Integrated pest management for Aster yellow diseases and flea beetles

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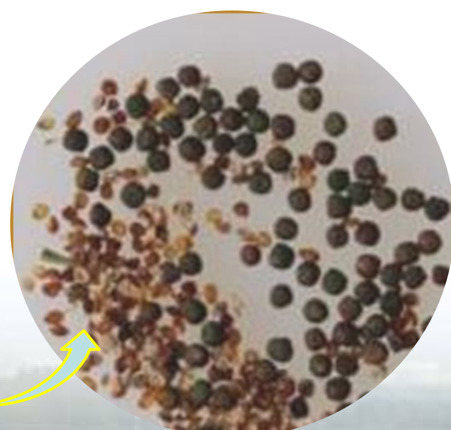
Integrated Pest management Is

The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

Food and Agriculture Organization of the United Nations

for a world without hunger

IPM of Aster yellows diseases & flea beetles



Epidemiology, production losses & management

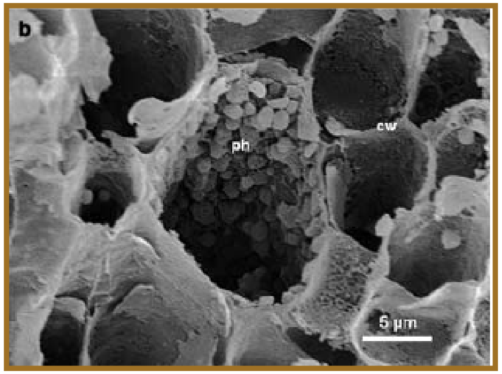
Development of IPM
What needs to be done

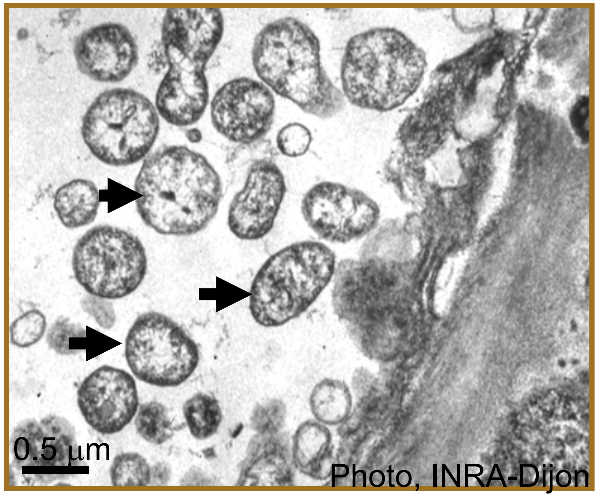
Development of IPM,
What has been done
(Bioassays & results)

Development of IPM,
Future projects

Epidemiology, production losses & management of Aster yellow diseases

Phytoplasmas are wall-less bacteria that are obligate parasites of plant phloem and of their insect vectors.





Characteristics

- Unculturable: Classification based on molecular characteristics.

↓

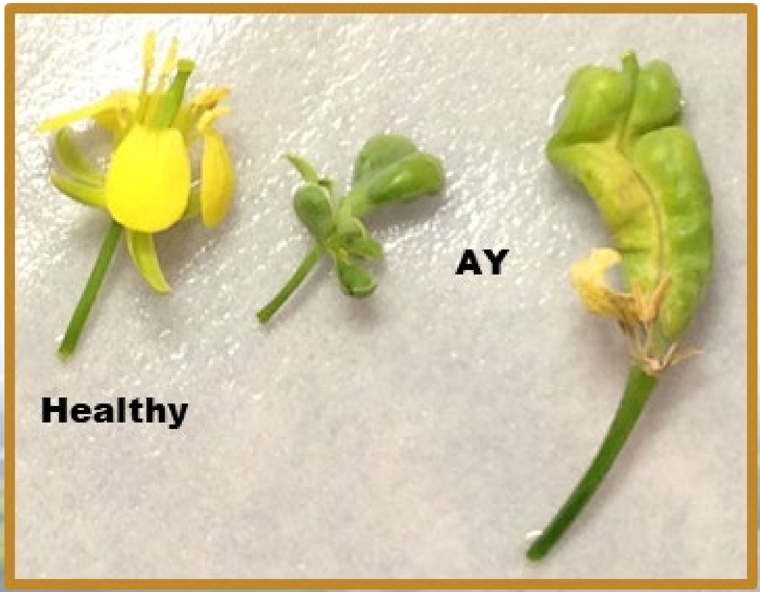
- 33 groups worldwide & 7 groups in Canada
- Aster Yellow = '*Candidatus* Phytoplasma asteris'
- **AY the most common and widespread, present in the Canadian prairies**

Characteristics of Phytoplasma

- Transform floral organs into leaf like structure
- Overwinter in roots of perennial plants (disease reservoir)
- Once infected, insects and plants are infected for life

No chemical to control phytoplasma (except antibiotics)

Use of insecticides to control the insect vector

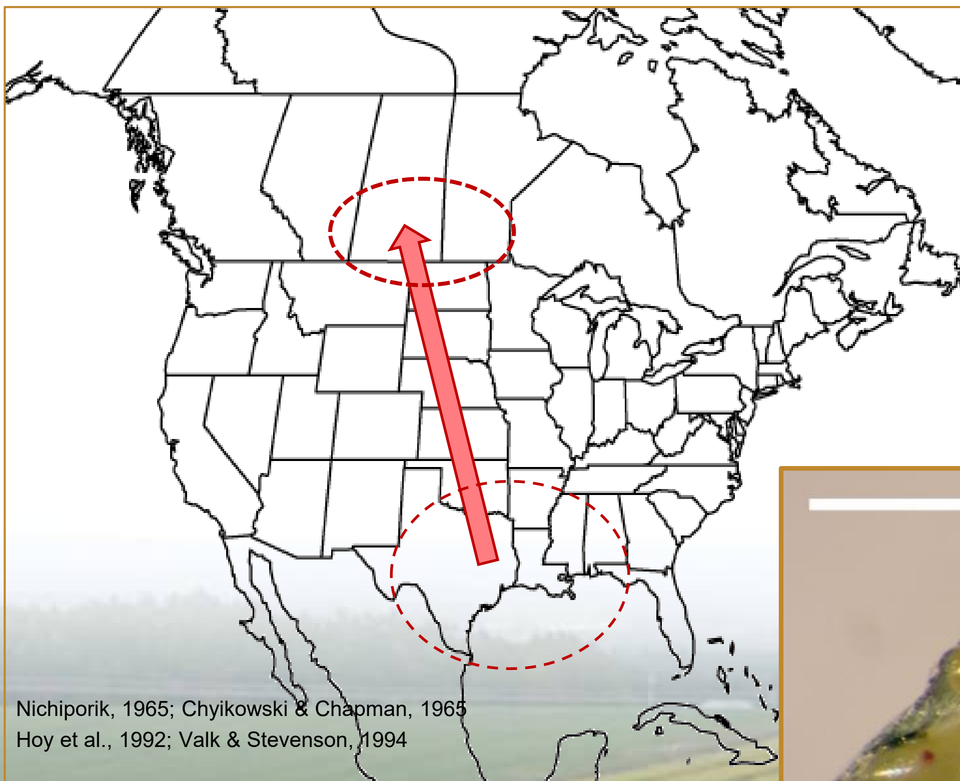


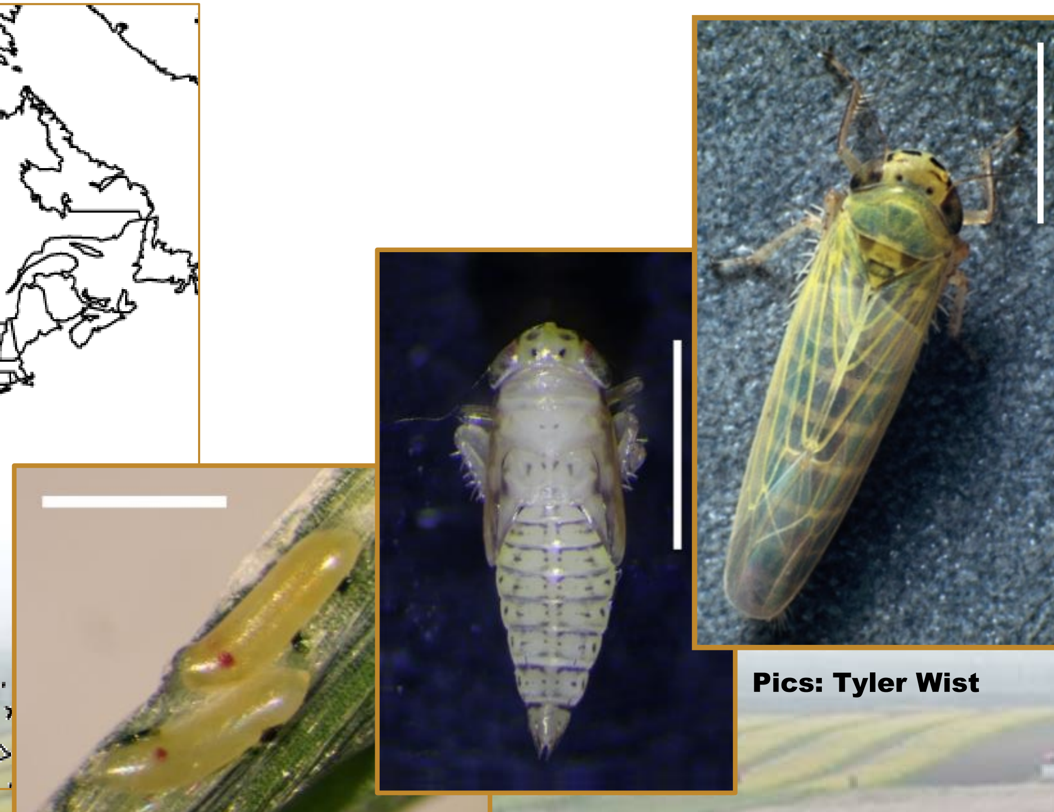
AY disease in canola

Symptoms of bladder-like pods, green flowers & misshapen seeds

-Main AY vector: the migratory aster leafhopper ***Macrosteles quadrilineatus*.**

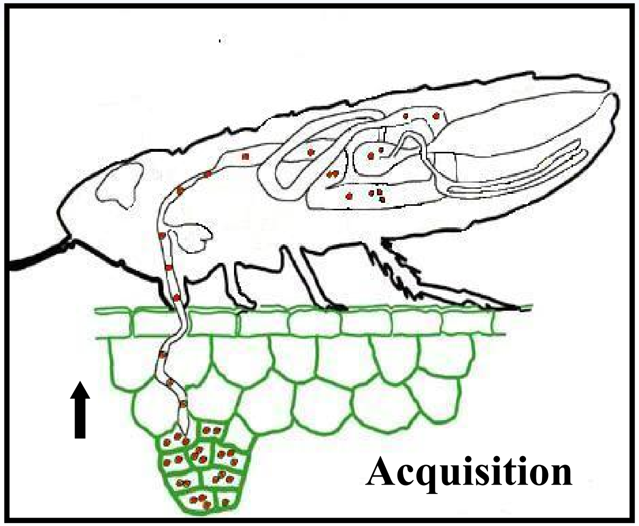
-Other potential vectors:11 leafhopper species (low number).



