# Perennial Grass Breeding

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## Hybrid brome

- Duel purpose
- AC Knowles (2000)
- AC Success (2003)
- Biomass yield
- Seed yield
- NDF digestibility
- Leaf disease

Meadow brome X Smooth brome = Hybrid brome

## Perennial grass breeding- crested wheatgrass

**Parkway** (2X) | **AC Goliath** (4X) | **Kirk** (4X)

Photo: B. Coulman

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# Genetic improvement of Alfalfa

Bill Biligetu

Crop Development Centre, University of Saskatchewan

Jan 24 2019

## History of Saskatoon Forage Breeding Program

- **Began at the U of S in 1922-1940**
  - Dr. Lawrence Kirk
- **AAFC Saskatoon 1941-1986**
  - Dr. Robert P. Knowles
- **AAFC-UofS 1993- 2014**
  - Dr. B. Coulman
- **Crop Development Center, UofS 2014**
  - Dr. B. Biligetu
- **Released many major grass varieties in western Canada**

## Current Joint forage breeding program

### Grasses

Meadow brome
Hybrid brome
Hybrid wheatgrass
Crested wheatgrass

## Annual Forage Breeding

- Collaboration with CDC barley breeders Aaron Beattie
- Forage Barley
  - CDC Maverick
  - CDC Cowboy
- Forage Oats
  - CDC Baler
  - CDC Haymaker

## Current Joint forage breeding program

### Grasses

Meadow brome
Hybrid brome
Hybrid wheatgrass
Crested wheatgrass

## New variety 2018

- Released a new hybrid brome in 2018
  - Hybrid brome S9356M

**Evaluation at 5 sites, 3 years:**

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

- Sask Forage Demo Trials 2017-2021
  - Terry, SFC (4 sites)


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# Alfafa Breeding program in Canada

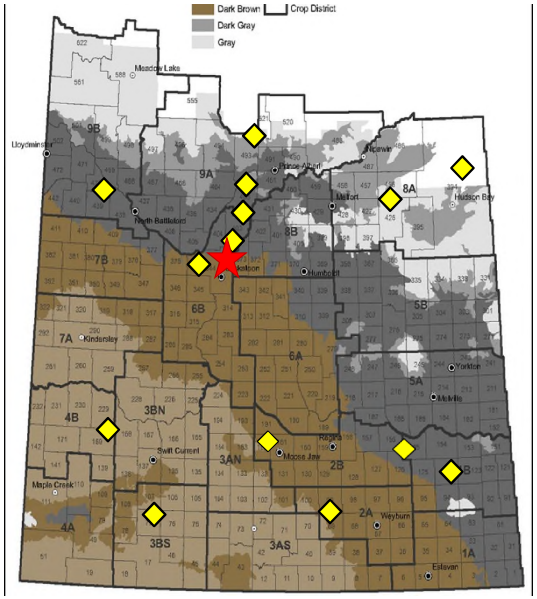
- AAFC-Lethbridge Research Center
  - Dr. Surya Acharya
  - AAC Meadowview - acid tolerant
- AAFC Kentville Forage Breeding
  - Dr. Yousef A. Papadopoulos
  - Tolerance to spring waterlogging conditions
- AAFC research Centre - Québec city
  - Dr. Annie Claessens
  - Persistent under cold and humid conditions
  - Selection for high stem sugar content and greater fiber digestibility



# Forage legume breeding

## Plant materials

- Wanted: 25-year old alfalfa
- Long-term grazing
- 4 soil zones
- 14 ranchers' sites
- 30 plants/site
- Soil samples




Map source: Government of SK

Alfalfa

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- **Ranchers/Alfalfa Seed Growers:**

David Espenant (Hudson Bay), Arnold Balicki (Shellbrook), Grant Tait (McDowall), Shirley Perillat (Duck lake), Jeremy Brown (North Battleford), Mark Vermeulen (Ceylon), Lyle Mclean (Arcola), Less Johnston (Fillmore), Dave Christensen (Pike lake), Andrew Olkowski (Dalmeny), Lynn Grant (Val Marie) Crooked river community pasture manager

