Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

2012 Aster yellow outbreak in Saskatchewan

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Agronomy update, Lethbridge
January 14th, 2012.

Canada

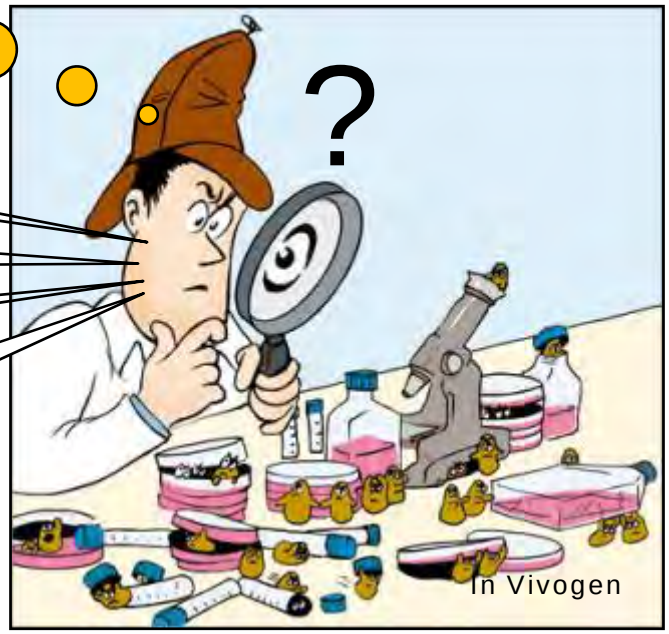
Phytoplasma

How to grow them?

How do they reproduce?

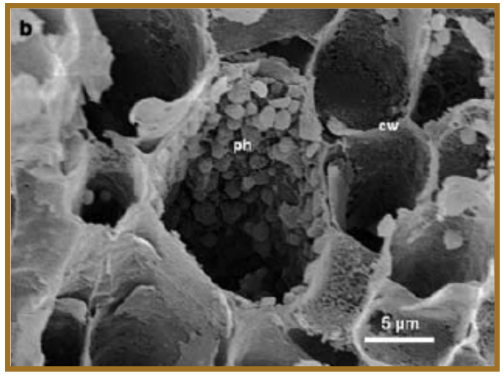
Identification and characteristics?

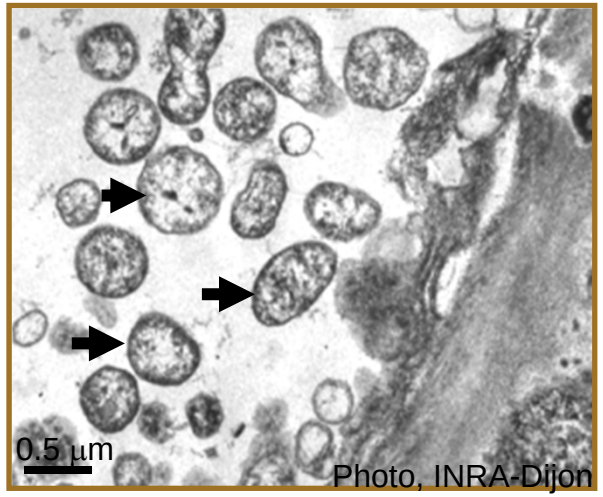
Transmission?



AY phytoplasma

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





Characteristics

- Pleomorphic, small genome (580-1350 kb).
- Classification based on molecular & ecological characteristics.

PCR

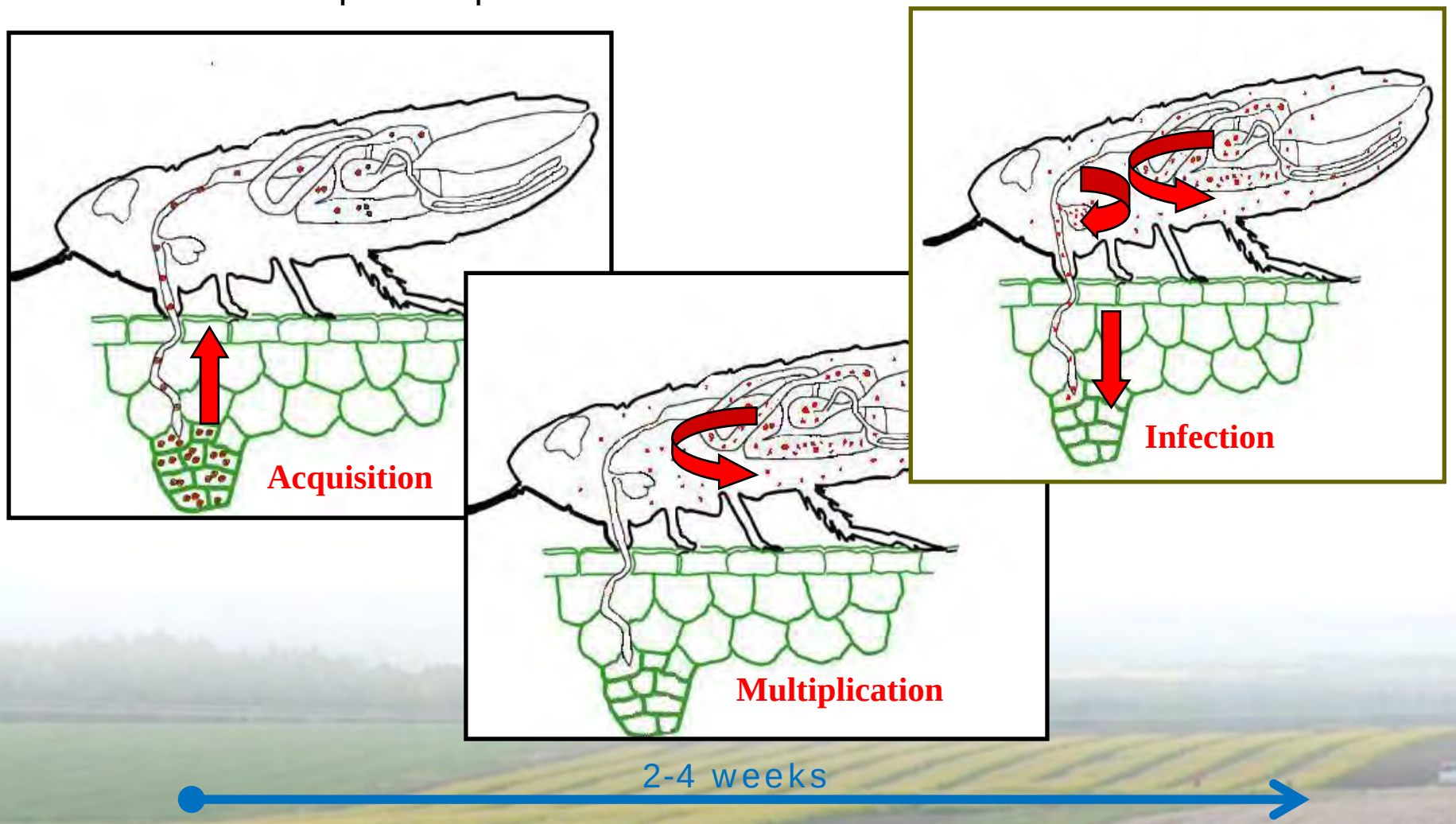
- 28 groups worldwide (Wei et al, 2007) & 7 groups in Canada (Olivier et al., 2009)
- AY the most common and widespread (Weintraub & Beanland, 2006)

AY phytoplasma

Transmission

- By insects, mostly leafhoppers (a few planthoppers, psyllids)

From plant to plant.



