Canola Viruses:

Ecology, Detection and Occurrence

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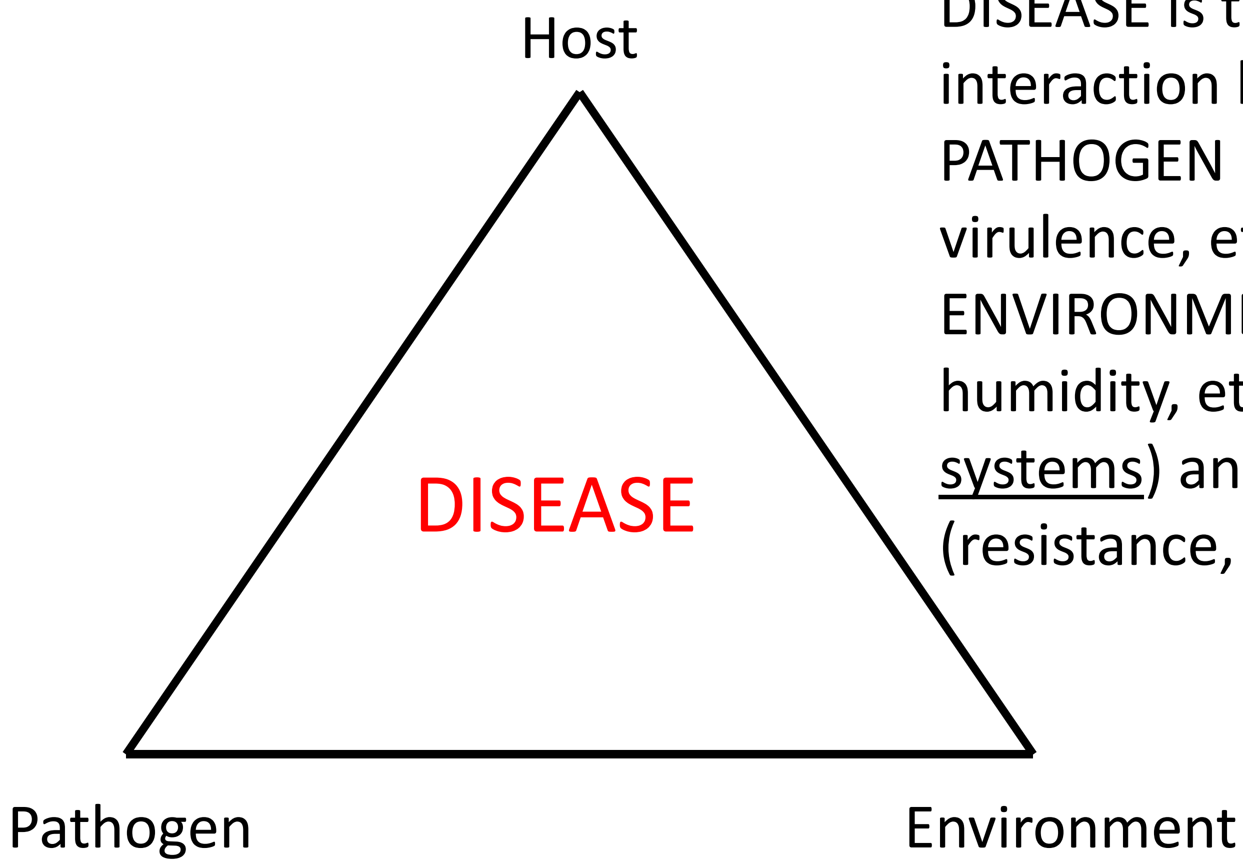
What are plant viruses?

- A relatively small amount of genetic material (mostly RNA) encapsulated by a protein coat.
- Most plant viruses need living plant tissue to survive between cropping seasons. Some can survive in seed embryo’s
- Most plant viruses need an insect vector (mostly an aphid) to spread from an infected plant to a healthy plant. **Vector ecology has to be understood in order to understand virus spread**
- Different modes of vector transmission exist; persistently transmitted and non-persistently transmitted viruses.
- **Once a plant is virus infected it can not be cured. Virus control strategies are therefore based on preventing virus infections.**