- **Sask Ministry of Agriculture Forage/livestock specialists:**

(Lorne Klein, Trevor Lennox, Andre Bonneau, Colby Elfort, Rachel Turnquist, Allan Foster, Nadia Morri, Sarah sommerfeld, Victoria Nameth)

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## Development of locally adapted alfalfa cultivars

**Research team:** B. Biligetu, Bruce Coulman, Xiao Qiu, Jacqueline Toews, Hu Wang

Fall 2015 (first year)

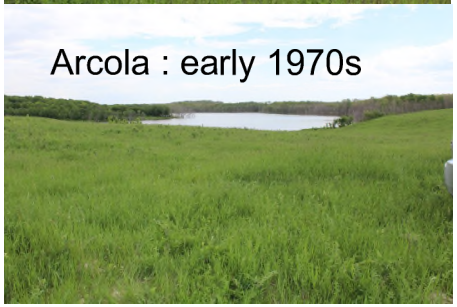
Summer 2016

Spring 2017

## Ranch site to a breeding nursery

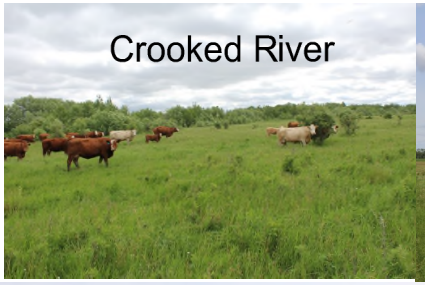


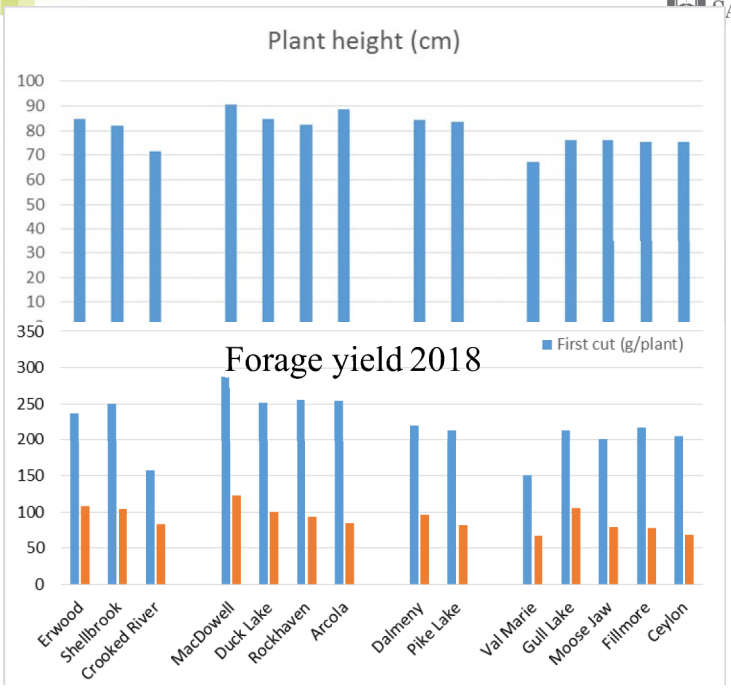

## Each Site Has a different History




## Flower Colour

R = Rockhaven – yellow flower
VM = Val Marie – yellow flower



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2017 summer

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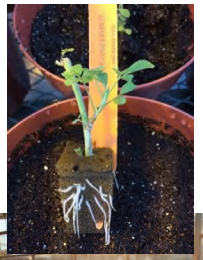
## Evaluation in the greenhouse for disease resistance

- **RCBD**
  - 13 Populations
  - 4 Replications
  - Verticillium wilt resistance
  - Bacteria wilt resistance