AY phytoplasma


Scaphoideus titanus, photo INRA-Dijon

Transmission

- By insects, mostly leafhoppers (a few planthoppers, psyllids)
  - From plant to plant
  - Via eggs (=transovarially)
    - 4 species (3 exotic, *Scaphoideus titanus* in Canada)

- Overwinter in roots and dormant tissues of perennial plants (dandelion, quackgrass, shrubs, ..)

Disease reservoir

AY phytoplasma


Scaphoideus titanus, photo INRA-Dijon

Transmission

- By insects, mostly leafhoppers (a few planthoppers, psyllids)

  From plant to plant

  Via eggs (=transovarially)

  - 4 species (3 exotic, *Scaphoideus titanus* in Canada)

- Overwinter in roots and dormant tissues of perennial plants (dandelion, quackgrass, shrubs, ..)

  - By seeds?

  - Detection in embryos of mulberry, coconut and alfalfa (Jiang et al., 2004; Necas et al., 2008; Nipah et al., 2007).

  - Detection in flowers, seeds & seedlings of *Brassica napus, B. rapa,* tomatoes and corn (Olivier et al., 2008; 2010; Bertaccini et al., 2012)

Phytoplasma

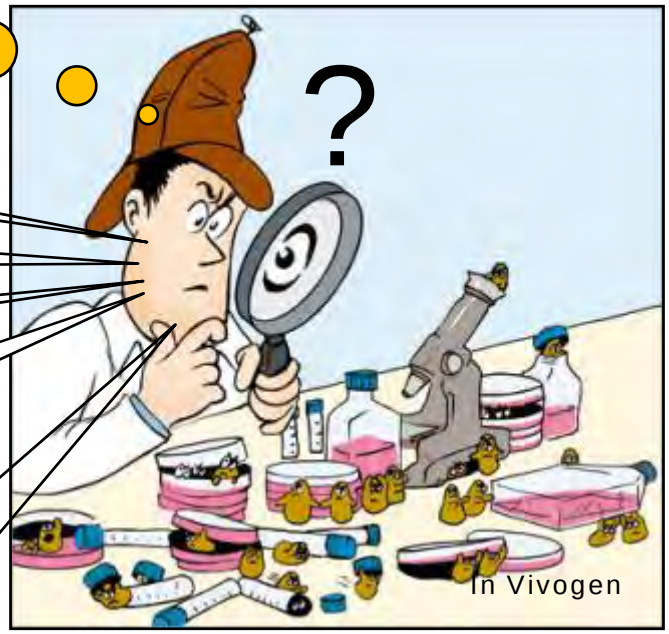
How to grow them?

How do they reproduce?

Identification and characteristics?

Transmission?

How do they manipulate plants & insects?



AY phytoplasma

Symptom expression

After a latent period: 2-6 weeks, depending on the weather/strain, varieties, stresses, … (parameters?)

Cause of symptoms: Poorly understood!

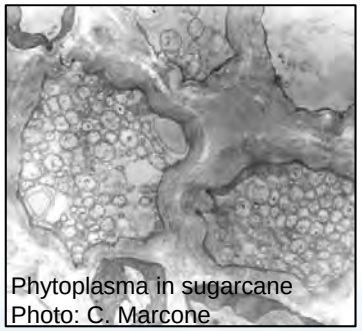
Up/down gene regulation

Phytoplasmas lack genes for a lot of metabolites

Pump all the metabolites directly from the plant phloem

Multiplication of phytoplasmas → Clogging of sieve elements

Chlorosis, stunting, poor growth
Flowers become leaf-like structures



Phytoplasma in sugarcane
Photo: C. Marcone

Poor seed production

AY phytoplasma

Consequences of AY on vectors

- Beneficial: Increased lifespan and fecundity, better survival , host range expansion & higher flight activity.
- Neutral: No consequences
- Detrimental: Decreased lifespan, fecundity, …

Beneficial effects usually on primary vectors
Neutral / detrimental effects usually on secondary vectors

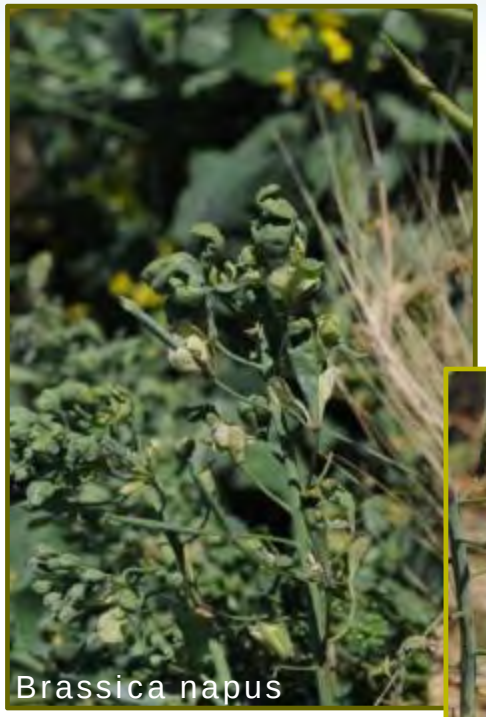
?

Co-evolution between phytoplasma / vector ?

AY symptoms on canola

- Sterile bladder like pods
- Small witches'-broom
- Yellowing, purpling
- Other causes for purpling:
    - Varieties
    - Deficiency in minerals
    - Herbicide injuries

AY symptoms in 2012


Brassica napus


Brassica juncea


Brassica napus


Sinapis alba

AY symptoms in 2012

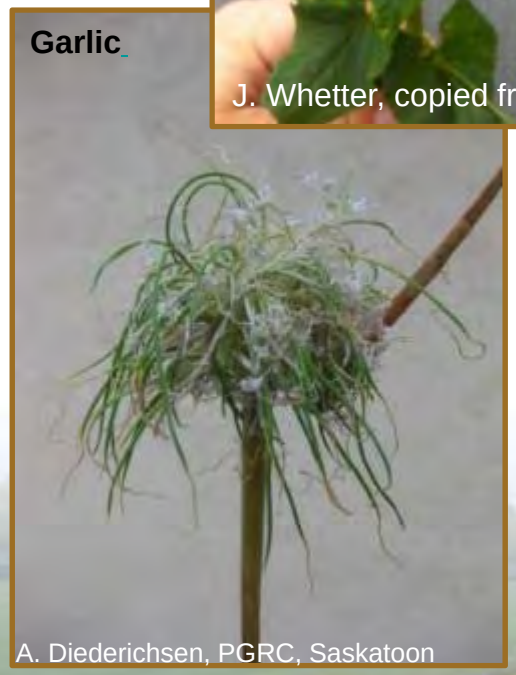
Re-growth of symptomatic branches at the base?

-AY: induce the plant to keep growing…. to attract leafhoppers.

-High temperatures slow down phytoplasmas in above-ground tissues, but in roots may induce symptoms later in the season.

AY symptoms on Camelina sativa & Sinapis alba

AY symptoms on other plants



AY symptoms on other plants

Photos: CABI

Yield losses: AY symptoms on seeds

- Sterile bladder-like pods.
- Normal looking pods with germinated seeds.
- Normal looking pods with normal-looking & misshapen seeds.

Healthy

AY-infected

Photo: E. DeMilliano, AB

Photo: E. DeMilliano, AB

~30-60% misshapen seeds in AY infected canola (2002-05).

Same in 2012 ?