Basis of fungal plant disease epidemiology



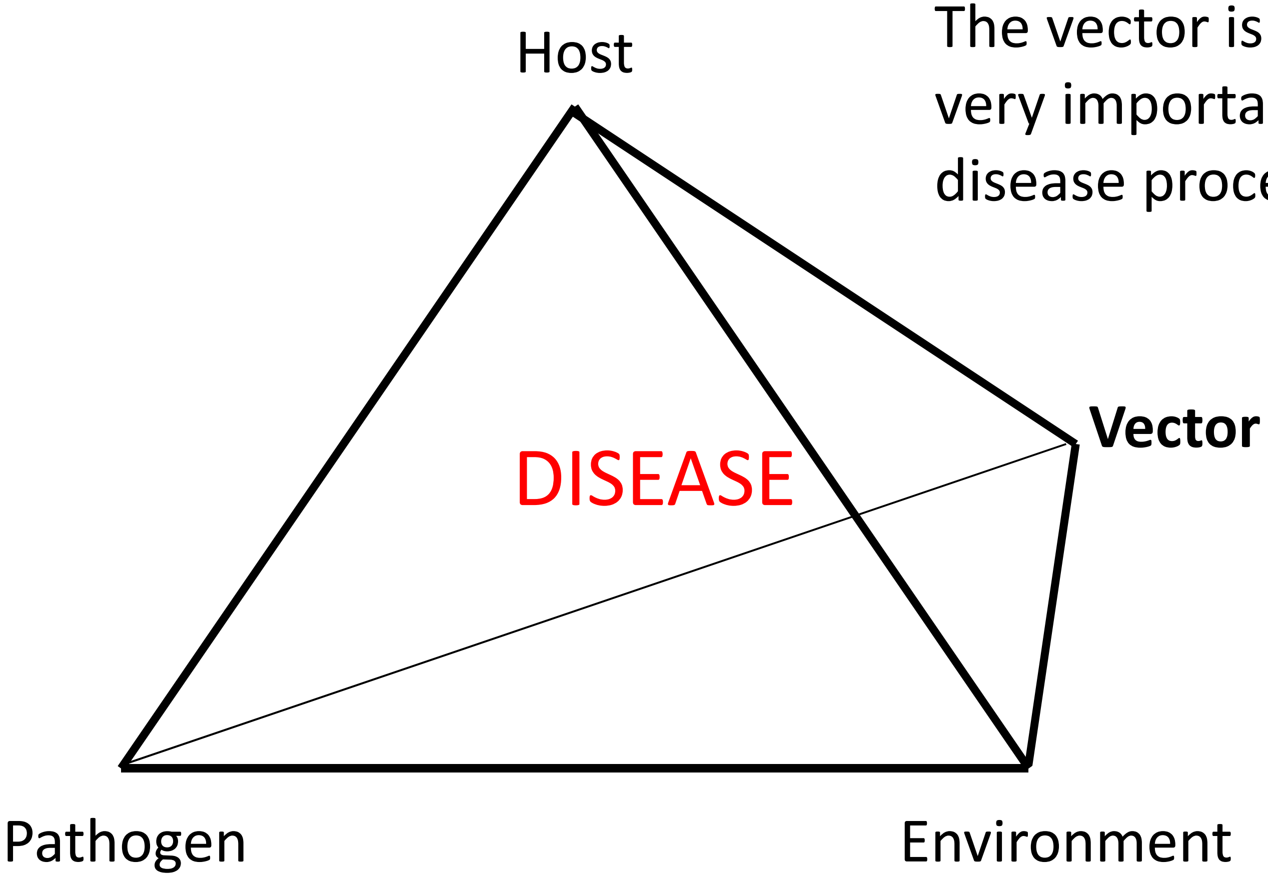
Disease Triangle:

DISEASE is the result of an interaction between the PATHOGEN (inoculum load, virulence, etc), the ENVIRONMENT (temperature, humidity, etc <u>but also farming systems</u>) and the HOST (resistance, plant age etc)

Fungal v. viral disease epidemiology

Virus tetrahedon:

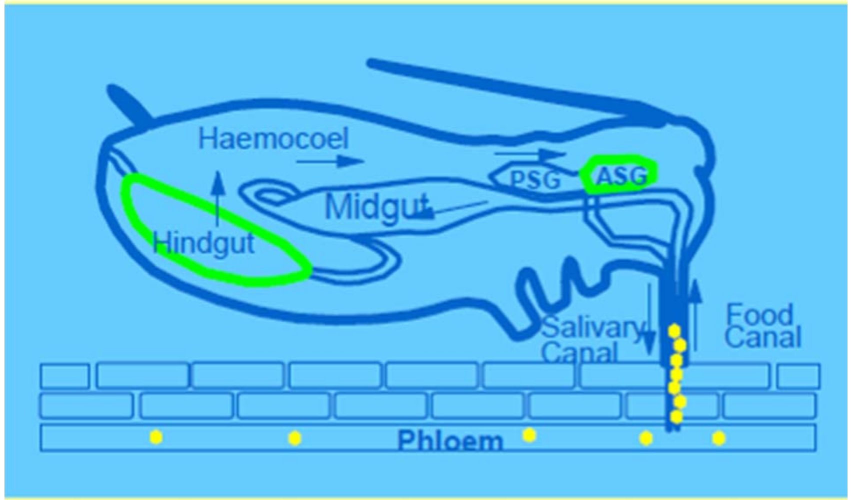
The vector is an additional and very important dimension in the disease process.



The importance of vectors to virus epidemiology

- Vectors are the most difficult and therefore least studied component in virus ecology.
- Nearly all of the important pulse viruses require aphid vectors for their spread.
- The way the virus is transmitted (persistently or non-persistently) is of crucial importance to design control strategies.
- **Not every aphid is viruliferous!**
- **Without aphid <u>movement</u> there will be no spread of plant viruses**: Colonising aphids are not necessarily the most important virus vectors.