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## Soil test results

| Site Name | Soil Zone | Soil Texture | pH | Soil Extractable Nutrient Levels (kg/ha) | | | |
|---|---|---|---|---|---|---|---|
| | | | | $NO_3$-N | P | K | $SO_4$-S |
| Crooked River | Grey | Loam | 6.8 | 3 | 25 | 754 | 8 |
| Shellbrook | Grey | Loam | 7.8 | 4 | 13 | 548 | 8 |
| Hudson Bay | Grey | Loam | 7.2 | 10 | 85 | 1131 | 13 |
| MacDowall | Black | Loam | 6.9 | 10 | 7 | 1054 | 8 |
| Duck Lake | Black | Loam | 7.6 | 7 | 75 | 691 | 8 |
| Rockhaven | Black | Loam | 6.5 | 6 | 10 | 1020 | 10 |
| Arcola | Black | Loam | 7.9 | 15 | 12 | >1344 | 18 |
| Ceylon | Brown | Loam | 8.0 | 11 | 22 | 585 | 8 |
| Gull Lake | Brown | Loam | 8.4 | 11 | 22 | 538 | 20 |
| Val Marie | Brown | Loam | 7.7 | 8 | 13 | 1103 | 11 |
| Moose Jaw | Brown | Loam | 8.0 | 21 | 16 | 704 | 10 |
| Dalmeny | Dark Brown | - | - | - | - | - | - |
| Pike Lake | Dark Brown | - | - | - | - | - | - |

ALS Laboratory Group Agricultural Services in Saskatoon

## Preliminary conclusions and future work

- Site Selection - longevity of an alfalfa stand
- Tendency in morphological characteristics
  - Slower regrowth (plants from Brown soil)
  - Slightly higher yield (plants from Black soil zone)
- Different among populations within/among soil zones
- Future work on gene expression, and other disease resistances

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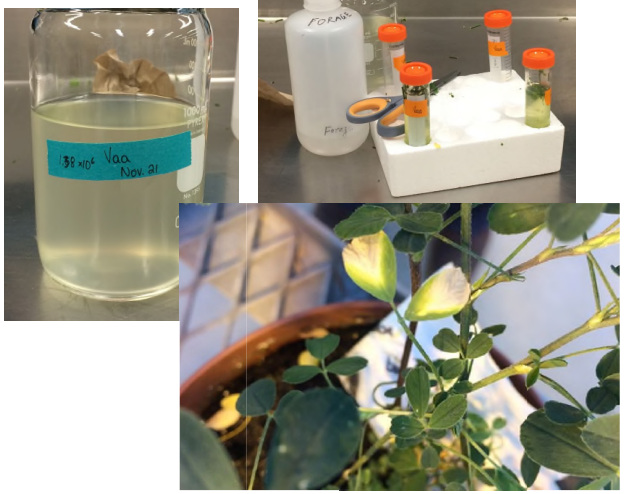
## Disease test: *Verticillium wilt*

- Spore Suspension
- Stubble Spray Inoculation



V-shaped yellow chlorosis

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## Planned future research

- First new breeding line in summer 2019
- More disease evaluations
- Genomic difference and relationship
- Graduate student is working on this project