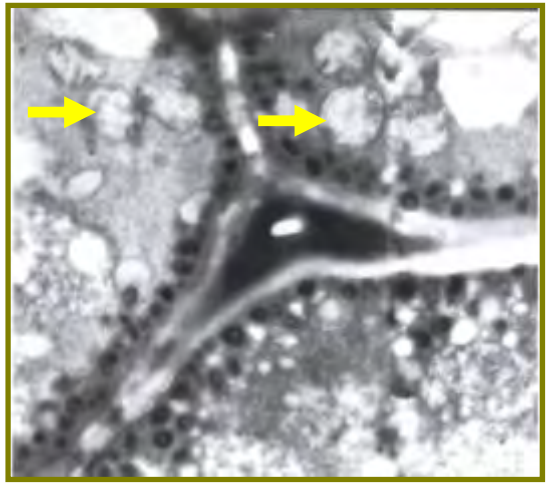
8-10% plants with no seeds

AY incidence in canola

About normal-looking seeds in infected plants?

- Phytoplasma DNA detected in seed coats and embryos (PCRs).
  2002-2005: <1% 2012: ~ 8% (AAFC small plot nursery)

- EMs show intact phytoplasma (?) in seed coats.
- 30-45% progeny plants malformed (high number of trichomes, no growing point, condensed flowers, strong growth delay).



AY incidence in canola

Healthy

Progeny of AY-infected plants

Phytoplasma infection

↓

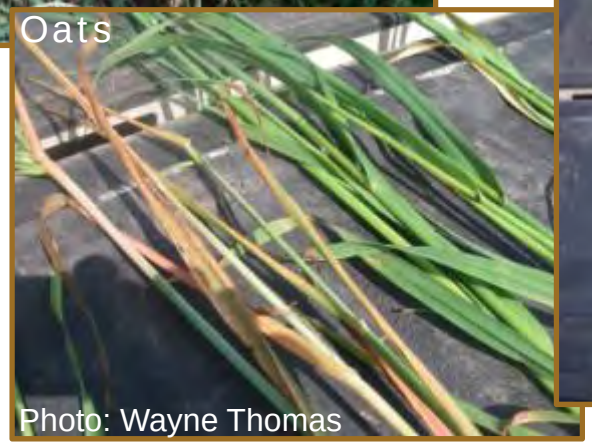
- Malformed progeny
- Strong growth delay on progeny, meaning no survival of malformed plants.

AY symptoms on cereals

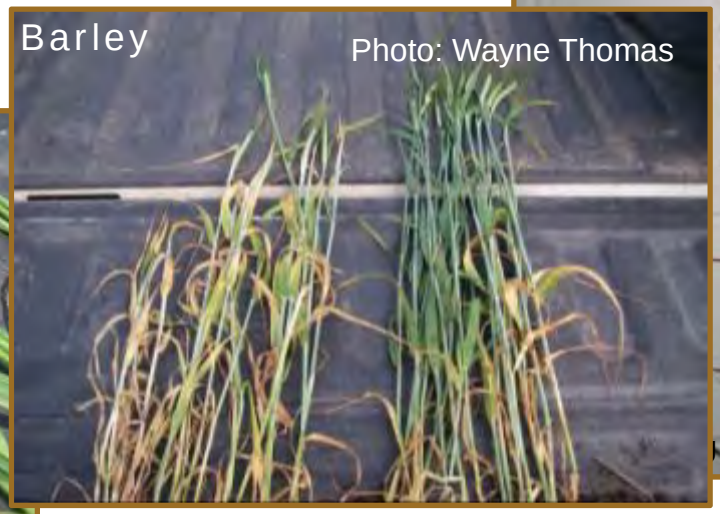

Wheat
U of Montana

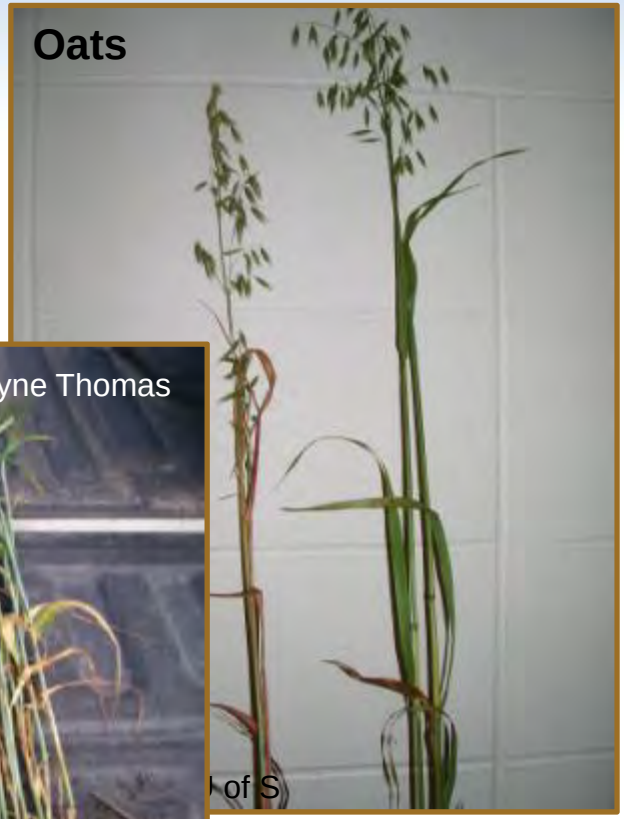
- Yellowing, red & purple pigmentation
- Leaf rolling, erect habit and necrosis
- Head small, sterile, distorted, twisted.
- *Very similar to BYDV....only way to differentiate: PCR*

AY symptoms on cereals



AY or BYDV ?





PCR on cereal samples:

- *Wheat: <5%*
- *Barley:~25%*
- *Oats: 17%*
- *More PCRs to do…*

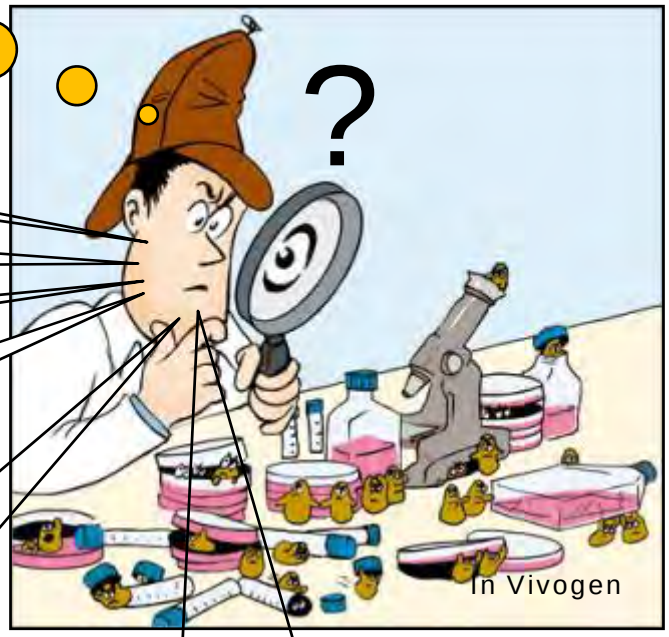
Phytoplasma

How to grow them?

How do they reproduce?

Identification and characteristics?

Transmission?



AY epidemiology In the prairies?

How do they manipulate plants & induce symptoms?