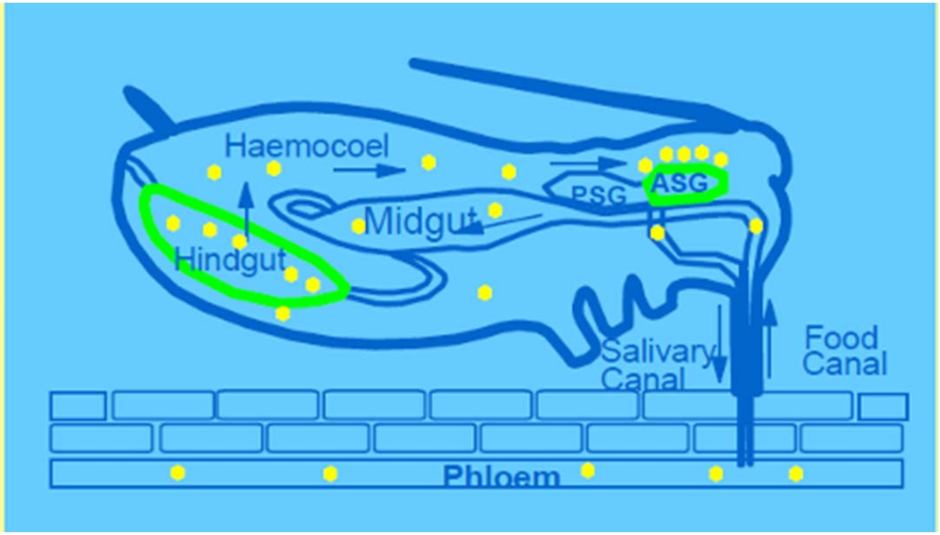
Non-persistently transmitted (stylet-borne) plant viruses



From RL Groves (2009) "Managing Viruses and Vectors in Vegetable Crops", University of Wisconsin

- **TuMV, CaMV,** BYMV, PSbMV, AMV, CMV
- Aphid only needs to probe the plant to acquire as well as to transmit the virus. **Insecticide applications have no or limited effect on virus transmission**.
- The virus can be transmitted by a large number of aphid species.
- The aphid looses the virus after a few probes and therefore transmits generally only over short distances.

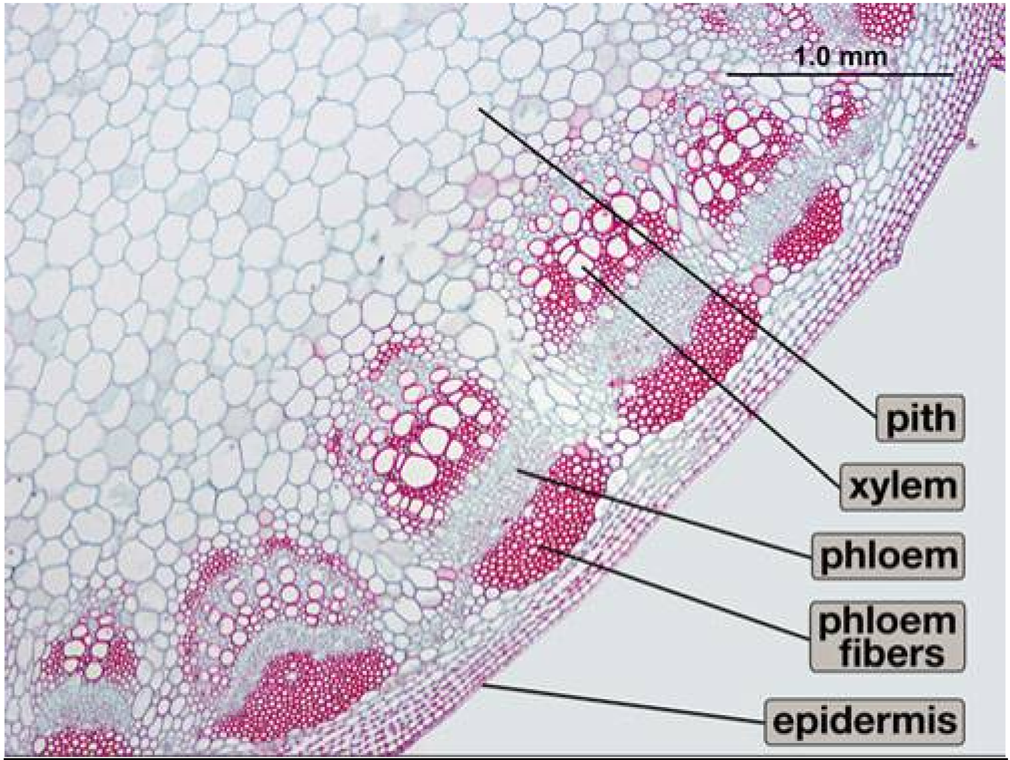
Persistently (circulative) transmitted plant viruses



From RL Groves (2009) "Managing Viruses and Vectors in Vegetable Crops", University of Wisconsin

- **BWYV,** BLRV, SbDV, SCSV
- Aphid needs to feed on the plant to acquire as well as to transmit the virus. **Insecticides can therefore prevent virus transmission.**
- The virus can only be transmitted by those (limited number) of aphid species that feed on the host plant.
- The aphid stays viruliferous and can therefore transmit over long distances.

Aphid transmission of persistently transmitted, phloem-limited, viruses



Location of xylem and phloem bundles in a dicotyle plant.
From McCauley (2012) www.deanza.edu

- Many aphid species can probe a plant and infect the plant with a non-persistently transmitted virus.
- Aphids feed on phloem tissue, sucking sugary fluids through their stylets. Aphid feeding (and plant colonisation) is generally species specific.
- Persistently transmitted phloem-limited viruses (ia BWYV, BLRV) can only be transmitted by aphids feeding on the phloem.
- The minimum Inoculation Access Period (time needed to transmit a virus) depends on an aphid's stylet reaching the phloem.