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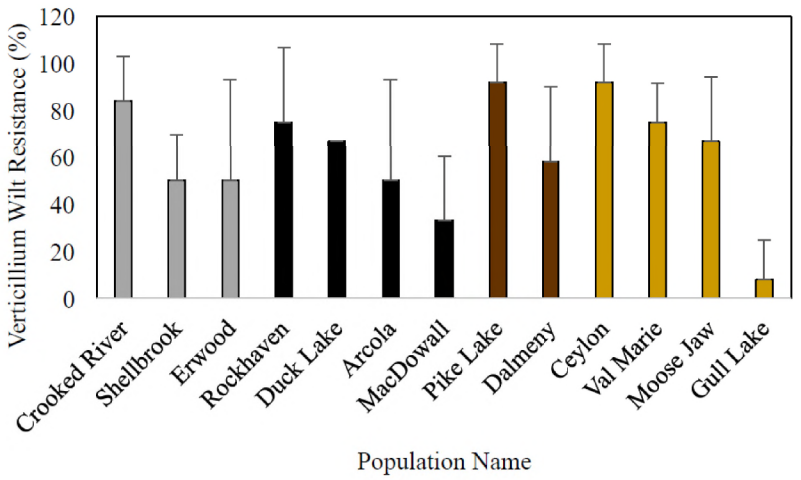
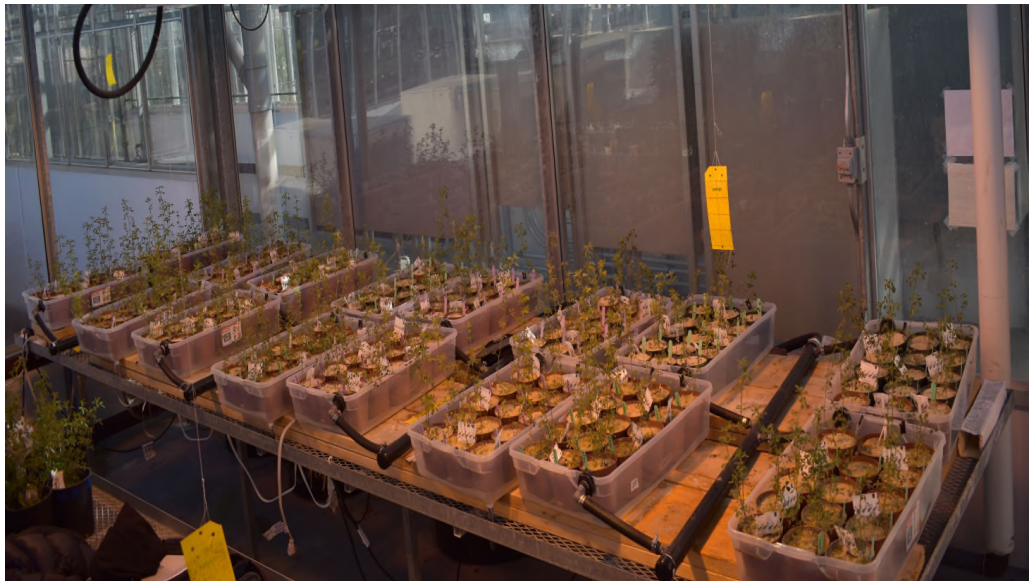



**Figure 13.** Resistance (%) to *V. albo-atrum* of the 13 alfalfa populations collected from sites with long-term grazing history in Saskatchewan



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# Alfalfa salinity tolerant research

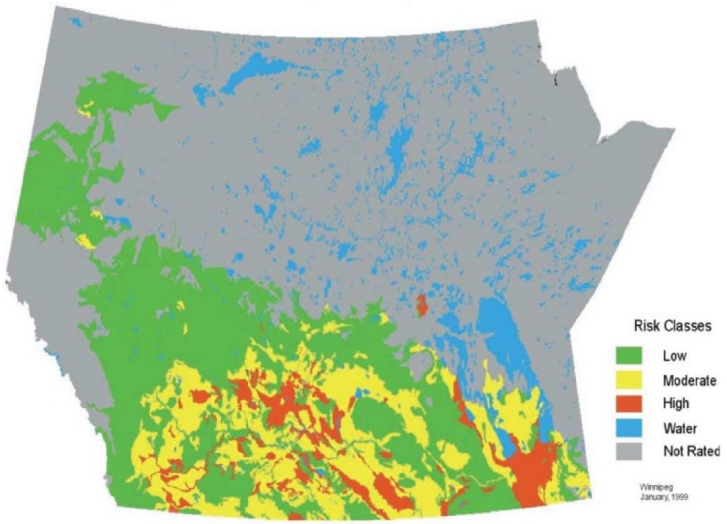


**Fig. 1.** View of the Canadian prairies with the 1996 soil salinity risk evaluation based on five physical and biological factors including the existence of root-zone salts [taken from Wiebe et al. (2007)].