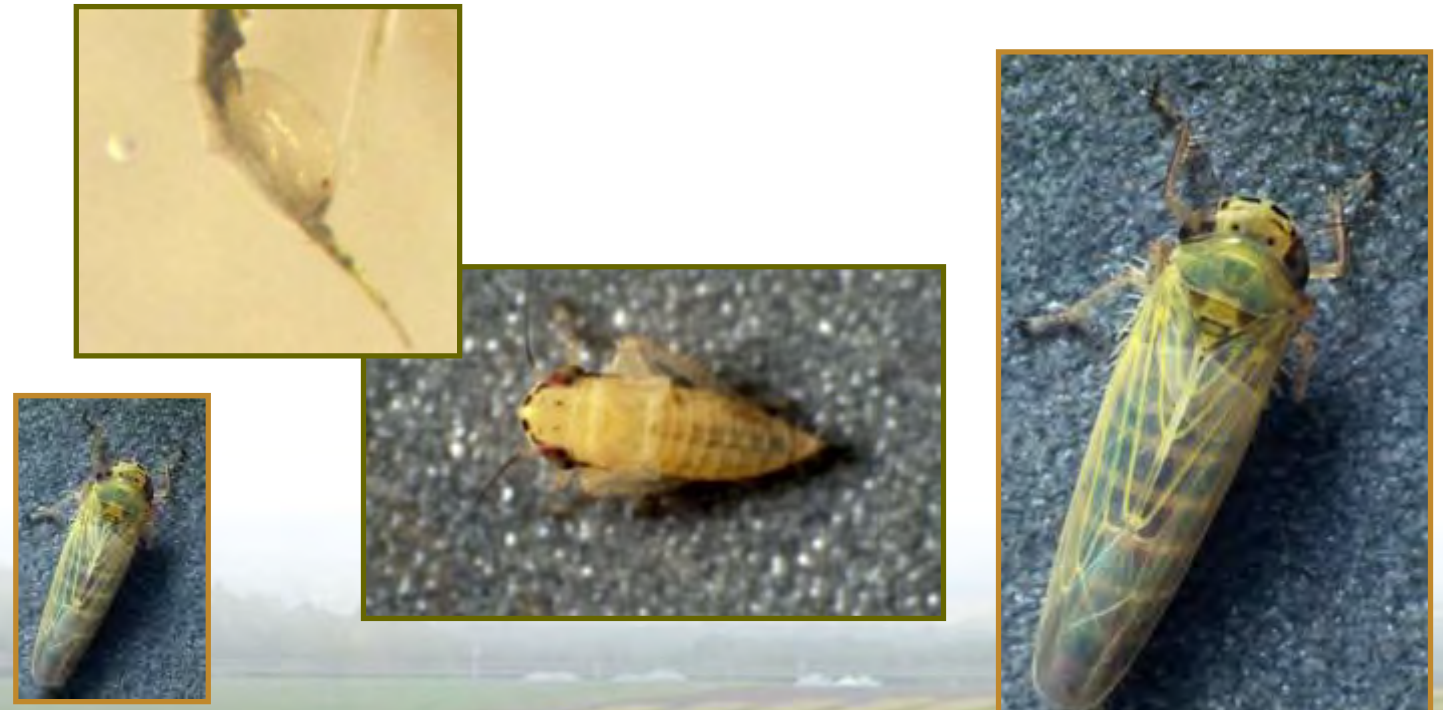
AY phytoplasma

Aster Yellows phytoplasma (16SrI)

In oilseeds in Canada

- 3 strains (16SrI-A, B, C), +200 plant species.
- Vectors

Main vector: Aster leafhopper (*Macrosteles quadrilineatus)*



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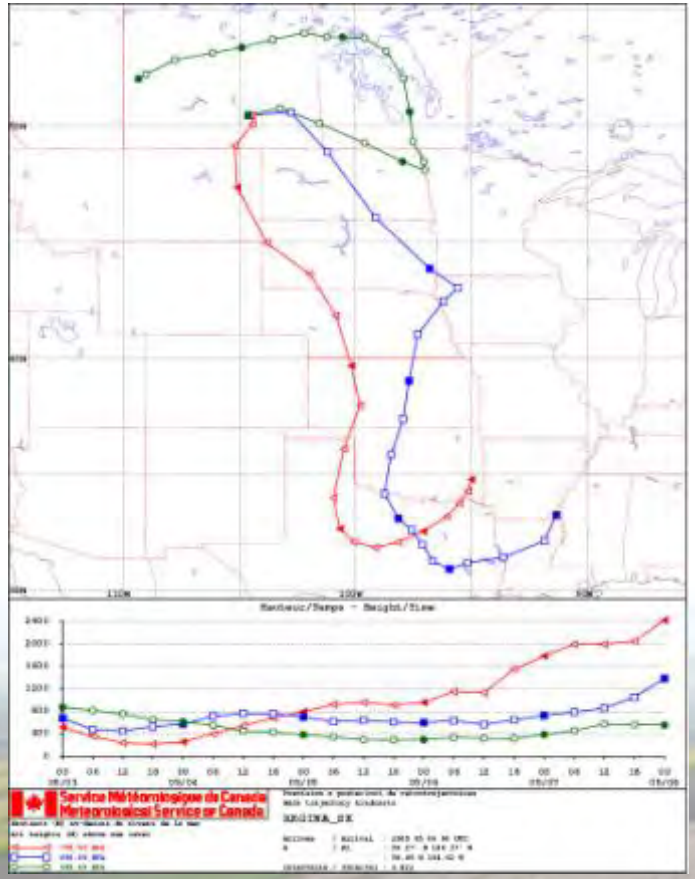
Main vector: Aster leafhopper (*Macrosteles quadrilineatus, formerly M. fascifrons)*

Migratory: South winds in spring
- High number of leafhoppers
- Infection in South USA
- Several South winds

Local pop.: abundance?



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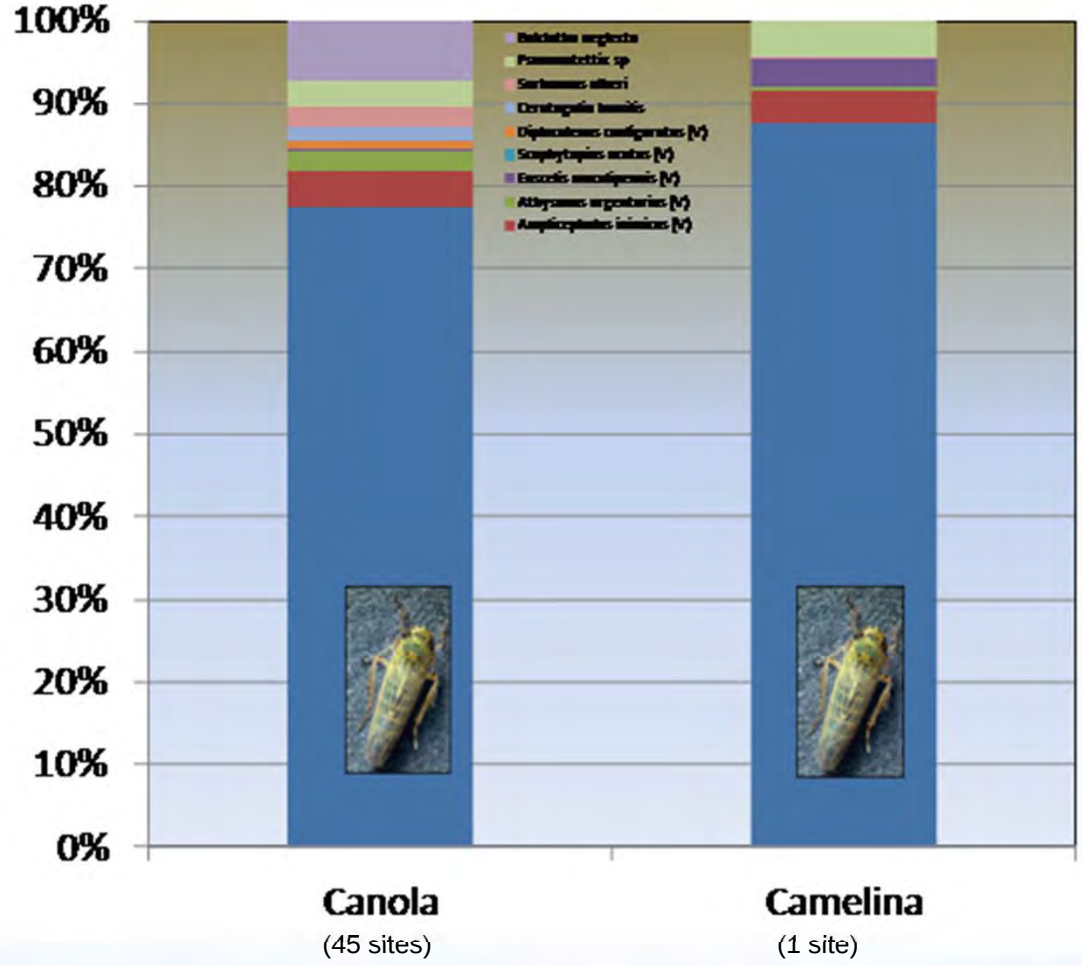
7 other potential leafhopper vectors (role in outbreak, maintain reservoir?, abundance?)