Importance of Green Peach Aphid (*Myzus persicae*) as a vector of BWYV in canola crops

- Highly efficient vector of BWYV and a number of other viruses.
- Will feed on a large number of plant species (polyfagous). Can therefore bring the virus from summer hosts in a canola crop.
- Active in autumn when emerging seedlings are particularly vulnerable to viruses and aphid feeding.
- Moves more in the crop than the other canola aphid species (?)
- Has developed resistance to a range insecticides.

Virus Control Strategies

- Virus control strategies are based on preventing infection as there are no curative options.
- First virus infections in a crop originate from immigrating vectors.
- By the time aphids are noticed in the crop, infection is likely to have already occurred.
- Avoiding virus infection (sow in stubble, higher sowing densities, later sowing, good management practices)
- Control of / Distance from inoculum sources (weeds, pasture legumes)
- Compensation for affected plants (high sowing densities)
- Use of aphicides seed dressings for persistently transmitted viruses
- **Virus resistance**

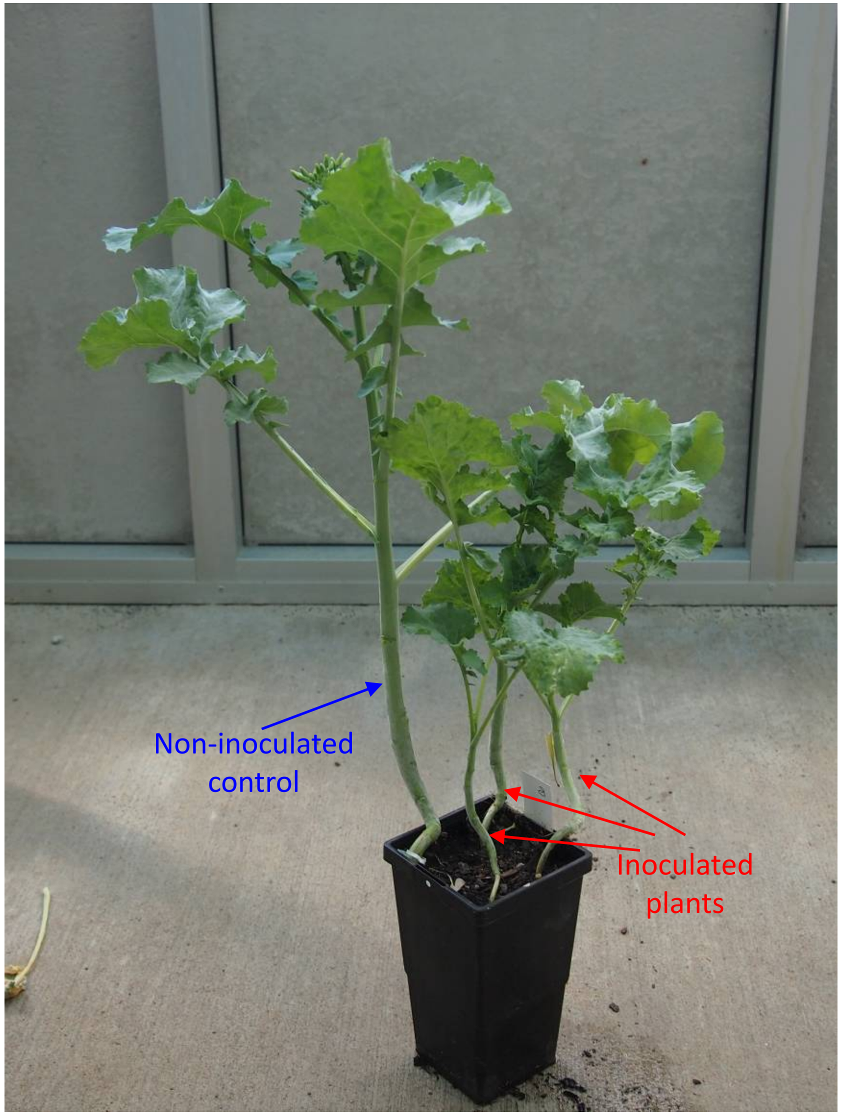
Canola viruses reported in Australia

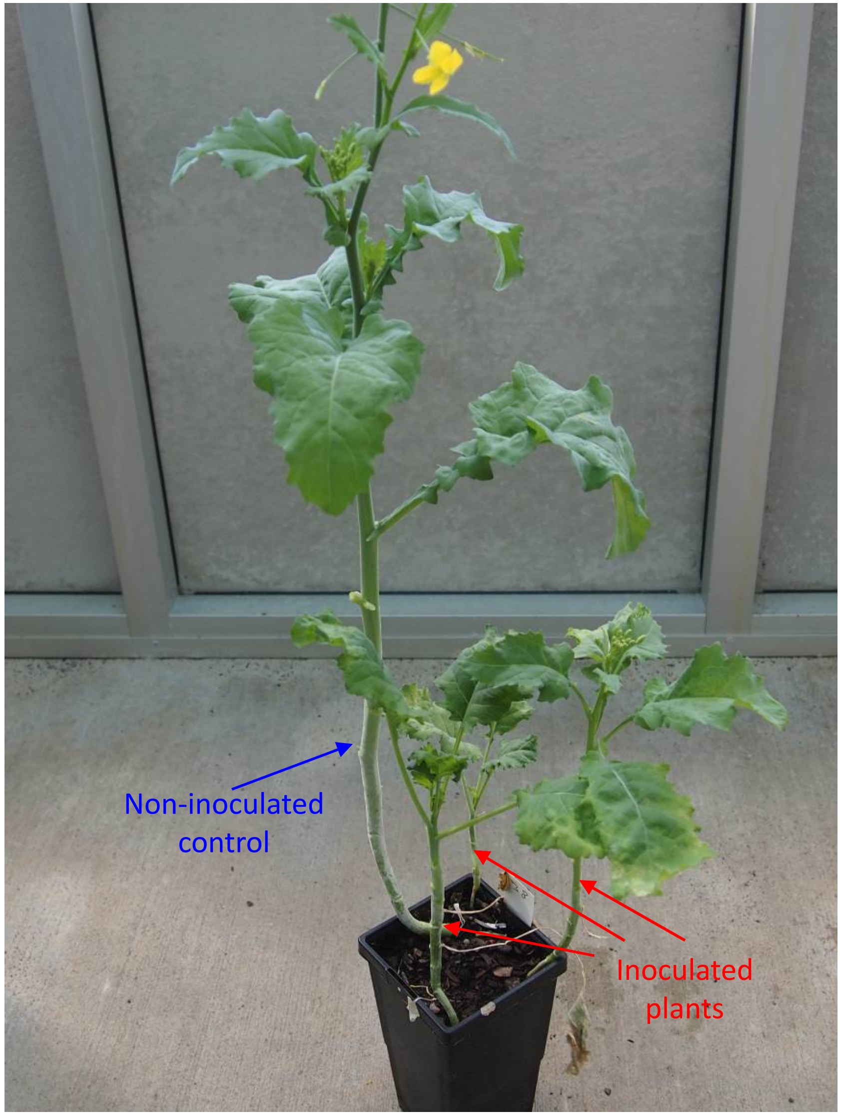
- *Beet western yellows virus* (BWYV) / *Turnip yellows virus* (TuYV)
  - Persistently transmitted
  - Wide host range (> 150 species)
  - Early infection can cause yield loss
  - Frequently reported, but generally low levels
- *Turnip mosaic virus* (TuMV)
  - Non-persistently transmitted
  - Very wide host range
  - Can cause severe losses
  - High levels reported in juncea, rarely (**so far**) in canola
- Cauliflower mosaic virus (CaMV)
  - Non-persistently transmitted
  - Limited host range
  - Only low levels reported

Turnip mosaic virus (TuMV)

Clear mosaic symptoms on *B. juncea*

Greenhouse screening for TuMV resistance: Effect on plant growth of two canola varieties





Beet western yellows virus (BWYV, syn: *Turnip yellows virus*, TuYV)