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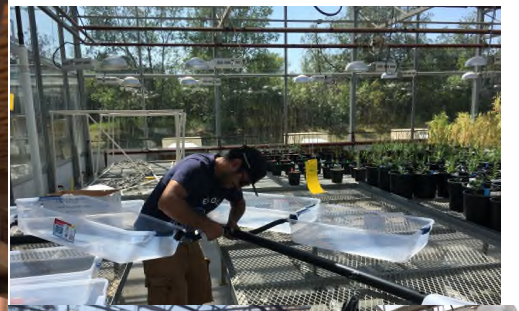
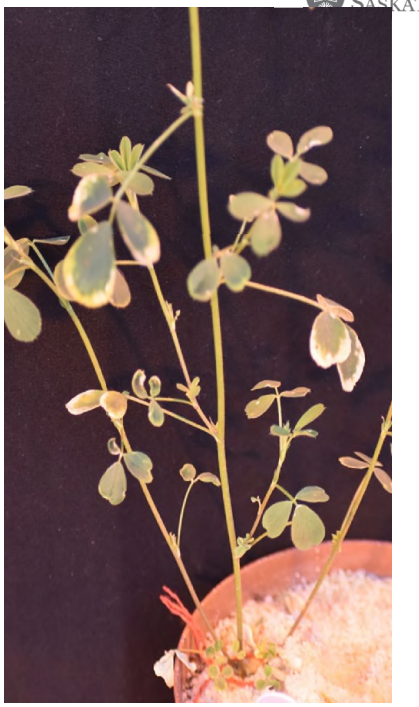
# Hydroponic system set up in greenhouse



## Alfalfa cultivars

| |
|---|
| Bridgeview |
| Halo |
| Rangelander |
| Rugged |
| Vernal |

Seedling to flowering stage



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## Hoagland solution and 99% silica sand


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## Shoot and Root Biomass

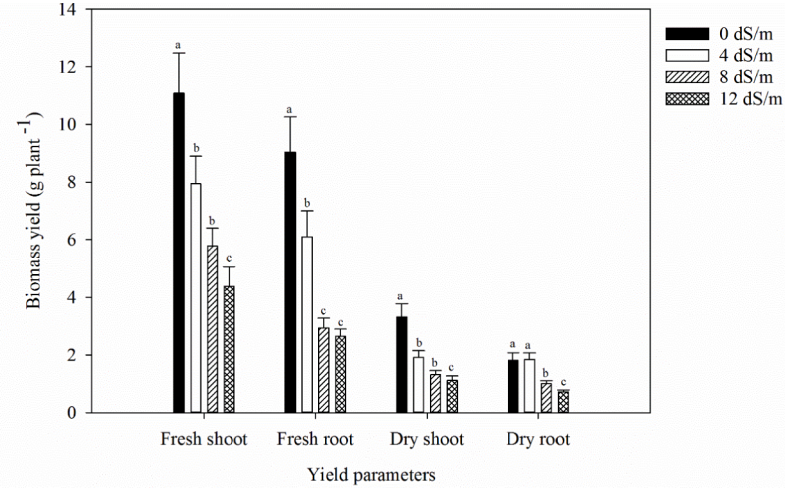



Figure 4. Fresh and dry root and shoot biomass yield of five alfalfa varieties under four gradient of salt stress (Electrical conductivities of 0 dS/m, 4dS/m, 8dS/m and 12dS/m) (error bar represents standard errors of means; within each yield parameters means followed by same letter are not significantly different at P<0.05)

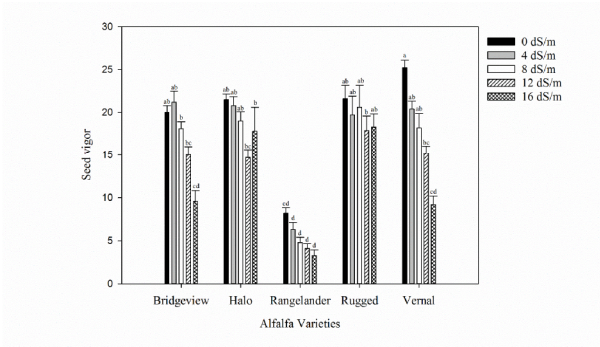



Figure 1. Seed vigor of five alfalfa varieties under five gradient of salt stress (Electrical conductivities of 0 dS/m, 4dS/m, 8dS/m, 12dS/m and 16dS/m) (seed vigor was calculated as multiple of germination percentage with seedling length divided by 100; error bar represents standard errors of means; means followed by same letter are not significantly different at P<0.05)

# Results

## Salt tolerance index

| | 4dS/m | 8dS/m | 12dS/m |
|---|---|---|---|
| **Bridgeview** | 0.33 | 0.33 | 0.20 |
| **Halo** | 0.80 | 0.50 | 0.57 |
| **Ranglander** | 0.30 | 0.20 | 0.20 |
| **Rugged** | 0.76 | 0.53 | 0.31 |
| **Vernal** | 0.78 | 0.44 | 0.43 |

Stress tolerance index = $(Yc \times Ys)/(\hat{Y}c)^2$ (Fernandez, 1992),

where 'Yc' is shoot dry weight at control,

'Ys' is shoot dry weight under salt stress, and

'$\hat{Y}c$' is the means of all genotypes under control condition.