Potential vectors in oilseeds
Endria inimica
Colladonus montanus
Colladonus geminatus
Euscelis maculipennis
Scaphytopius acutus
Exitianus exitiosius
Paraphlesius irroratus

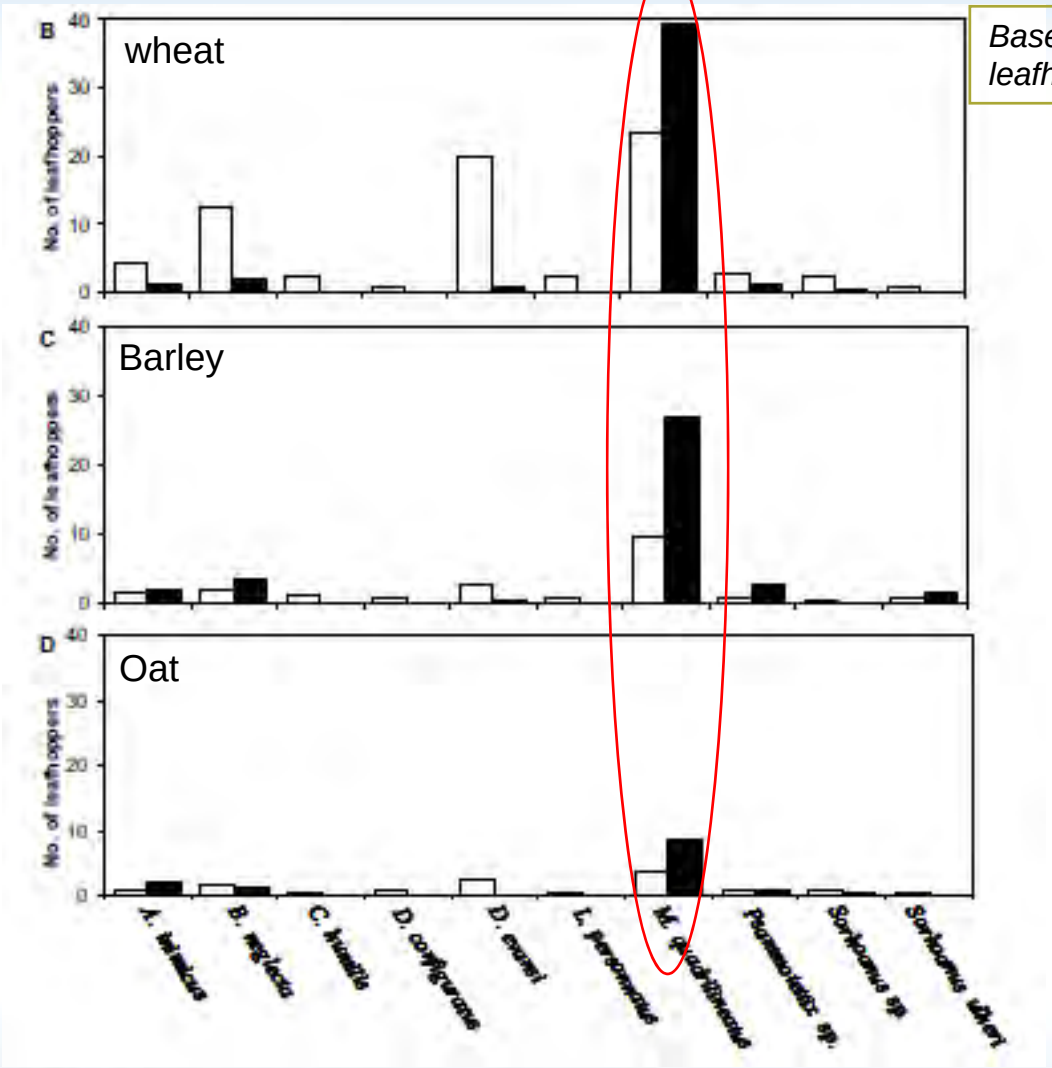
Leafhopper distribution



Based on the average no. of leafhoppers in 2007-2011.

- *M. quadrilineatus is* the most abundant leafhopper in canola and camelina..