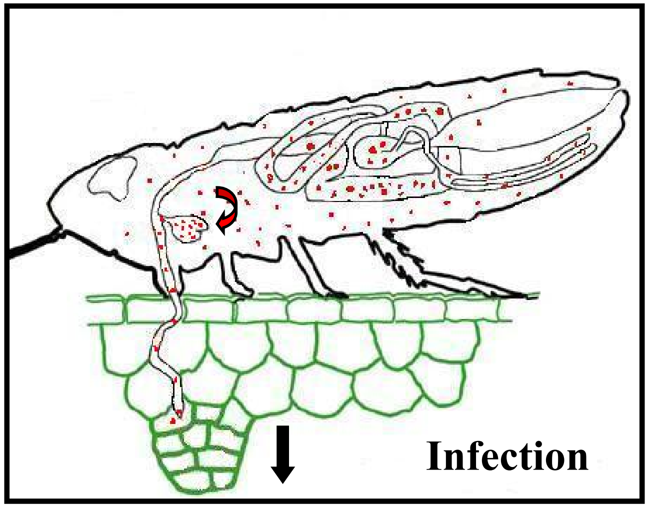


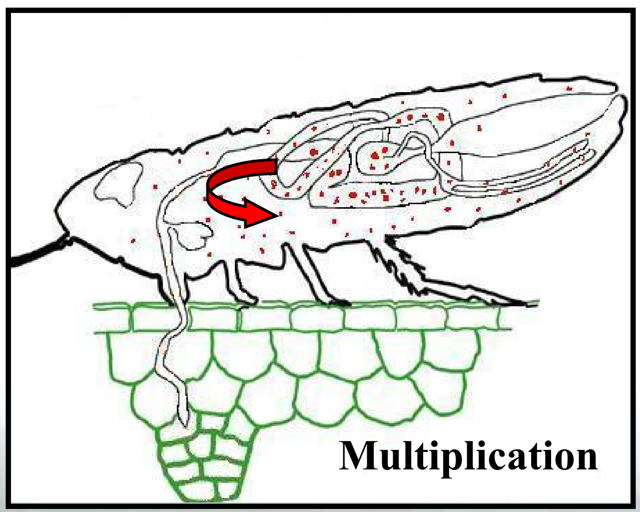
Pics: Tyler Wist

AY transmission



2-4 weeks

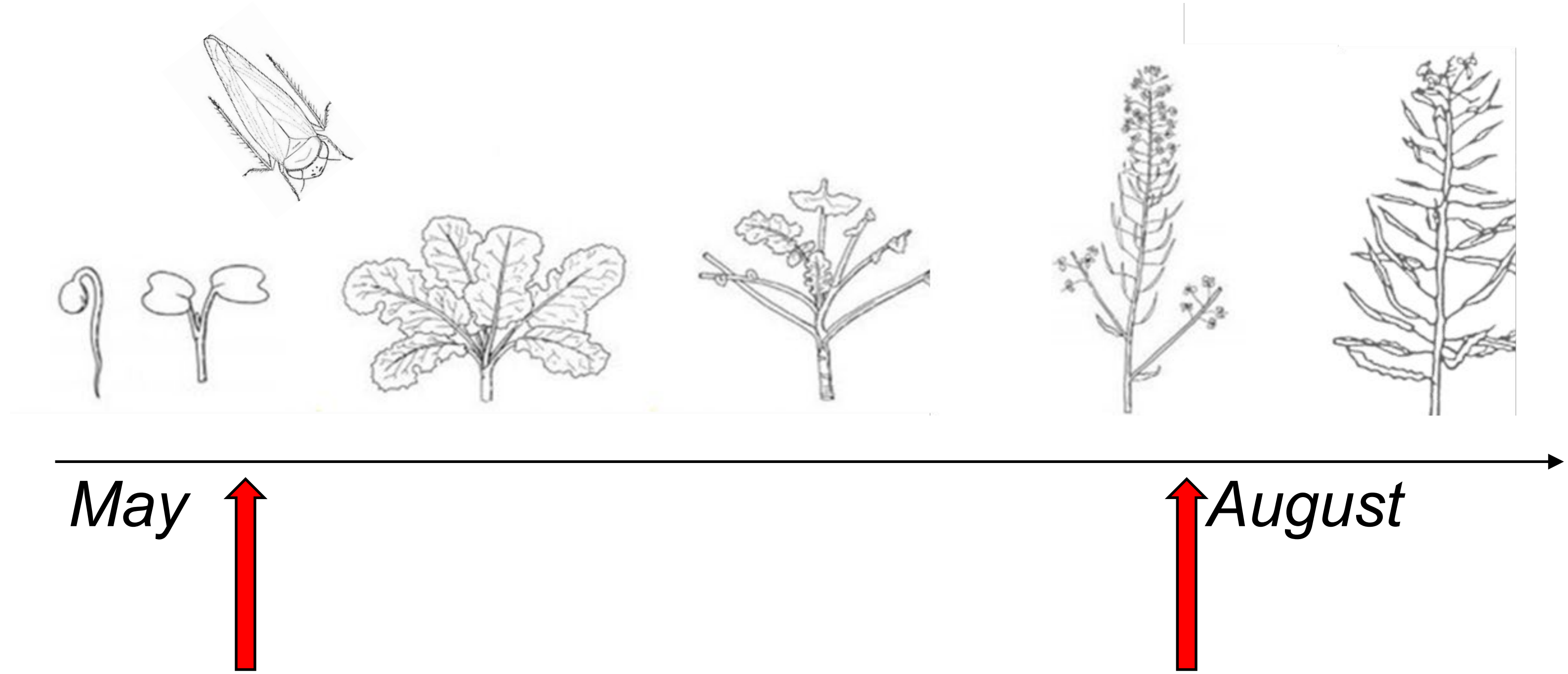




<u>NOT</u> transmitted via:

- Leafhopper droppings
- Eggs (from mother to larvae)
- Soil

AY transmission

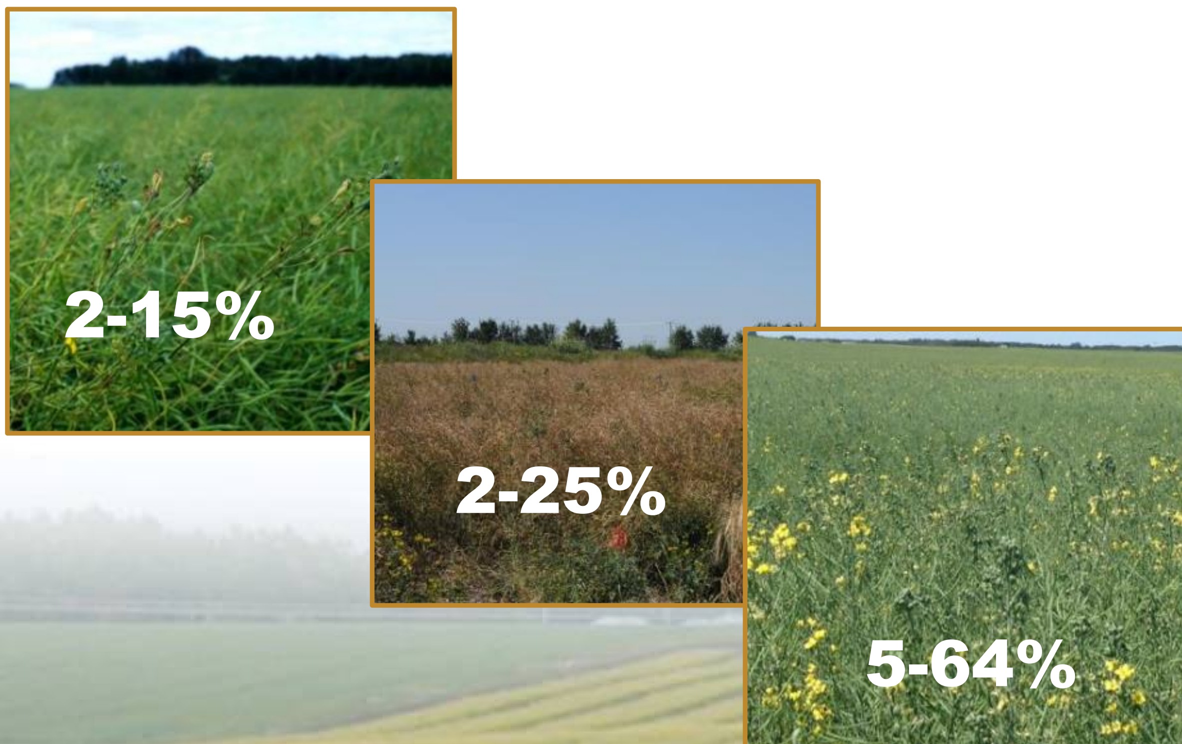


AY transmission
- **% infected leafhopper**
- **Number of leafhoppers**

AY symptom
(8-10 weeks)

- Most years: <0.1% incidence.
- Past 20 years: increase of incidence
- 2012: ~$400 millions losses

1957 (2-10%) — 2000 — 2007 — 2012 — 2019?



Development of IPM
What is needed

<u>Epidemiology</u>:

Production losses due to AY?

Economic threshold for AY?

Rapid determination of leafhopper infection level?

Disease reservoir (plant host, other vectors)?

<u>Management</u>

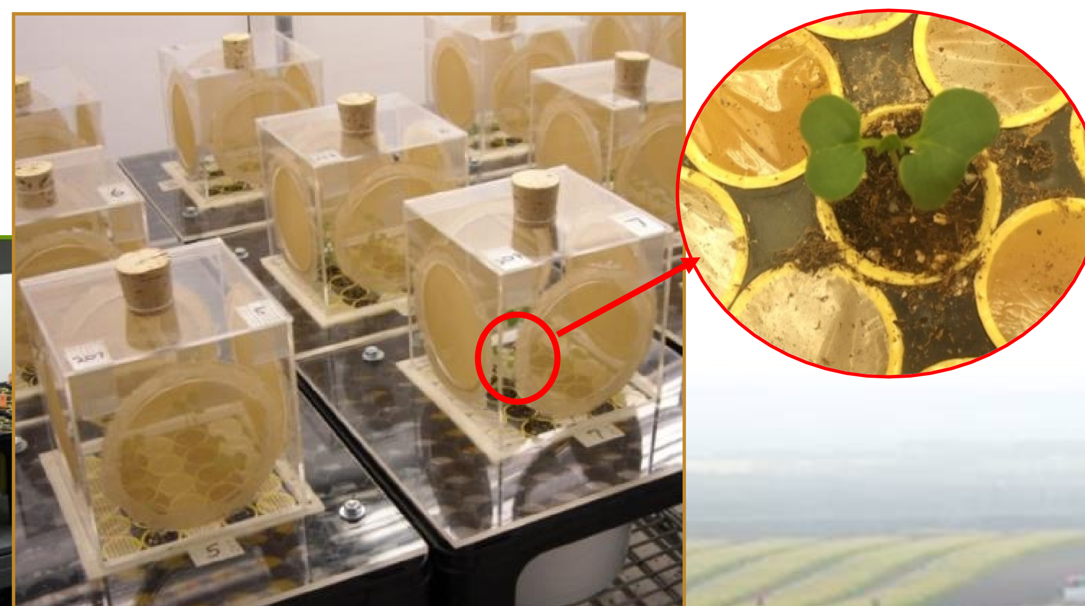
Efficiency of seed treatments to control AY?