Symptoms are similar to nutrient disorders

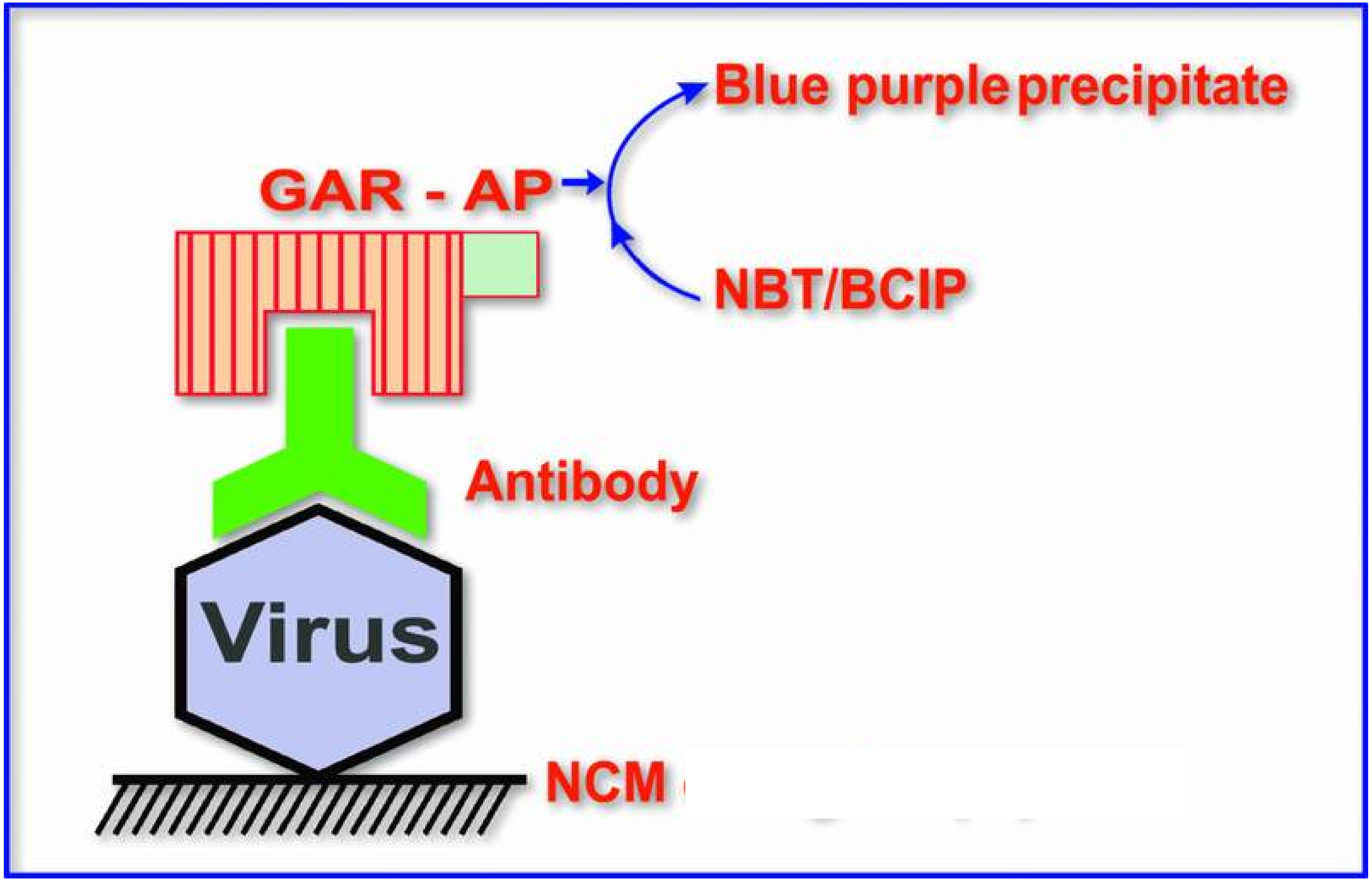
Need for virus diagnostics

- Symptoms caused by a range of biotic and abiotic stress factors can easily be confused with those caused by viruses.
- Need to determine latent (non-symptomatic) infections.
- The diagnostics need to be reliable, yet fast and able to handle large numbers of individual plant samples.
- For diagnosis of field samples from surveys and screening trials cost is often more important than precision.

Virus diagnostic techniques

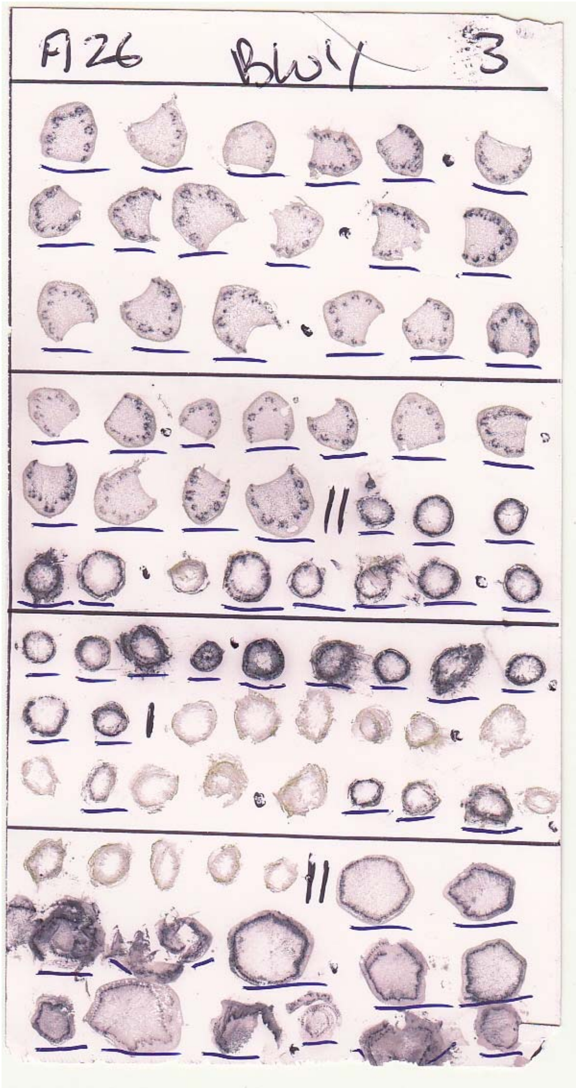
- Polymerase chain reaction (PCR)
  - High degree of precision
  - High costs
- Enzyme-linked immunosorbent assay (ELISA)
  - High degree of precision
  - Moderate costs
- Tissue-blot immunassay (TBIA)
  - Acceptable degree of precision
  - Relatively low costs

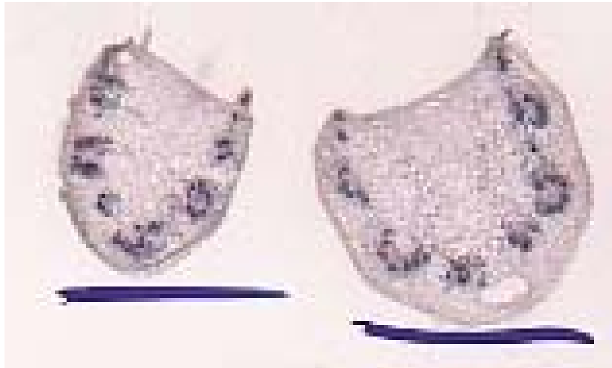
Schematic representation of the Tissue-blot immunassay (TBIA) method to detect plant virus



Tissue blot immuno-assays (TBIA) combines relatively simple operation procedures and low costs with reliability.