Leafhopper distribution

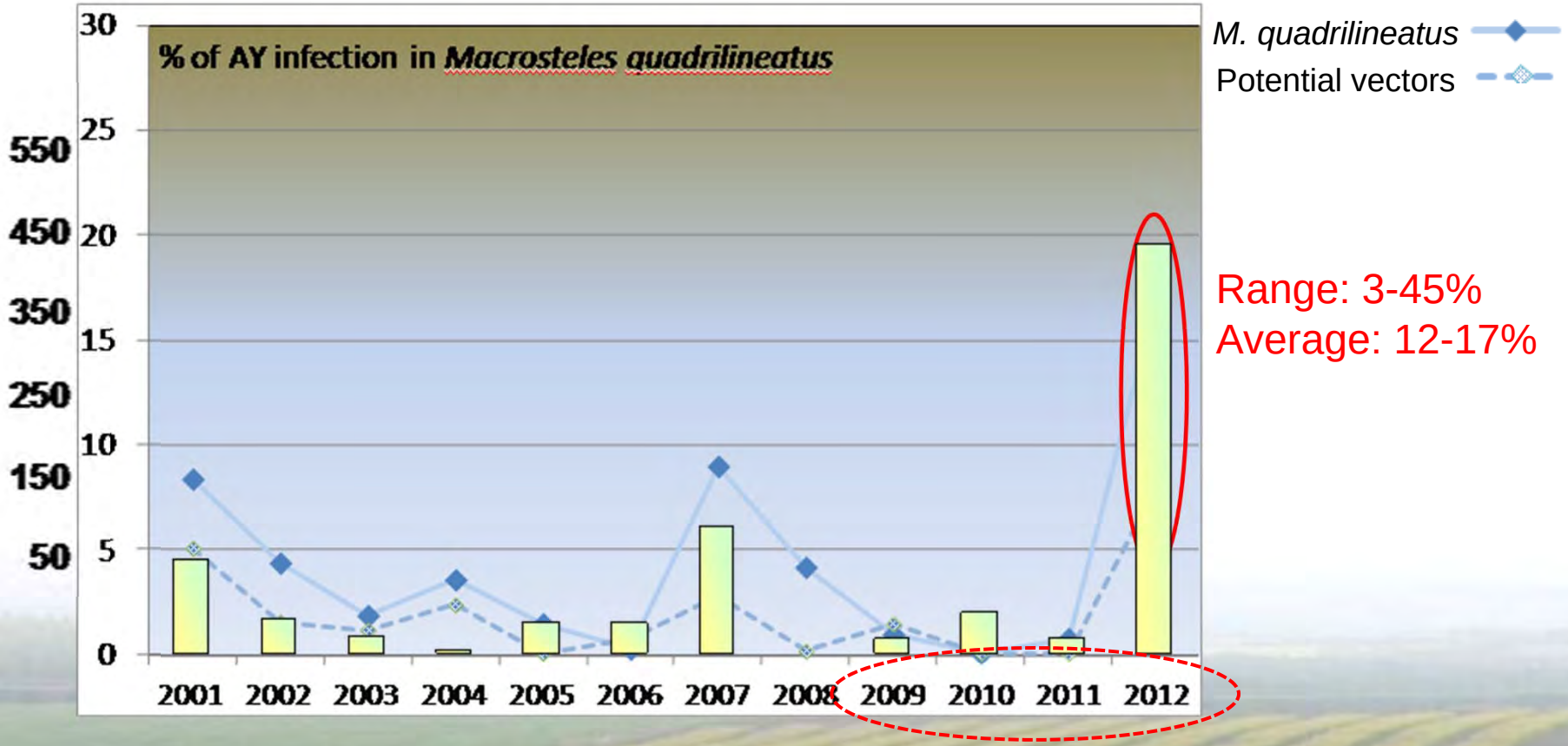


Based on the average no of leafhoppers in 2004-2008.

- *M. quadrilineatus is* the most abundant leafhopper in cereal.
- 2012: analysis of samples in process.