Early warning system of AY ?

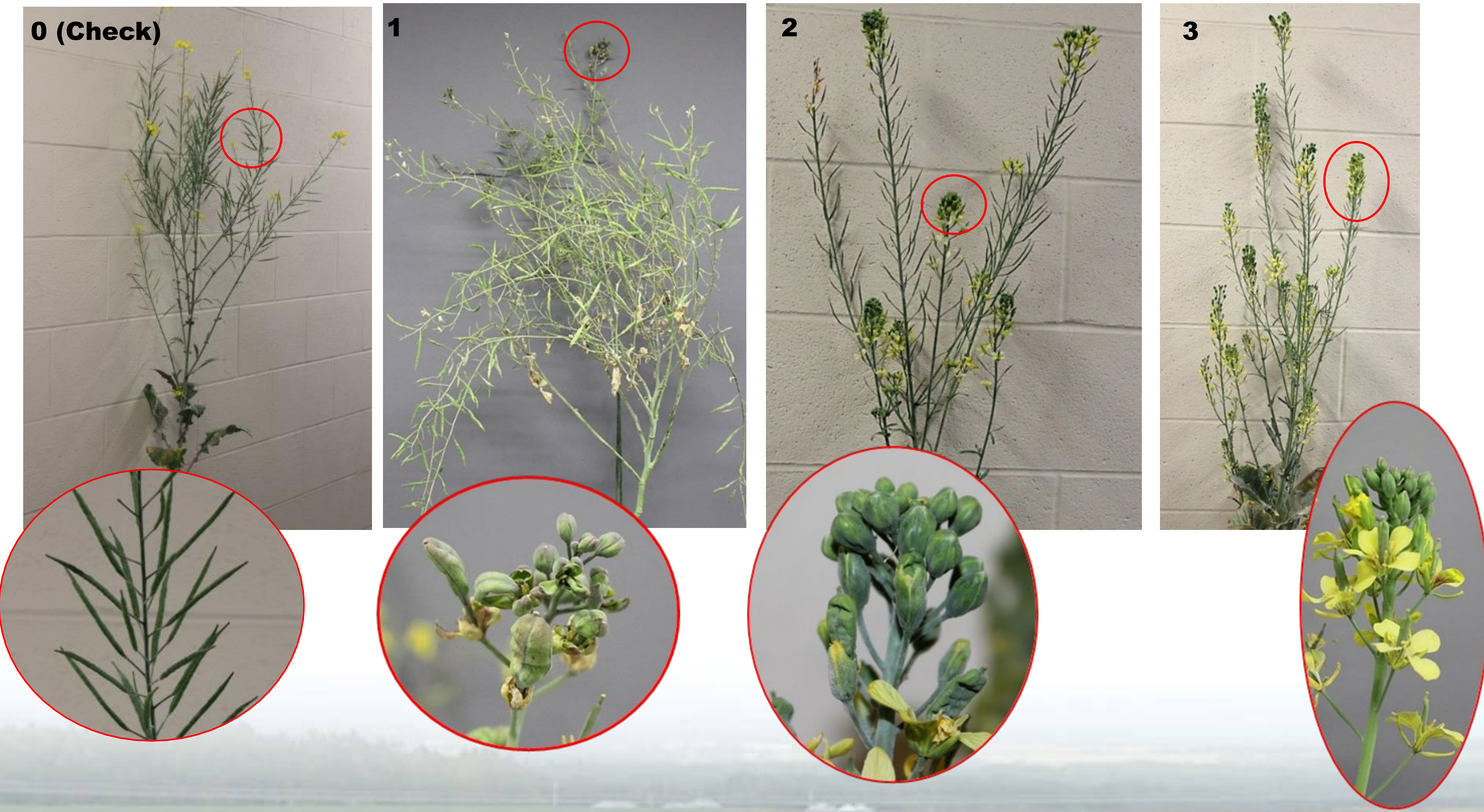
Other management system (biopesticide, plant resistance, ..)?

Development of IPM, Bioassays & results

- Wet (70-100%) and dry (20-30%) soil.
- Plants at various growth stage (cotyledons, 1^{st} – 5^{th} true-leaf, prebolting, bolting)
- AY-infected leafhoppers for **10 hours**.
- Plants grown for 10 weeks at 20ºC and high light intensity
- AY symptoms rated at 10 weeks & plants harvested for seed yield.



AY Rating Scale 0-3



AY Rating Scale 4-5

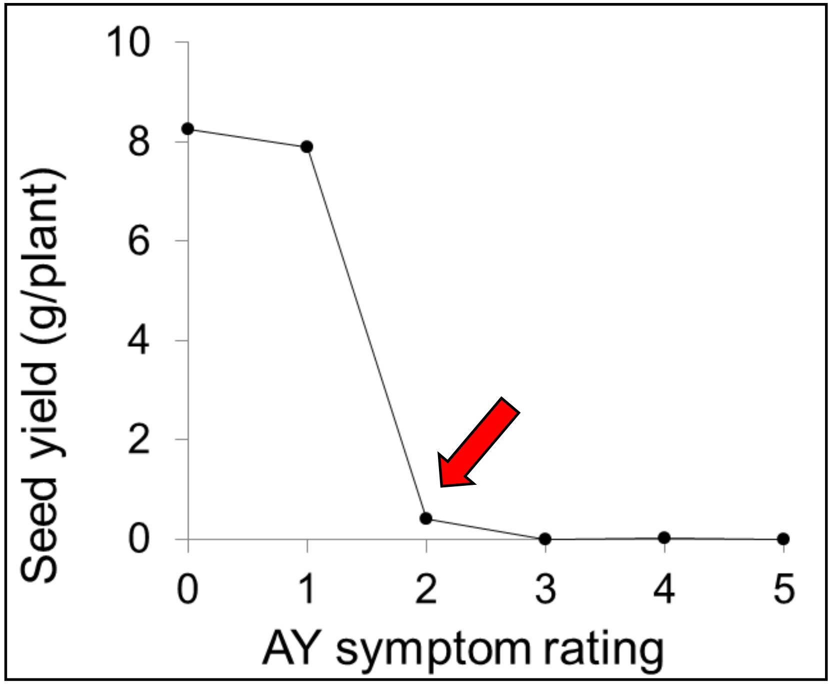
Development of AY symptoms - seeds

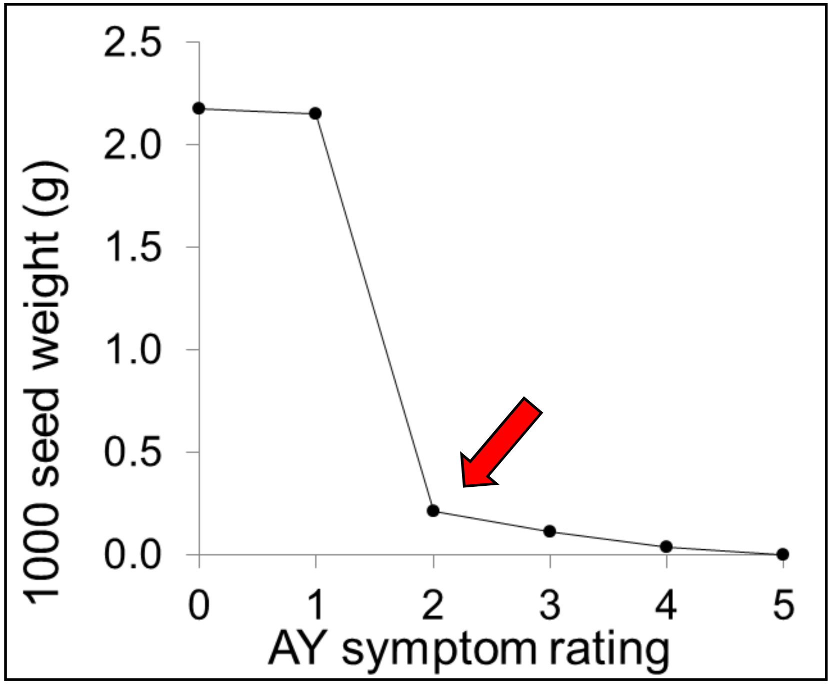
Healthy
(R0)

Abnormal
seeds
(R1-3)

Bladder-like
pods
(R4-5)

Correlation AY symptom ratings / seed yield

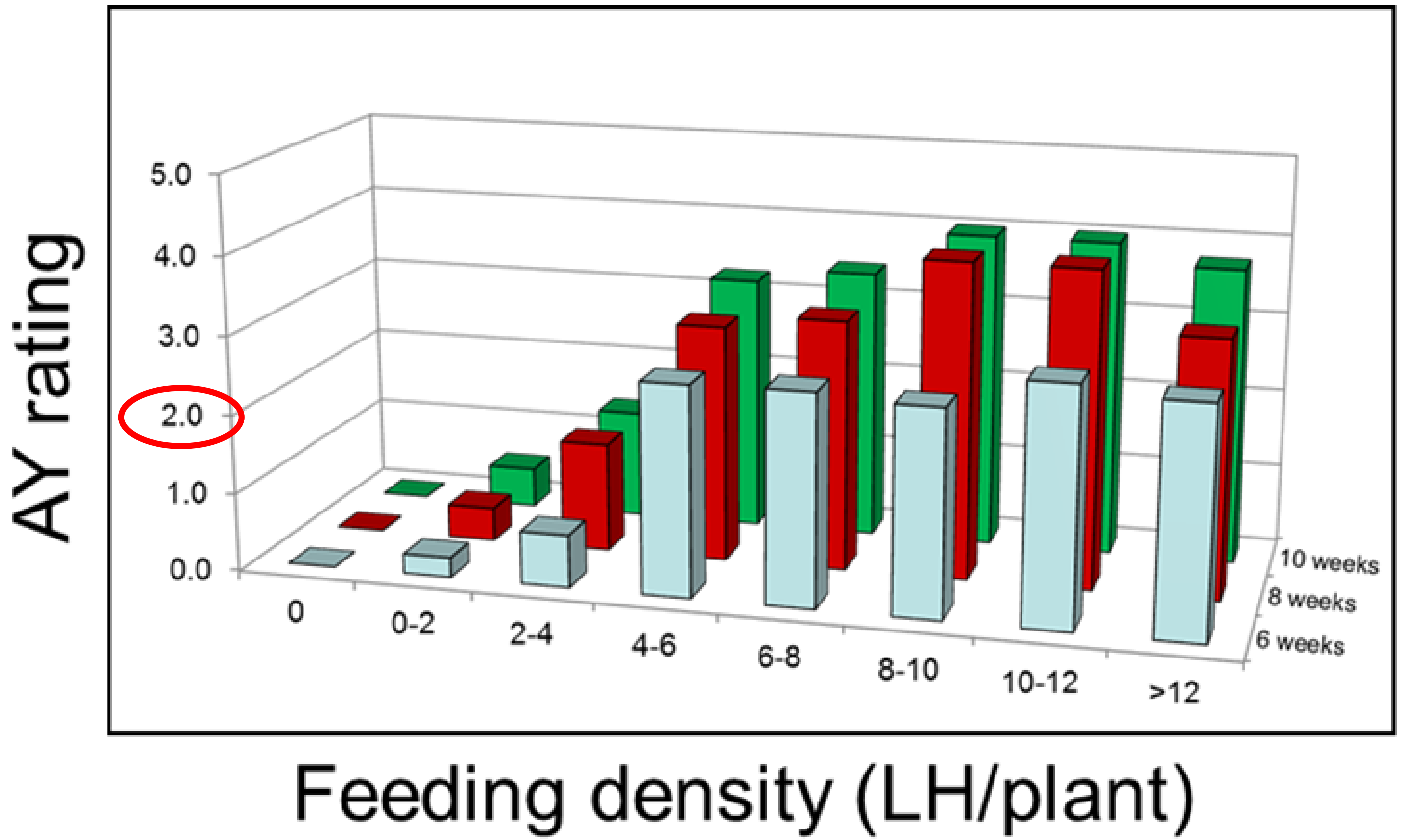




- Plants with AY ratings of 1-2 produced malformed seeds
- Plants with AY ratings of 3-5 produced no seed