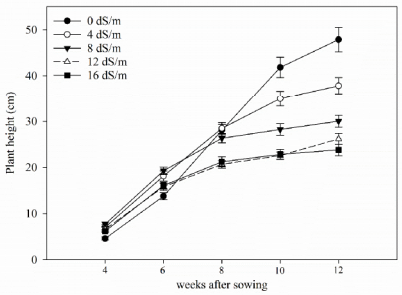
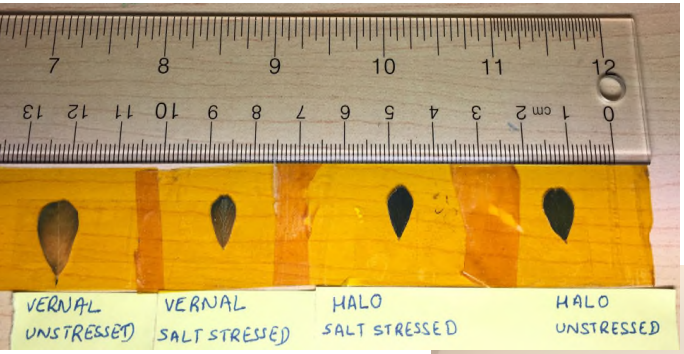


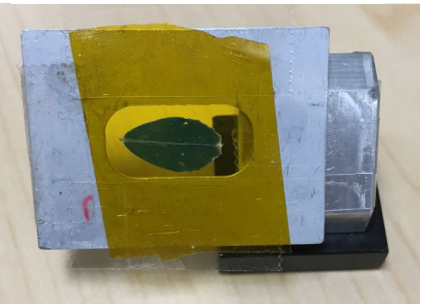

Figure 3. Average plant height (cm) of alfalfa plants at different stages of growth under five gradient of salt stresses (Electrical conductivities of 0 dS/m, 4dS/m, 8dS/m, 12dS/m and 16dS/m)
(salt stress was applied on 4 weeks old plant; error bar represents standard errors of means)