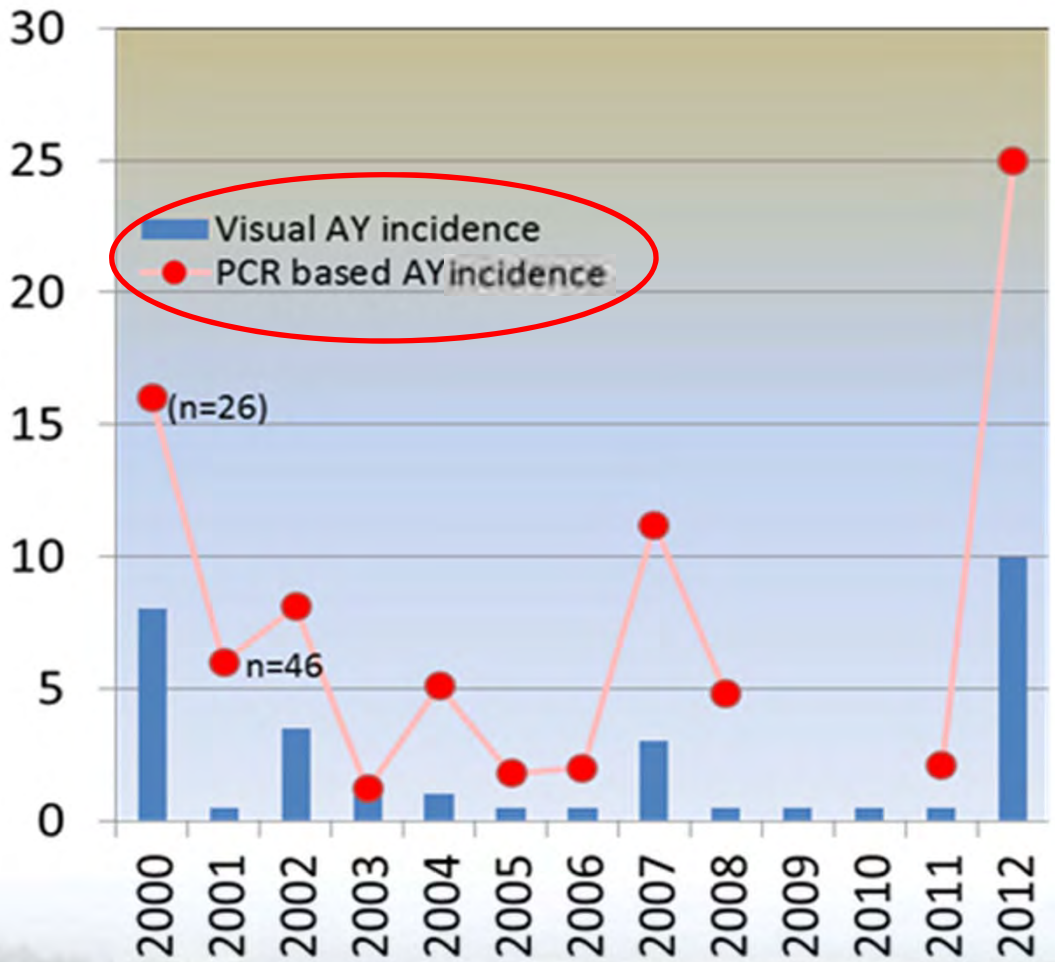
Olivier et al., 2011

Leafhopper infection and number



AY epidemiology

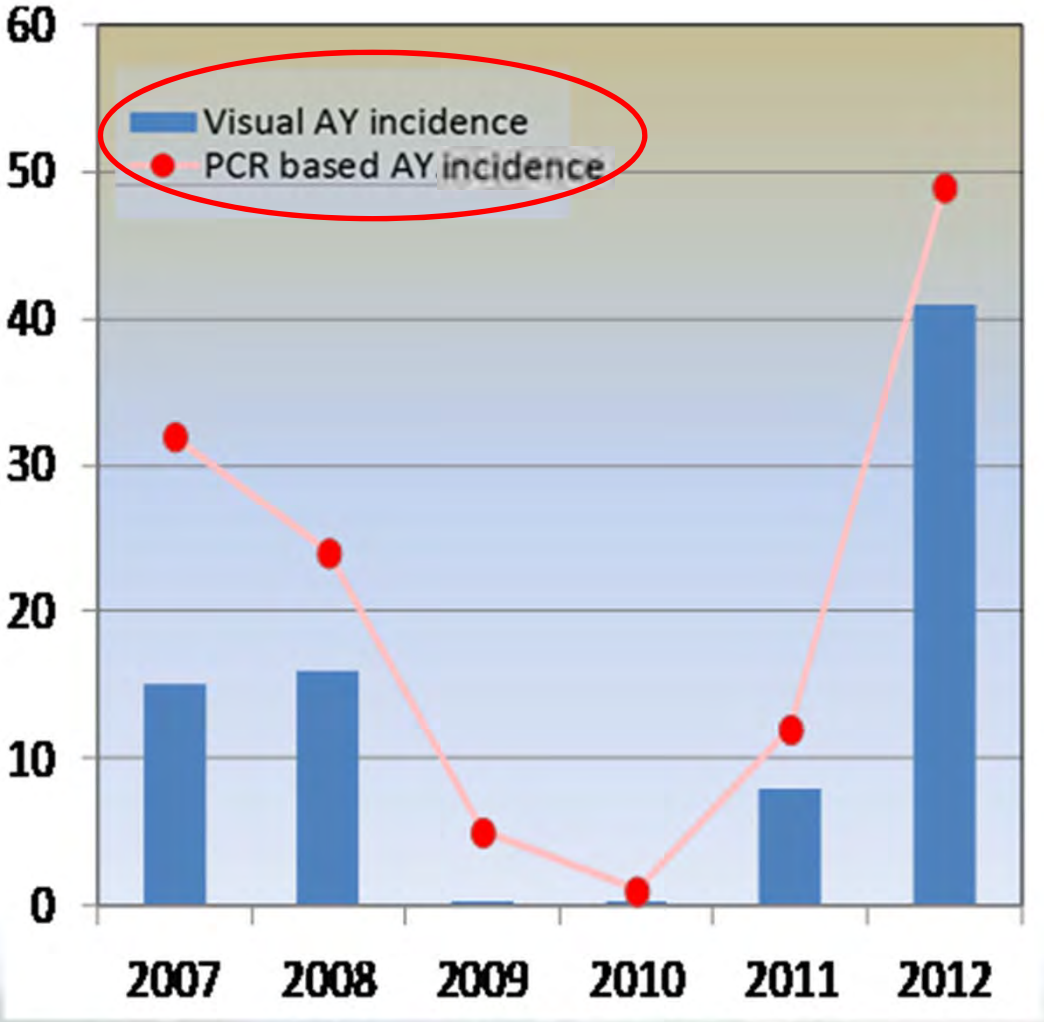
Canola



High % of asymptomatic infected plants

AY epidemiology

Camelina sativa



High % of asymptomatic infected plants

AY epidemiology

SK	Barley		Wheat		Oat	
	Visual	PCR	Visual	PCR	Visual	PCR
2005	(-)	9.4	(-)	6.4	(-)	7.2
2006	(-)	9.3	(-)	24.5	(-)	6.9
2007	(-)	66.6	(-)	38.8	(-)	25.4
2008	(-)	14.3	(-)	10.3	(-)	7.3
2012	(?)	25	(?)	5.0	(?)	17

From samples collected in 2004, AYp was detected from 48% (present in 12 of 25), 36% (present in 9 of 25), and 40% (present in 10 of 25) of plant collections made at transect location points 1, 3, and 5, respectively. Samples of DNA originat-

Hollingsworth et al., 2008

Very high % of asymptomatic infected plants

AY epidemiology

Next outbreaks????

Cannot forecast the date...

need to monitor winds, and leafhopper arrival and infection.

Are we at risk of more outbreaks? YES!

- Local population of vectors on the increase, AY in weeds
- Warmer winters: higher survival of phytoplasmas and overwintered leafhopper adults and eggs.
- Southerly winds coming earlier ?

Inoculum coming earlier, with higher probability of survival

	Date
2001	April 29
2002	May 22
2003	June 20
2004	May 9
2005	May 7
2006	April 1
2007	**April1**
2008	April 10
2009	April 11
2010	April 13
2011	April 10
2012	**April 1**

Phytoplasma

How to grow them?

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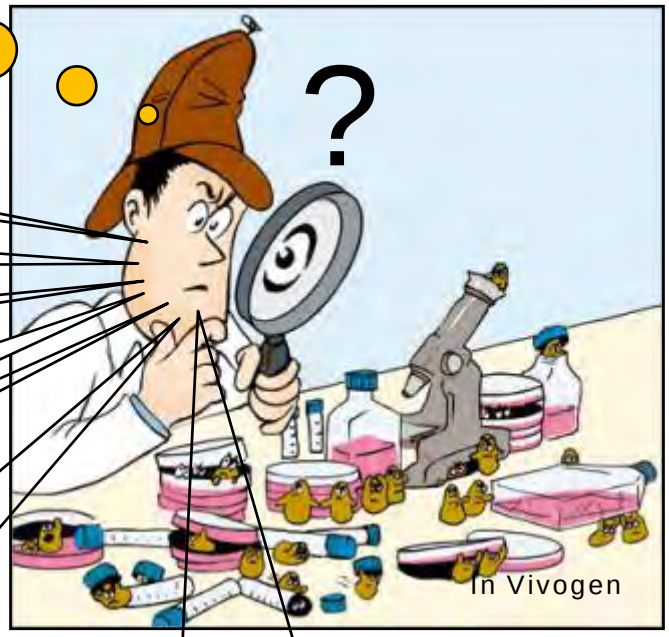
Identification and characteristics?

Transmission?

Control measures?

How do they manipulate plants & induce symptoms?

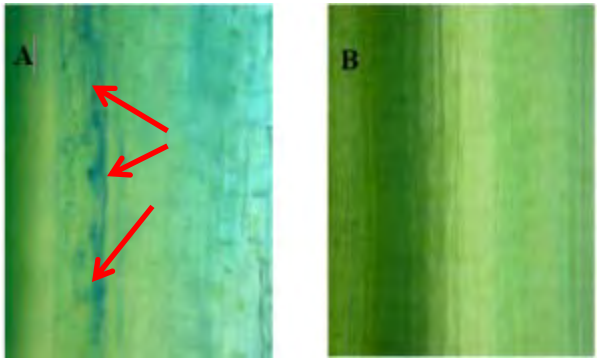
AY epidemiology In the prairies?



AY phytoplasma control

Phytoplasma weaknesses

- Antibiotics (tetracycline, erythromycin, streptomycin, chloramphenicol)…delay symptom expression
- Heat: > 32ºC for several days slows down phytoplasmas
  40ºC-50ºC for several hours kills phytoplasmas
- No commercially available chemicals to control phytoplasmas



Chiesa et al., 2007

plants. If treatments were stopped a bit short of the minimum, the treated plants would recover from the disease and would appear to be cured. Eventually symptoms would reappear, however, and in due course the treated plants become thoroughly diseased.

Kunkel, 1953. Exp.at + 40ºC

Commercially non viable to control phytoplasma in annual plants

AY phytoplasma control

Insecticides to control the vector population.

- Need several sprayings (waves of southerly winds).
- Negative impact on beneficial insects and environment.
- Leafhoppers are mobile, can transmit the disease before being killed.
- Latent period of 2-6 weeks for symptom development on canola (& most annual plants) after inoculation by leafhoppers.