Correlation AY ratings / LH/plant

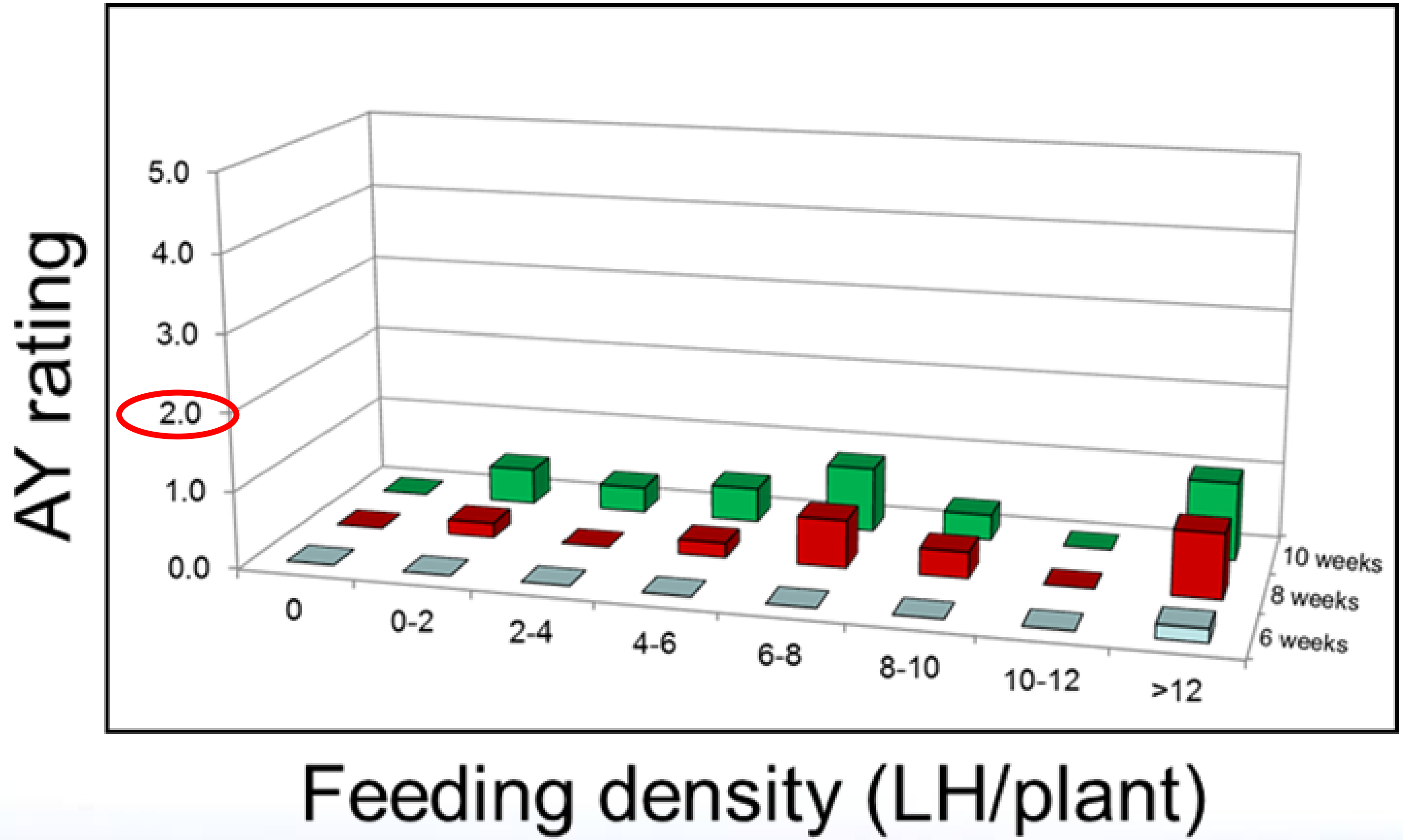
Wet soil, early stage infection



Wet soil & LH/plant > 2-4: High yield losses (R>2)

Correlation AY ratings / LH/plant

Dry soil, early stage infection



Dry soil & LH/plant >12: low yield losses (R<1)

AY inoculation at early growth stage (cot,1st -5th leaf) versus late growth stage (prebolting, bolting)

		% plants with typical AY symptoms
Early stage	Dry soil	38% (76/196)
	Wet soil	78% (161/204)
Late stage	Dry soil	0% (0/31)
	Wet soil	6% (2/31)

AY incidence high when inoculation at early growth stage

	Early growth stage (cot – 7^{th} leaf)	Late growth stage (prebolting, bolting)
Wet soil	Severe symptoms Heavy losses ET < 4LH/plant/10hrs	Mild symptoms Minor losses ET: 16+ LH/plant
Dry soil	Mild symptoms Mild losses ET: 12+ LH/plant	No symptoms No losses

Rapid determination of leafhopper infection level

May 2000: ~8% infected leafhopper & 15 lh / 100 sweeps

June 2007: ~10% infected leafhopper & 20 lh / 100 sweeps

May 2012: ~23 % infected leafhopper & 50+ lh/100 sweeps

Fast determination of % infected leafhoppers

↓

Fast action from the growers

Rapid determination of leafhopper infection level

Sampling + transportation+ storage+ DNA extraction + PCR: 1 week

Field-adapted DNA extraction and PCR (**1hr**)

A Rapid, Simple, Laboratory and Field-Adaptable DNA Extraction and Diagnostic Method Suitable for Insect-Transmitted Plant Pathogen and Insect Identification

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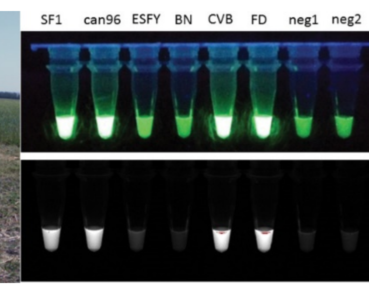


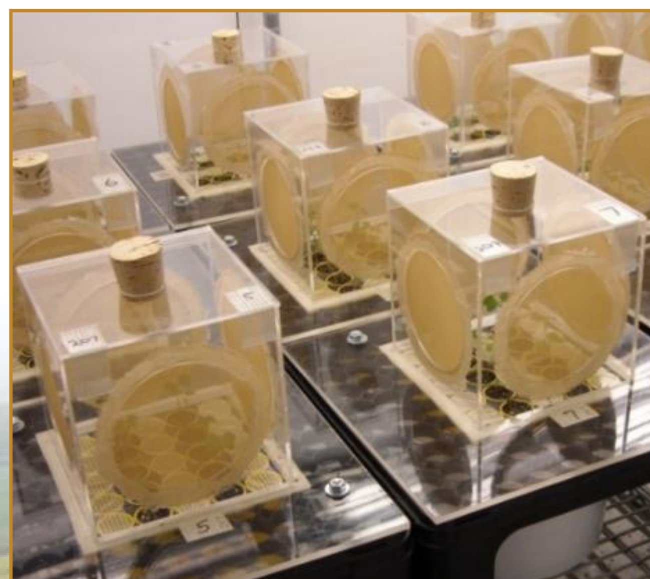
AY vector control: Seed treatments

Bioassays with untreated / Neonicotinoid seed treatments

-20 LH/cage; 4 plants/cage; 20C

-AY inoculation at cotyledon, 1st, 2nd , 3rd, 4th , 5th , 6th and 7th true leaf stage.

-**Leafhopper mortality at 24-72 hrs and AY transmission** (PCR test on leaf, stem, roots10 weeks after bioassays)



% LH mortality at 24hrs - 72hrs

Growth stage	Dry soil, 20ºC		Wet soil, 20ºC	
	Untreated	Neonic Treated	Untreated	Treated
Cotyledon	5-10%	96-100%	3-12%	81-91%
1st-2nd leaf	0-3%	96%	0%	71-88%
3rd- 4th leaf	0-4%	98-100%	0-4%	87-98%
4th-5th leaf	0-4%	98-100%	0%	95-98%
6th-7th leaf	0-4%	99-100%	0-3%	94-97%

*Seed treatment: Helix Xtra

Higher LH mortality with seed treatment in dry soil as compared to wet soil

% plants with AY (PCR test)

Growth stage	Dry soil, 20ºC		Wet soil, 20ºC	
	Untreated	Neonic Treated	Untreated	Treated
Cotyledons	0%	0%	18%	0%
1st-2nd leaf	8%	0%	27%	7%
3rd- 4th leaf	6%	0%	39%	5%
4th-5th leaf	17%	0%	8%	6%
6th-7th leaf	14%	0%	33%	0%

30 plants/exp

Seed treatment: Helix Xtra

Reduction of AY incidence with seed treatment, more efficient in dry soil as compared to wet soil

Conclusion - AY

Inoculation at early growth stage and in wet soil cause severe AY symptoms and yield losses.

Economic threshold for early growth stage: 12+ LH/plant in dry soil, and less than 4 LH/plant in wet soil.

Seed treatment (Helix Xtra): More efficient in dry soil as compared to wet soil and reduce AY incidence.

Development of a rapid method to estimate the level of infection of the leafhoppers

Development of IPM
Ongoing/Future projects

Epidemiology:

AY disease reservoir in SK: AY-infected perennial plant hosts. *B. Romero, MSc project, U of S & AAFC, ADF funds.*

Government of Saskatchewan

Management

Early warning system of AY: Wind trajectories, satellite images, origin of leafhopper populations by molecular & stable isotope technics. *K. Pusz-Pochenska, PhD, U of S & AAFC, WGRF funds)*

Western Grains Research Foundation

Plant resistance to leafhopper feeding*: hairy canola and feeding behavior of leafhopper (CARP funds)*

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Future projects:

Biopesticides (biopestides), leafhopper's love song (acoustic)

Epidemiology, production losses & management of Flea beetles

Most chronic & economically important Brassica pests in the Canadian prairies. Invasive species.

Adults are ‘shot hole’ leaf feeders.

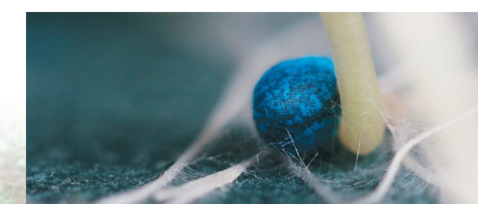
Cause seedling mortality, reduce plant stand, reduce seedling growth, delay maturity and lower seed yield. Spring and fall populations.

Annual losses $130-300M.