Tissue-blot immuno assay of canola plants for *Beet western yellows virus*





Tissue-blot immuno assay of canola plants for *Turnip mosaic virus*

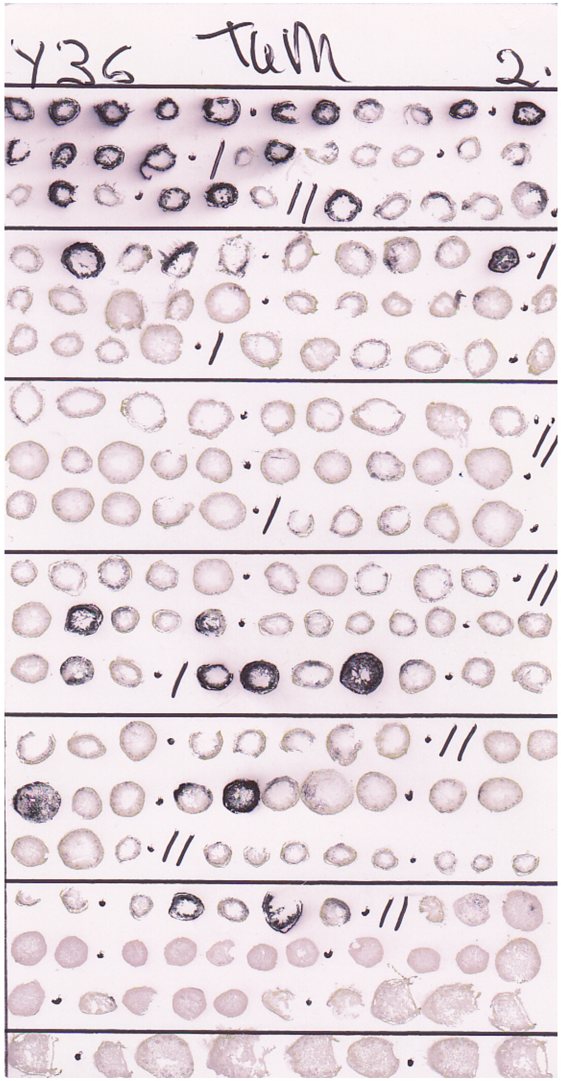


Table 1. Survey for canola viruses in the New South Wales, 2013

Survey period Region[1]	Canola					cruciferous weeds[2]						
	Sites	BWYV		TuMV		Sites	BWYV		TuMV		CaMV	
		Ave	Range	Ave	Range		Ave	Range	Ave	Range	Ave	Range
July												
North	19	0.1	0 – 2	0.0		10	0.0		9.1	0 – 83	0.0	
Liverpool Plains	1	0.0		0.0								
South	5	2.2	0 – 9	0.0								
August – mid September												
Liverpool Plains	11	0.7	0 – 6	3.6	0 – 28	8	0.0		27	0 – 67	3.3	0 – 17
South	5	1.6	0 – 4	0.0		4	0.8	0 – 3	4.3	0 – 10	2.0	0 – 8
mid September – October												
North	3	40	23 – 55	0.7	0 – 2	1	0		96		0	
Liverpool Plains	3	21	2 – 38	44	0 – 100	2	4.0	0 – 8	44	31 – 55	11	0 – 22
South	15	63	6 – 100	0.0		8	17	0 – 50	33	3 – 100	5.8	0 – 22

[1] North; Moree, Narrabri, Gwydir shires. Liverpool Plains; Liverpool Plains and Gunnedah shires. South; Warrumbungle, Gilgandra, Wellington shires and further south.

[2] Mainly turnip weed (*Rapistrum rugosum*), some wild radish (*Raphanus raphanistrum*) and unidentified species.

Table 2. Virus development[1] in NVT / Blackleg sites in New South Wales, 2013

Site	Location		Early sampling		Late sampling	
	Lat	Lon	Date	%BWYV	Date	%BWYV
Bellata [2]	29.97	149.79	17-07	0.0	01-10	23
Mullaley [3]	31.18	149.81	17-07	0.0	01-10	1.7
Parkes	33.04	148.26	16-07	1.7		
Cudal	33.25	148.79	16-07	0.0	05-11	45
Grenfell	33.86	148.09	24-07	0.0	05-11	57
Cootamundra	34.63	148.15	24-07	0.0	05-11	87
Wagga Wagga	35.12	147.37			06-11	100
Lockhart	35.24	146.78	24-07	9.3	06-11	100
Gerogery [4]	35.82	147.00			06-11	99

1 % positive plants based on random sampling of 3 replicates of border plots with 20-25 plants / replicate.
2 Additional early and late sampling of B. juncea plots in blackleg trial; no virus in early sampling, 45% BWYV and 35% TuMV in late sampling.
3 Additional early sampling of B. juncea plots in blackleg trial; no virus found.
4 One plant in late sampling found to be CaMV positive.

Table 3. BWYV incidence in samples from symptomatic plants and non-symptomatic canola plants in New South Wales, 2014

Northern NSW			Southern NSW		
Town	Symptoms	'Healthy'	Town	Symptoms	'Healthy'
Maules Creek	6	0	Ariah Park	100	100
Moree	95	20	Barmedman	100	100
			Beckom	100	100
			Galong	100	91
			Galong	40	0
			Galong	7	0
			Harden	83	70
			Harden	35	100
			Harden	82	92
			Henty	93	100
			Illabo	100	100
			Temora	100	100
			Temora	89	100
			Temora	95	77
			Young	69	40
			Young	94	100