When symptoms are observed, it is too late to spray

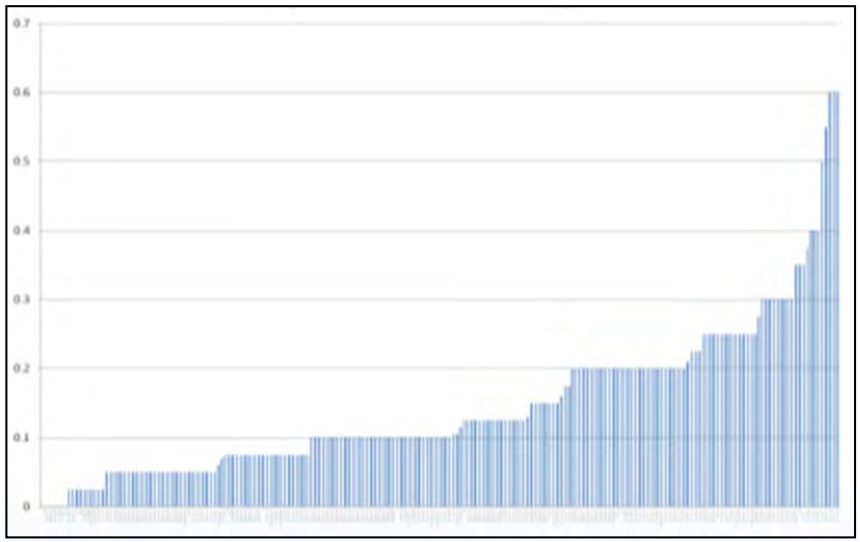
Talk to your agronomist

AY phytoplasma control

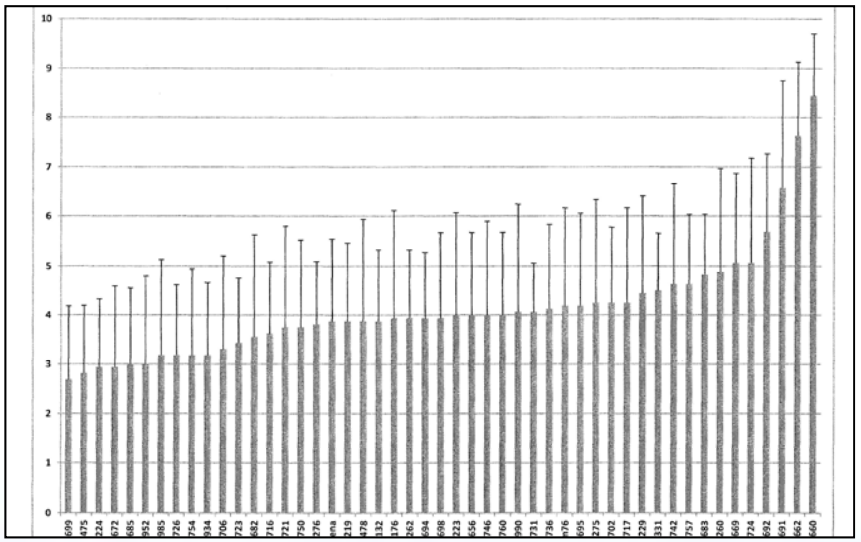
Other control measures:

- Resistance or disease avoidance (?): small plots (no field scale trials yet)

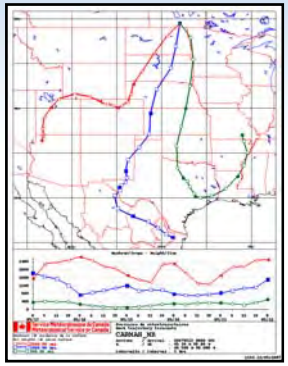
Canola – 2012 (0-80%)



Camelina – 2012 (15-100%)



AY phytoplasma control



Other control measures:

- Resistance or disease avoidance
- Early warning system...feasible but lots of unknowns.
    - Ratio local / migratory population of *M. quadrilineatus*
    - Role of other vectors & of reservoir plants
    - Leafhopper movement crop-to-crop.
    - .....
- Weed management: weed abundance and diversity favors leafhopper population.
- Mulching (aluminium mulching on carrot)
- Insect-exclusion screens (vineyard in Australia)
- Predators / parasitoids...not well known for AY vectors in the prairies
- ....

Conclusion

- Phytoplasma diseases: difficult to study & to control.
  - Many unknowns…strains ID, role of vectors, symptom expression

- Risks of increased AY incidence in the future
  - Due to (?) climate change, increased number of leafhoppers, …

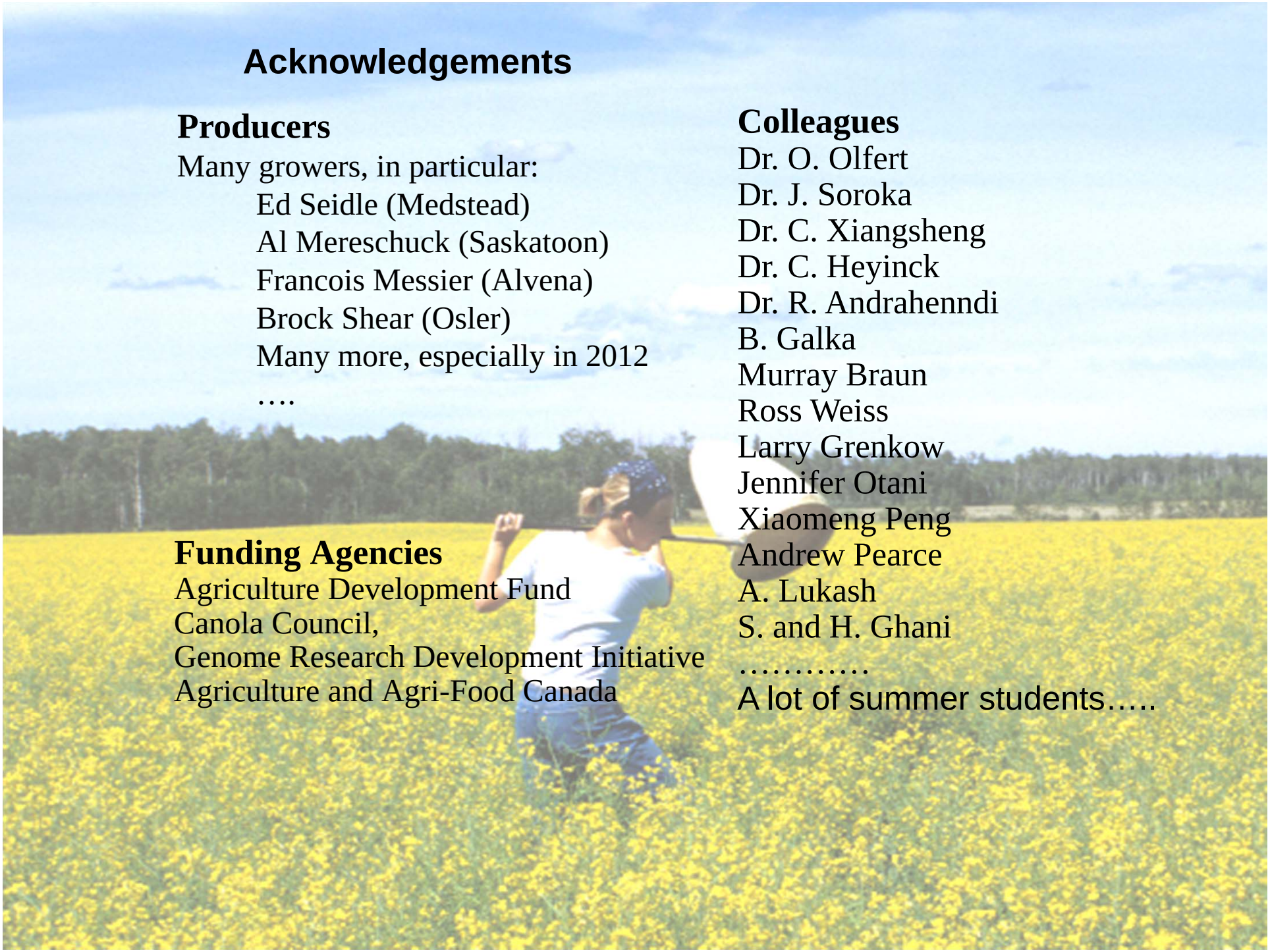
- Solutions?...few!
  - Insecticides: controversial
  - Early warning system and resistance / avoidance: need further study
  - Other options (symbionts, seed treatment…?)

Conclusion

- Phytoplasma diseases: difficult to study & to control.
  - Many unknowns
    - Accurate ID of phytoplasma strains
    - Why and how some leafhoppers are vectors?
    - Extent of the disease reservoir
    - Ratio local / migratory pop. & role of local population in AY outbreak
    - Correlation (symptom severity, incidence) with yield losses.
    - Seed transmission.
    - Parameters involved in symptom expression.

- Risks of increased AY incidence in the future: early warning systems

- Solutions?...few!
  - Insecticides: controversial
  - Other options
    - cultivar resistance
    - seed treatments
    - Symbiont



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Questions?