Usual management: Early seeding, large size/vigor seeds, 0-tillage, high seeding density & wide rows, seed treatments (neonicotinoids since 2003)

> 95% of canola seed treated in Canada (18+ million ha)

Foliar sprays at >25% leaf damage (ET)



Flea Beetle Species in the prairies

Striped flea beetle,
***Phyllotreta striolata* (F.)**

Crucifer flea beetle,
***Phyllotreta cruciferae* (Goeze)**

Hop flea beetle
***Psylliodes punctulata* (Melsh.)**

New challenges in flea beetle management

Population shift from crucifer to stripped flea beetles

Striped flea beetles less susceptible to seed treatments (Tansey et al. 2008, Elliott pers. comm.) & use of seed treatments may be selecting for striped flea beetles.

Striped flea beetles 1-4 weeks earlier than crucifer flea beetles

Most IPM for crucifer flea beetles

Ban on neonicotinoids

Re-evaluation by PMRA (due early 2020), some restrictions on the use of the imidacloprid, clothianidin and thiamethoxam, phase-out by 2020-2022 (?), water residues data shows low level, data still being analyzed…Seed treatments ?

→ Public push for healthier environment and food

Other management alternatives

Development of IPM
What is needed

Epidemiology:

Life cycle of striped flea beetle? (overwintering sites, temp/moisture influence on life cycle, parasitoids & predators)

Economic threshold for striped flea beetle? (new canola cultivars, production losses spring/fall population)

Management

Novel insecticide trials? Cause of neonic “resistance”?

Other management systems:

- Biopesticide, cultural practices, RNAi, plant resistance (wax, glucosinolate, …)
- Plant resistance (trichome)*: hairy canola project (CARP funds)*

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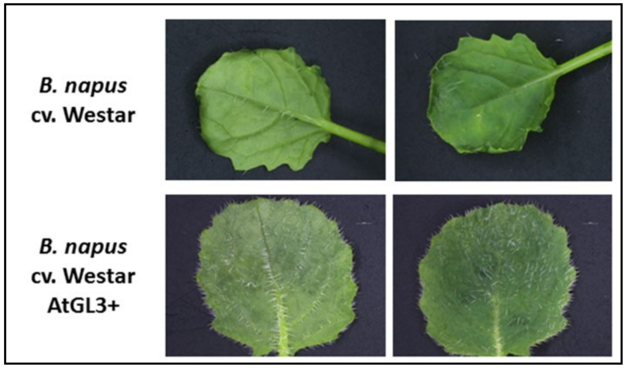
Hairy canola

Hairy canola: “Hairy” transgene reduced damages by crucifer FB (Gruber et al., 2006; Soroka et al., 2011; Alahakoon et al., 2016).



Genetic diversity study:

Hairy *B. napus* lines (DOS)
(Self pollination/double haploid)

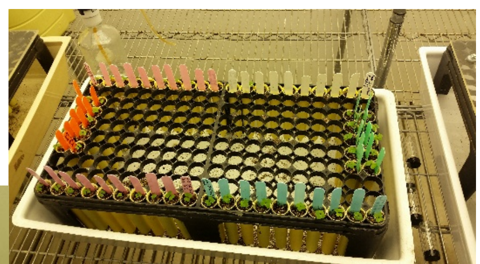
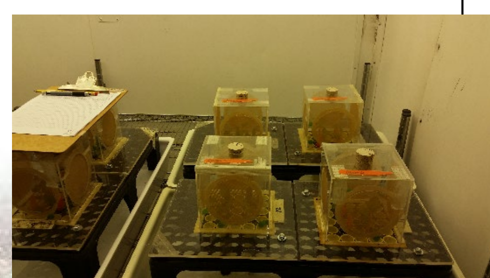
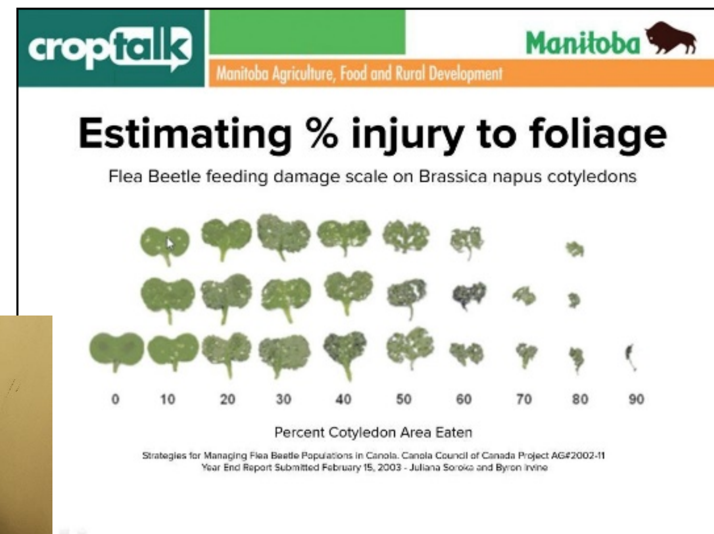
Hairy *B. villosa* (Bvil)

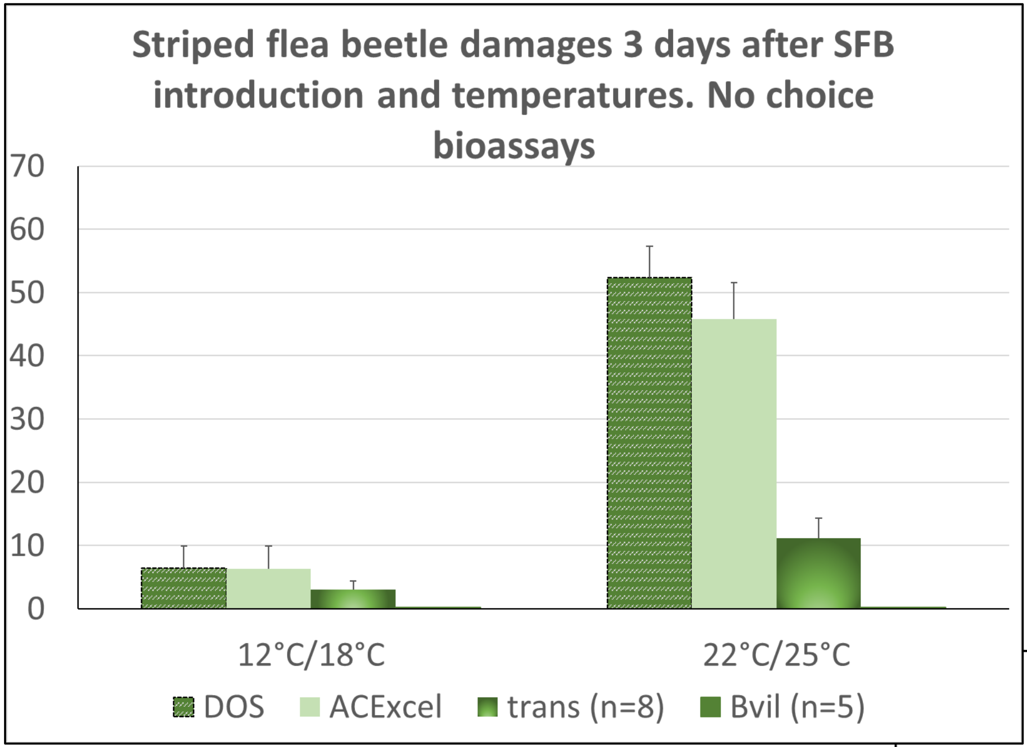
Bioassay-Feeding damages

Feeding damages after 1-5 days in choice/ no-choice bioassays with Ac Exel, DOS, Bvil, RR lines, transgene lines.

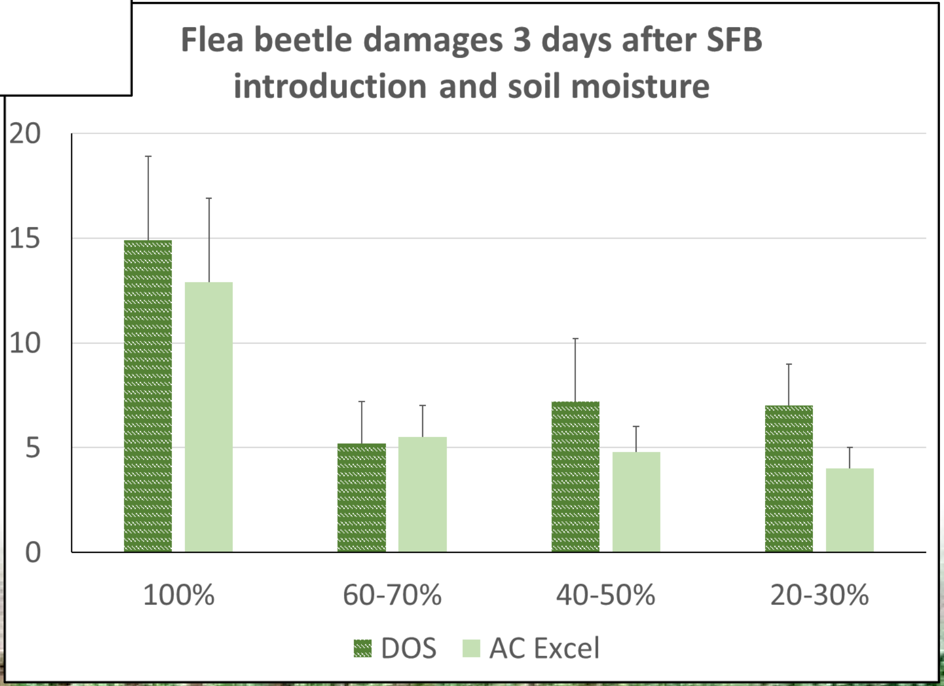
Set-up:

4 plants & 10 fb/cage; 5 rep
2 growth stages (cotyl, 1&2 leaf);
2 temperatures (12ºC night/18ºC day and 22ºC night/25ºC day);
4 soil moistures: dry (20-30%), wet (40-50%), very wet (60-70%) & saturated (100%).
16L/8D, 50-60% relative humidity, and 400-500 μmol/m^2 /s.
Damages: % damaged leaf areas.

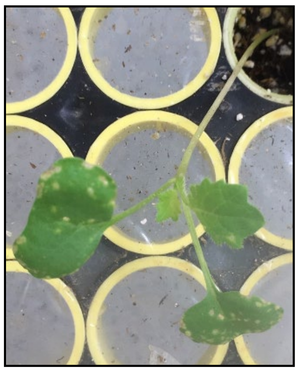


SFB damages is worse when temp and soil moisture are high



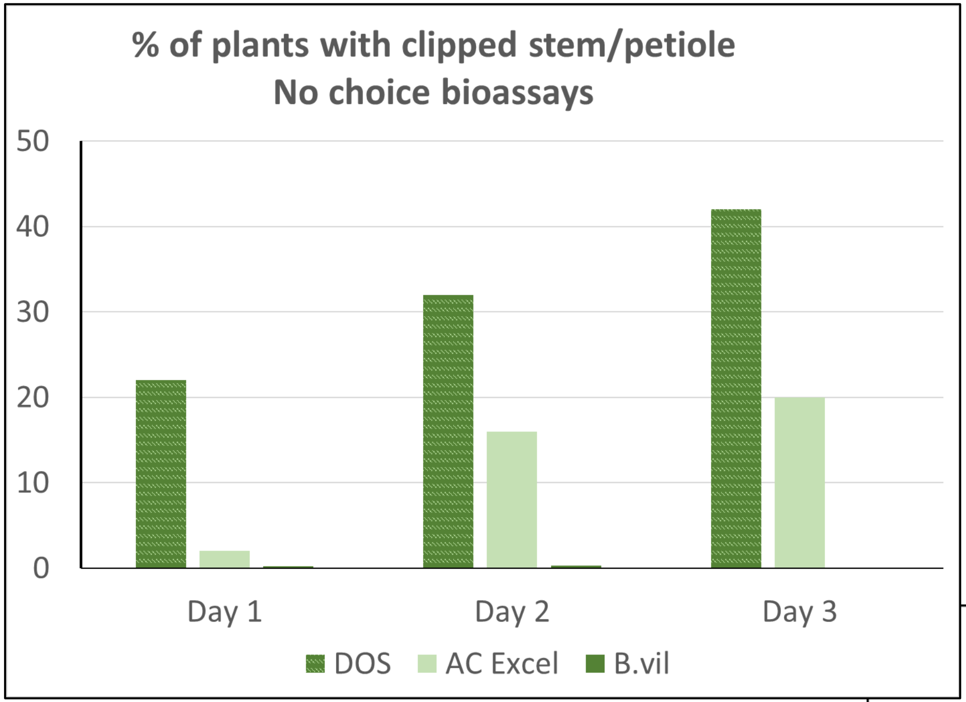
Spring population of SFB

DOS plants tend to be clipped by striped flea beetles at the stems and petioles, as compared to AC Excel.

