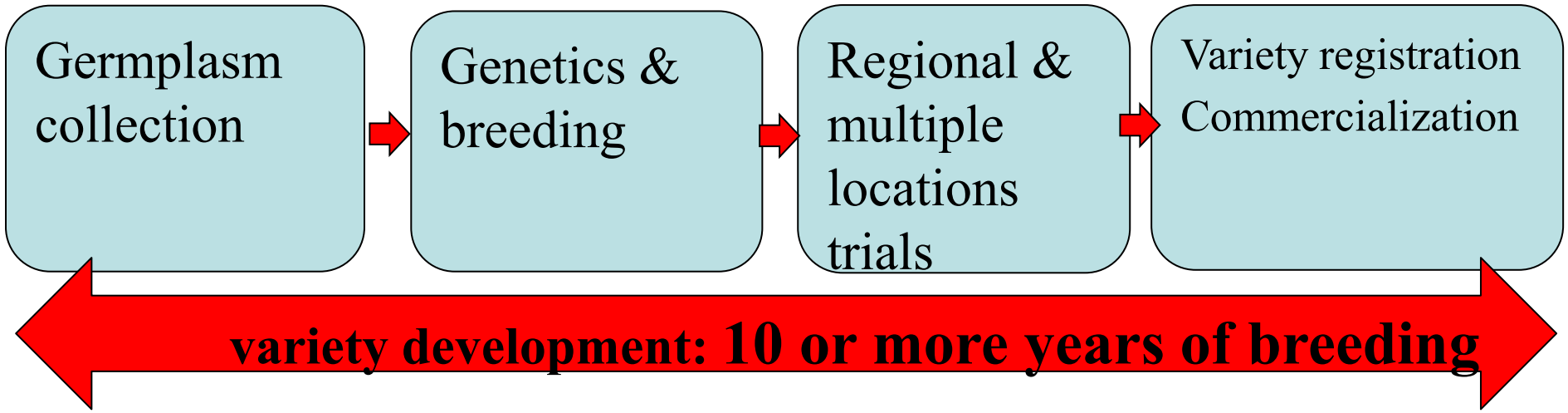

alfalfa


cicer-milkvetch


sainfoin


clover

- **Importance of industry groups' involvement**
  - Identify research need (breeding goals)
  - Forage seed, beef, dairy industries
  - Research Funding model
  - Royalty model to re-invest in forage breeding



Thank you!