High BWYV incidences in non-symptomatic ('healthy looking') canola plants

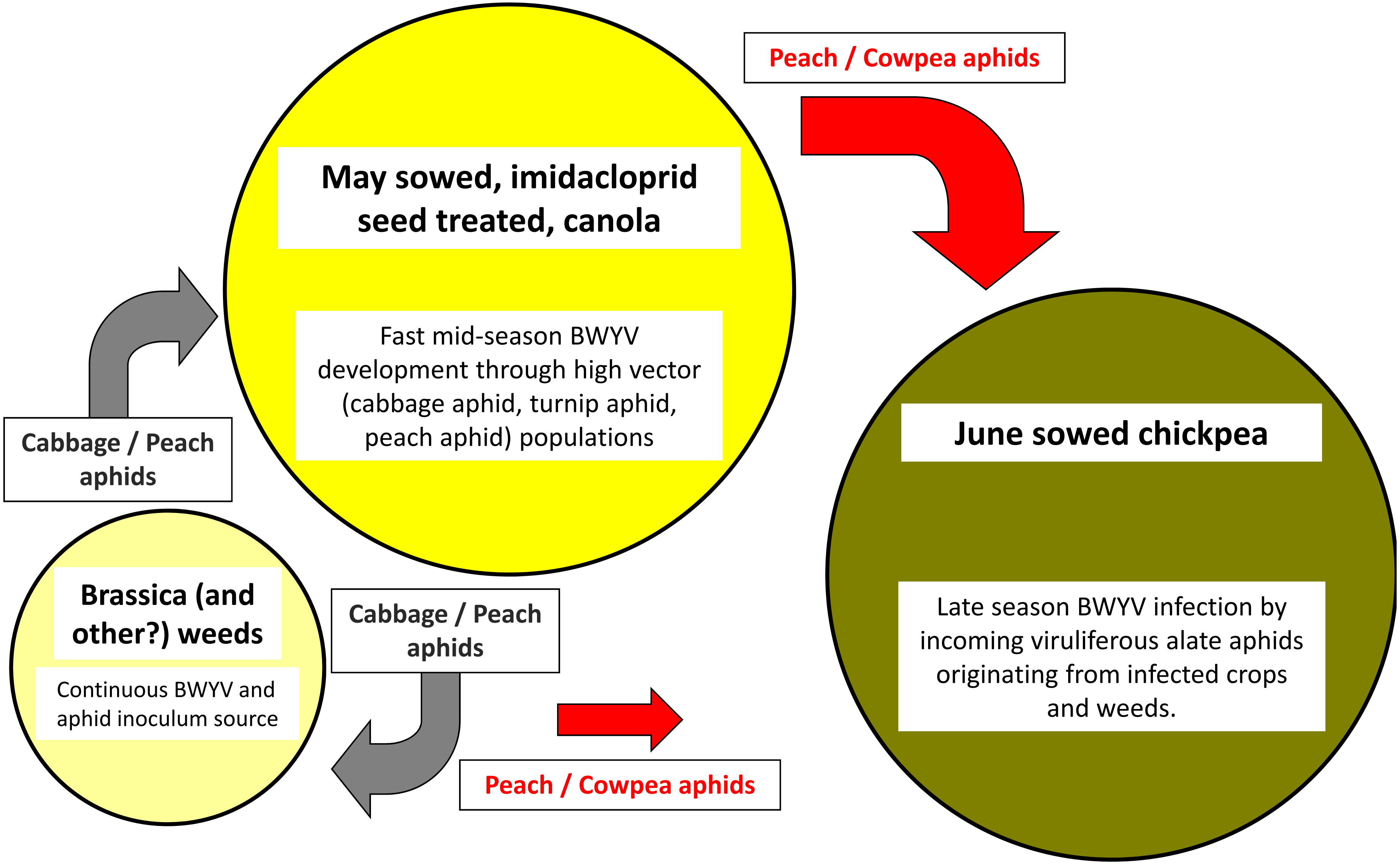
- Latent infections; symptoms will appear later.
- Later infections will not cause clear symptoms?
- Different BWYV strains?
- Symptoms result of an interaction of BWYV with other factors?

Options to reduce risk of BWYV induced yield losses in canola in 2015

- Follow best farming practices: Good growing plants appear to resist virus infection better and suffer less from virus infection.
  - Sow in stubble: Anecdotal evidence and some experimental results show that sowing in stubble reduces aphid landing in young plants.
  - Avoid low seeding rates: Low plant densities attract aphids and reduce compensation of infected plants by neighbouring healthy plants.
  - Control weeds in and bordering paddocks
- Proper seed treatment with effective systemic insecticide: Plant uptake of neonicotinoids is most effective through the roots. Length of protected period will depend on temperature and possibly seed size (larger seed will receive a higher insecticide dose)
- Foliar insecticide application: Early application of an effective insecticide in case of early sowing or mild autumn temperatures.

BWYV / Canola – Brassica weeds / Chickpea pathosystem

(hypothetical model)



Severe virus symptoms in chickpea during 2012 and 2013 were related to infection by *Beet western yellows* and/or closely related viruses

Risk of BWYV induced yield losses in pulse crops
Experience in the Northern Region

- No clear relation between BWYV infection in canola and BWYV infection in pulse crops was found in 2013.
- BWYV is readily found in faba bean and field pea, but does not appear to cause symptoms.
- BWYV can cause severe problems in chickpeas, but other BWYV related viruses that are not hosted by canola appear to be more important.
- Importance of BWYV in lentils is not clear. In the northern region lentils are infected by a range of viruses (BWYV, BLRV, CMV, AMV), causing regular crop failure.

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