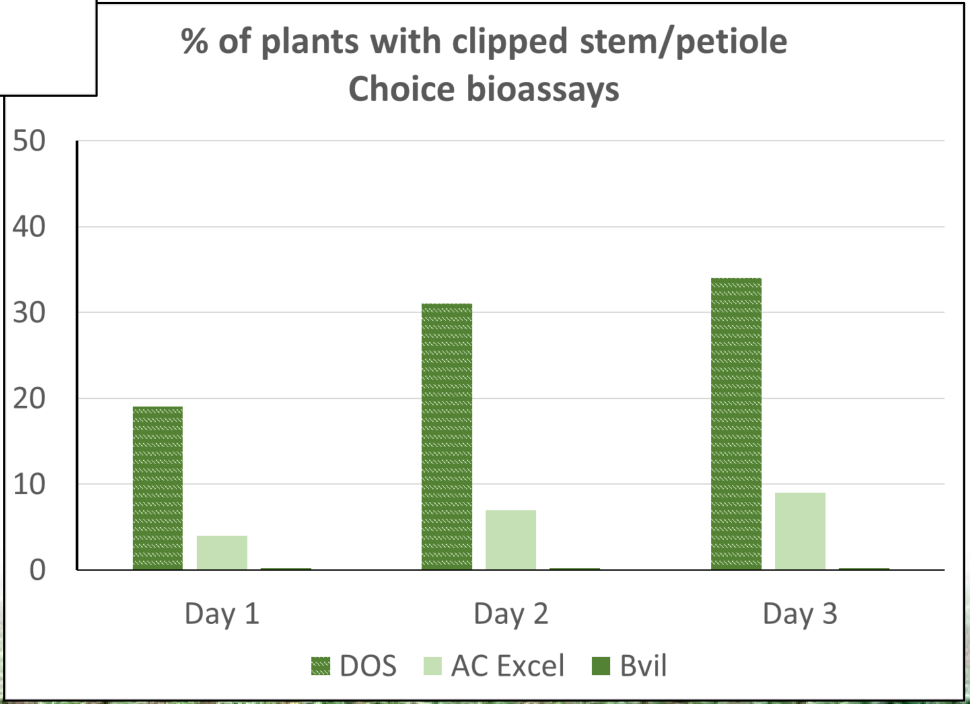


AC Excel

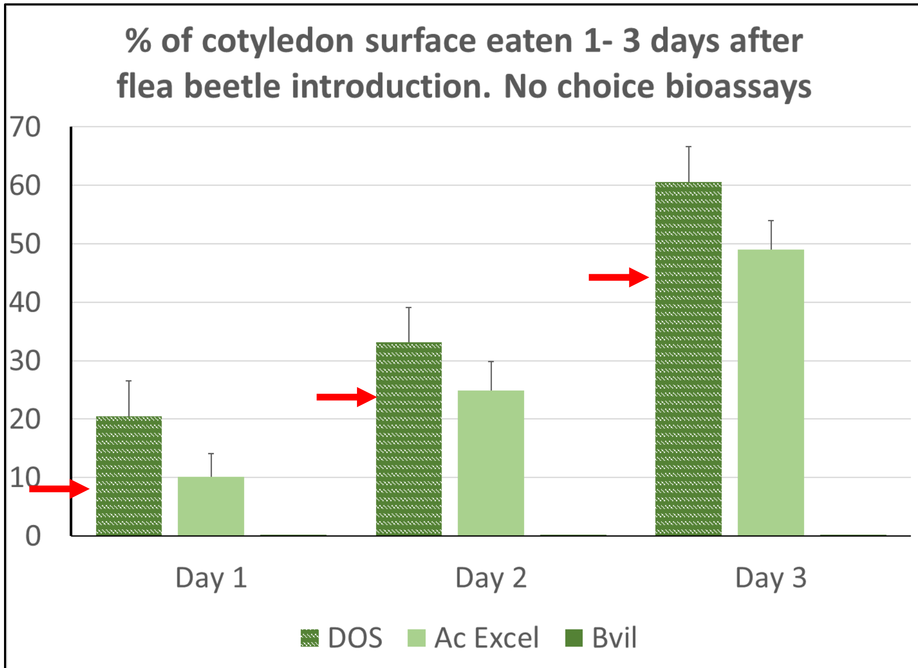
DOS

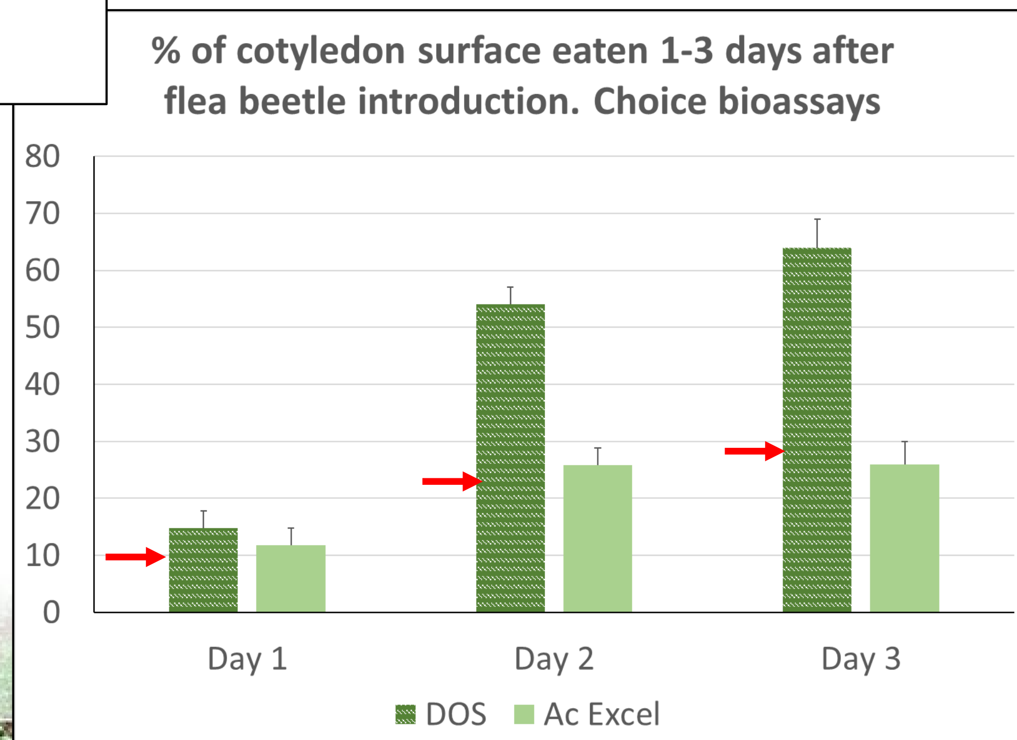


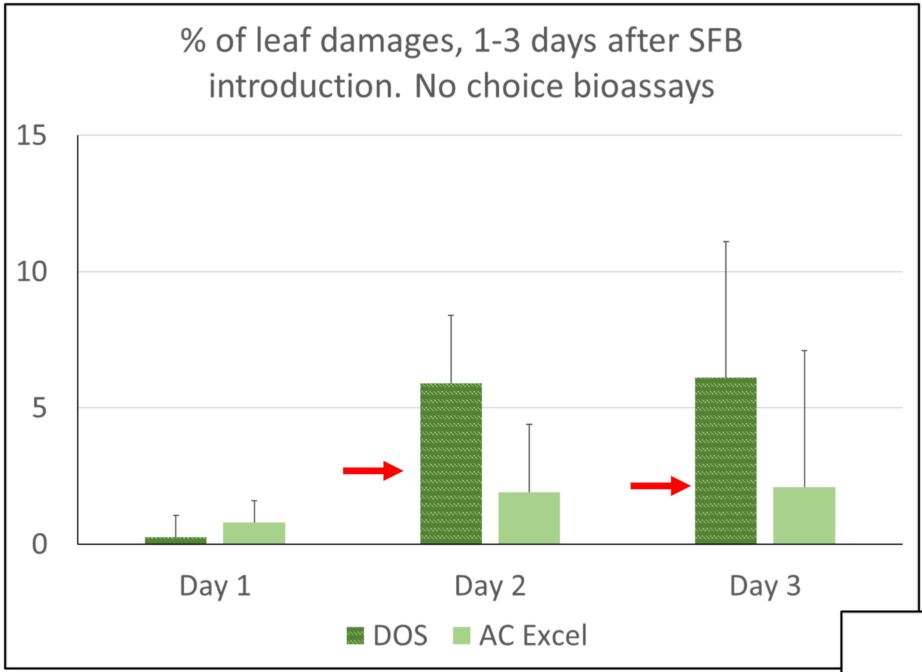
SFB tend to clip DOS more than AC Excel.
SFB don’t seem to clip *B. villosa*



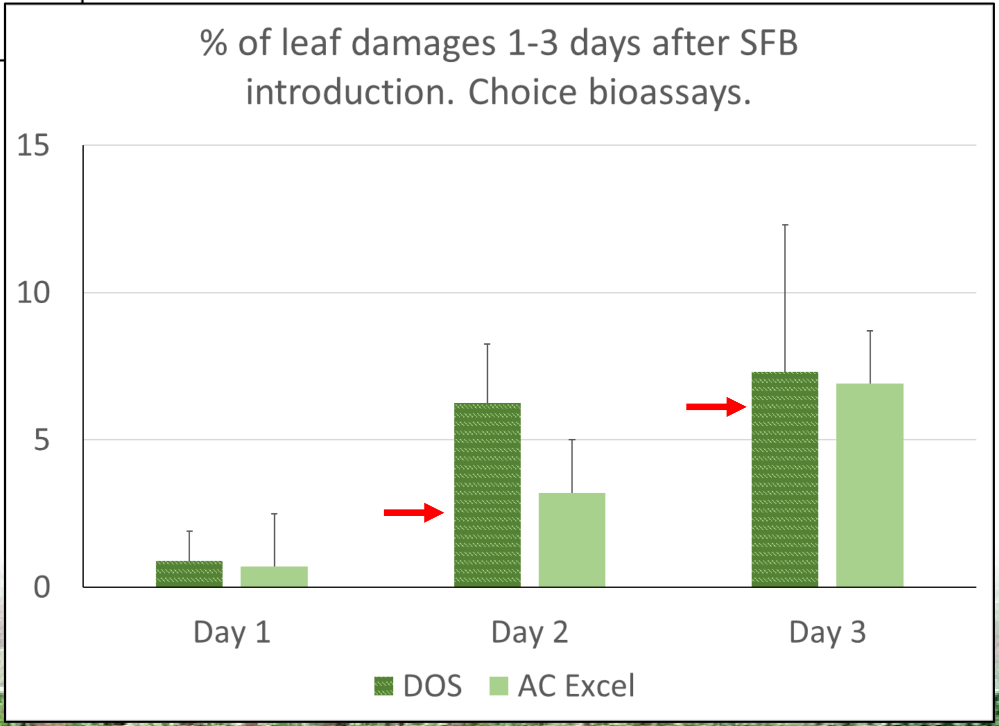
Little to no feeding on *B. villosa*.
Feeding in DOS and ACExcel similar after removing the clipped plants.
Damages on DOS higher because of plant clipping.