# Leaf samples for mapping in VESPERS

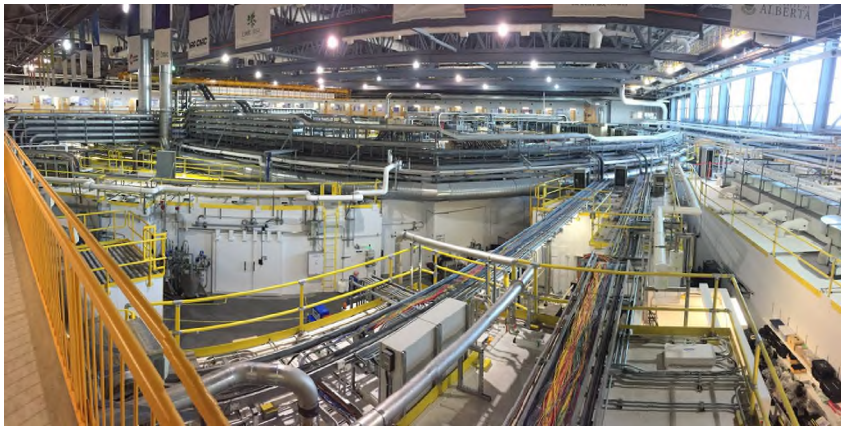





This is how it was hold in chamber



- **Synchrotron application**
  - Halo and Vernal
  - Different beam lines



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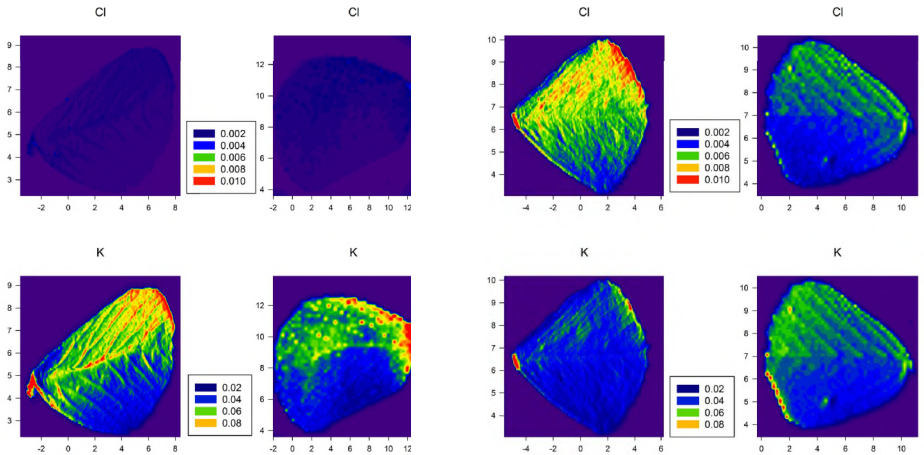
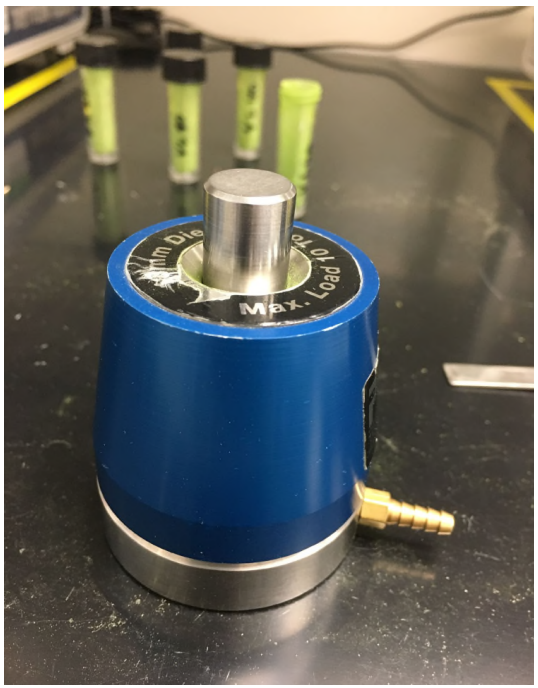
Distilled water

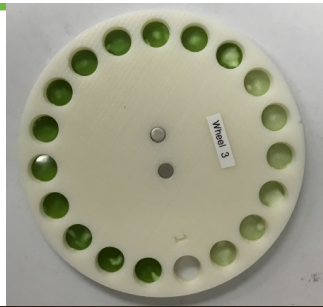
Salt treated (12ds/m)

Halo leaf | Vernal leaf | Halo leaf | Vernal leaf




Die to prepare pellet for bulk analysis





Alfalfa nursery established in 2015

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Intensive harvest (4-5 clippings/summer)

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## High yielding under local growth conditions

- Western Forage Test -alfalfa data (1999-2013)
- Top yielding 15 alfalfa cultivars
- Older Canadian varieties
  - Beaver, Rambler, Rangelander etc.
  - Yellow flowering alfalfa
- Evaluate 3-4 years for performance (disease)
- Produce new breeding lines
- Test forage/seed yields and quality in replicated trials

# Funding support

- Dairy Farmers of Canada
- Sask Milk
- Saskatchewan Ministry of Agriculture
- AAFC Saskatoon Research Center (in kind)
- Saskatchewan Forage Industry Network
- Saskatchewan Forage Seed Growers' Commission
- Sask Cattleman's Association
- Sask Pulse
- Western Grain Research Foundation
- Alberta Beef Producer
- Beef Cattle Research Council
- NSERC Discovery
- NSERC – CRD

# Research projects

- **Selection of clonal propagated alfalfa and sainfoin plants under grass or legume competition (**2017- 2022)
  - Biligetu, Coulman, Acharya
  - ADF, SaskMilk, SCA, WGRF

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- **Genomic selection of alfalfa** (2018- 2023)
  - B. Biligetu, Y-B Fu, A. Claessen
    J. Robin, M. Schellenberg
  - BCRC