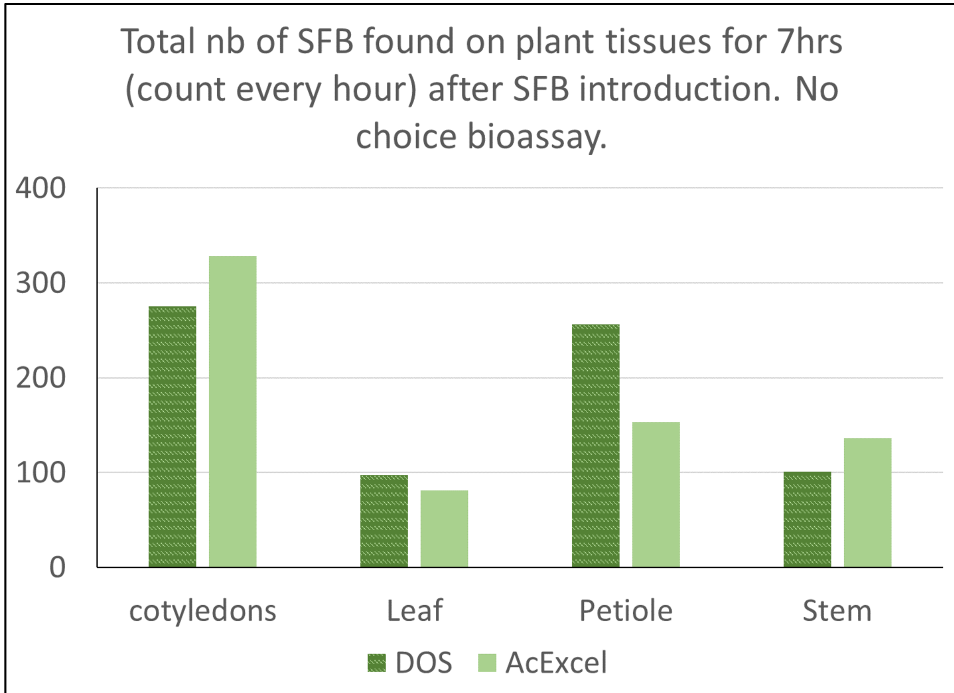




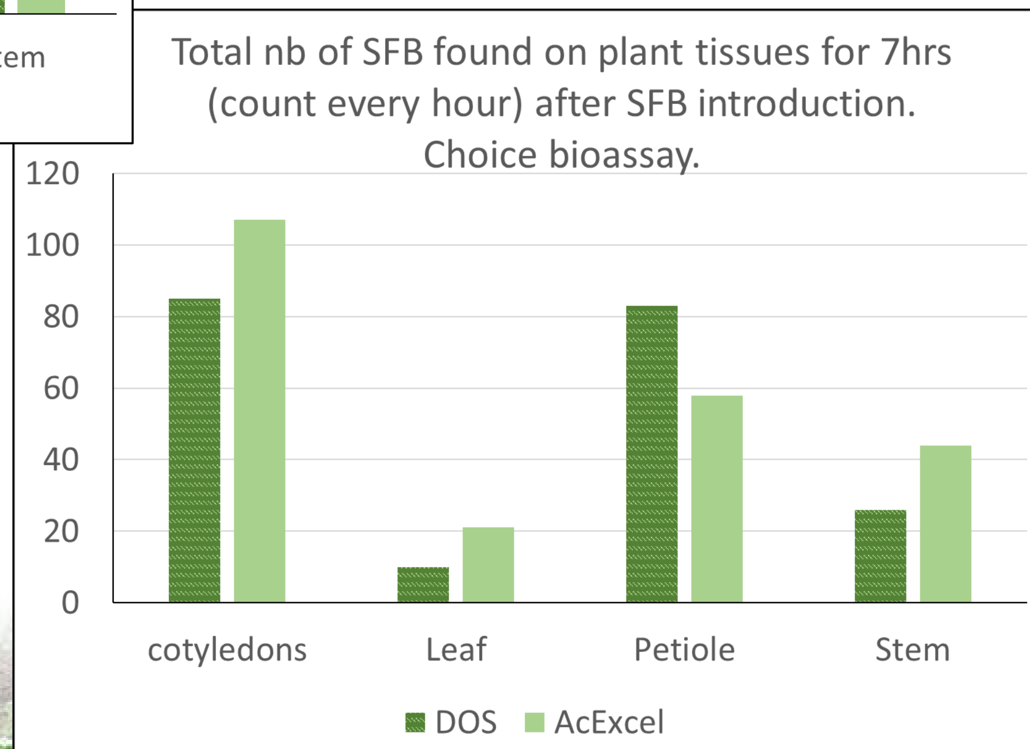


Feeding in leaves of DOS and ACExcel similar.

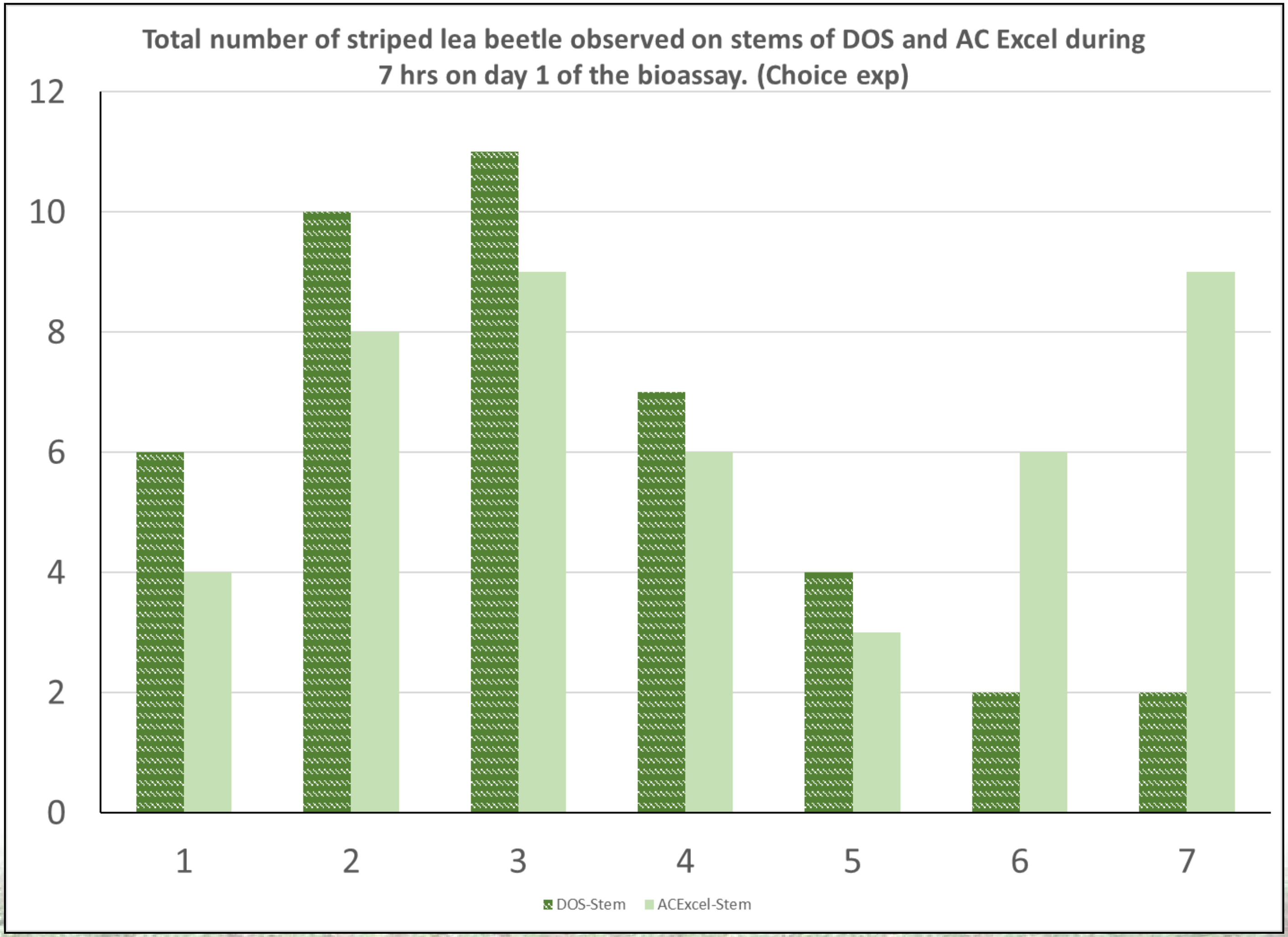




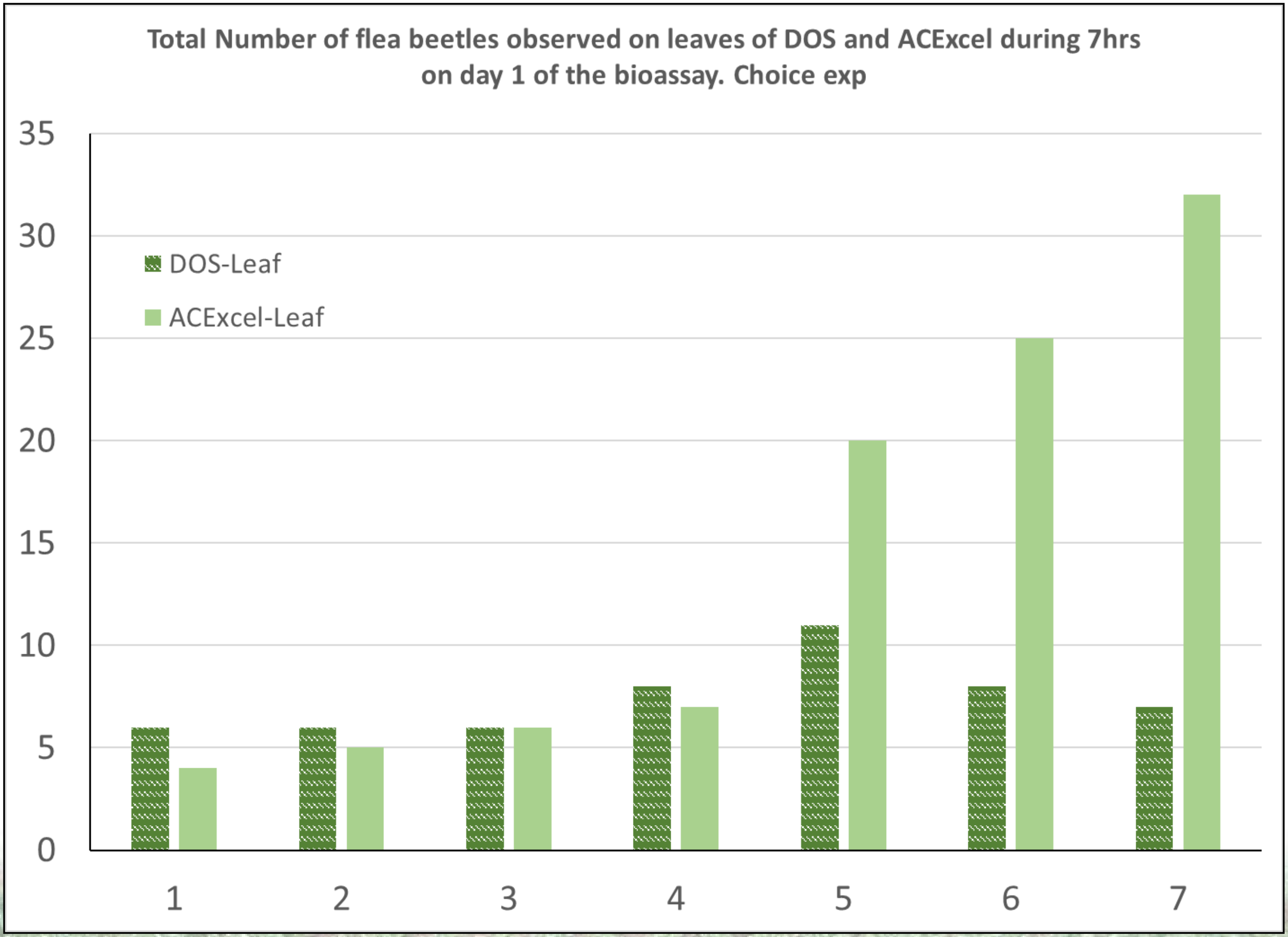
Striped flea beetles more observed on cotyledons and petioles as compared to leaves and stems.



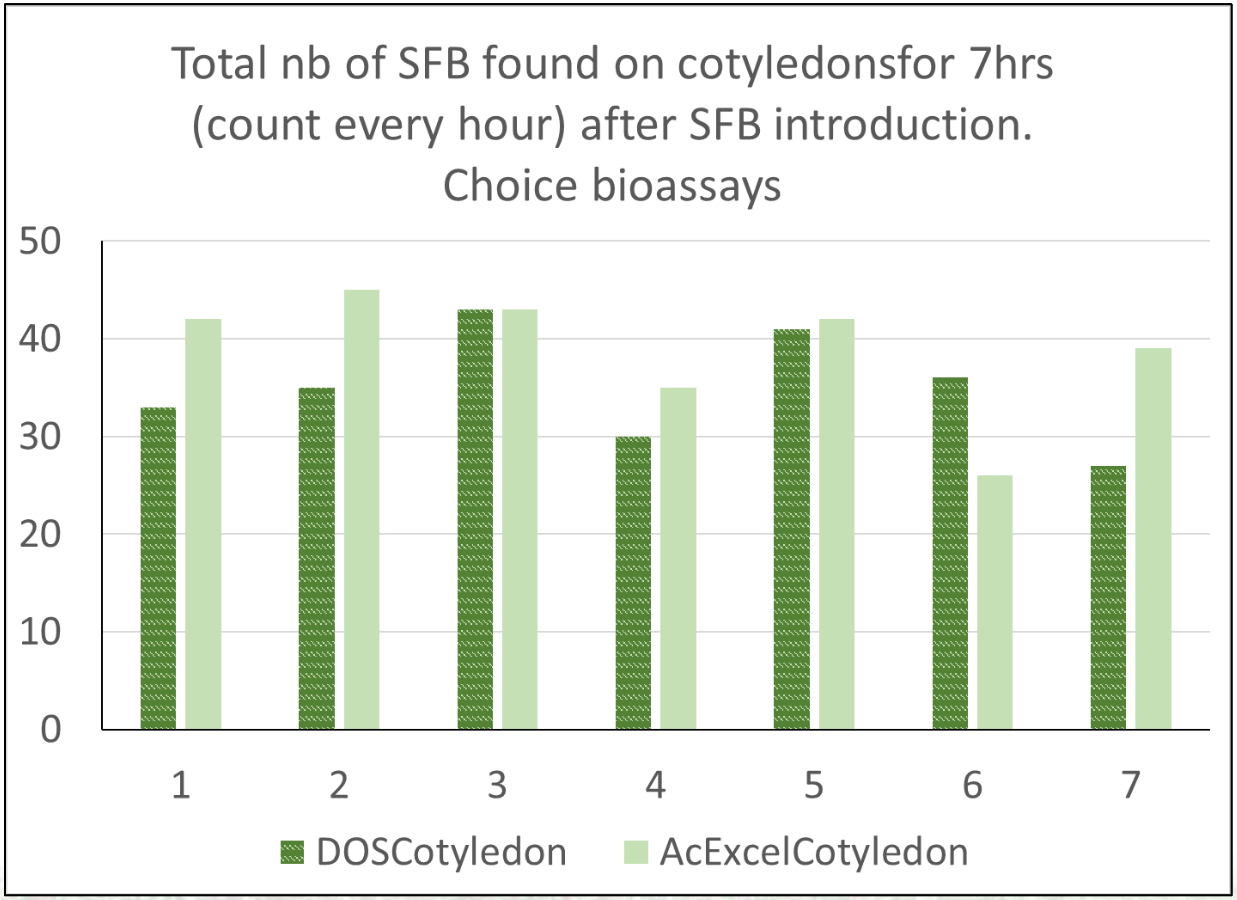
SFB observed on stems of DOS during 1-5 hours and observed more on stems of AcExcel after 5hrs: avoiding the DOS stems?.



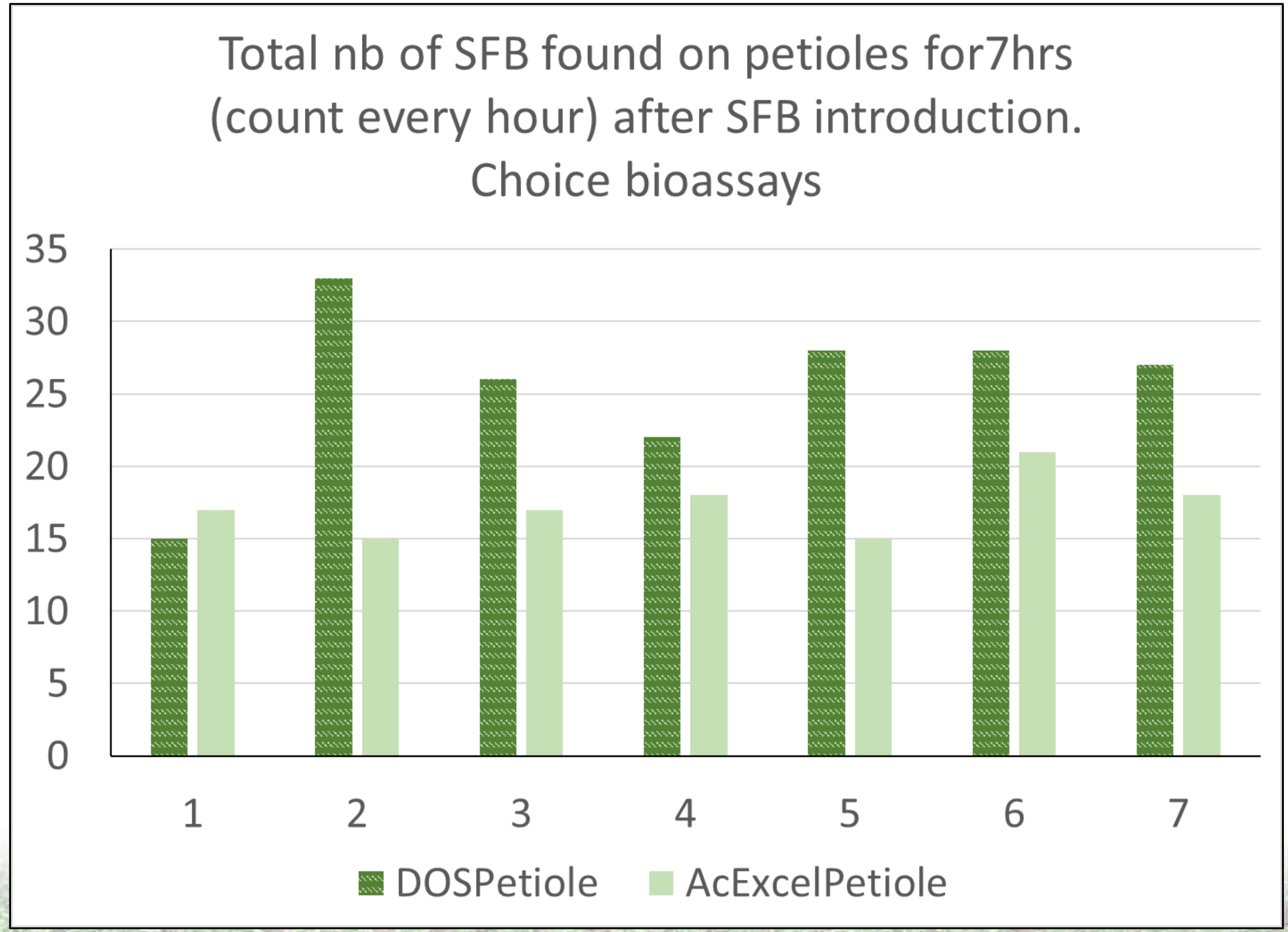
Flea beetles more observed on leaves of ACExcel as compared to DOS, after 5hrs: ***<u>avoiding the hairy parts?</u>***



Flea beetles more observed on cotyledons of ACExcel as compared to DOS during the first 2hrs: ***avoiding the DOS cotyledons?***



Flea beetles more observed on petioles of DOS as compared to AcExcel during the first 7hrs.



Conclusion- Flea beetles

Little to no feeding on *B. villosa* plants in choice/no choice bioassays using spring striped flea beetle populations.

Higher damages on DOS because of stem clipping on days 1 & 2, but similar losses in % of foliar damages in DOS and ACExcel in choice/no choice bioassays at 3 days.

Striped flea beetles tend to move from stems and leaves of DOS to stems and leaves of ACExcel, indicating that SFB seem to avoid hairy leaves of DOS.

Striped flea beetles tend to stay on petioles of DOS.

1 year to go….
More bioassays, repetitions and statistical analyses
Field trials (?)

Development of IPM
Ongoing/Future projects

<u>Future projects</u>:

Life cycle of the striped flea beetle? (overwintering sites, temp/moisture influence on life cycle, parasitoids & predators)

Economic threshold for striped flea beetle? (new canola cultivars, production losses spring/fall population)

Plant resistance (wax,..) ?

Cause of neonic “resistance”?

Other management system (biopesticide, cultural practices, RNAi)?

Acknowledgments

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Questions?