Managing PVY in Potato

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Potato Virus Y (PVY)

- Reduces yield and quality
  - Dependent on variety
  - Time of infection
  - Virus strain
- Symptom expression can vary by strain or cultivar
- Tuber borne
- Mechanical transmission
  - Seed cutting/cultivation
- Aphid transmission
  - Non-persistant, stylet- borne
- Multiple strain types
  - PVY^{O}, PVY^{N}, $PVY^{N:O,}$ PVY^{NT} PVY^{NTN}, PVY^{N-Wi}
  - High Recombination Frequency to allow for new strain formation

PVY yield reduction

- Yield reductions can be as high as 30-80%
  - $PVY^{N, NTN}$ strains cause internal necrosis and external blemishes that may preclude certain fresh and processing markets

- Losses depends on:
  - Variety
  - Strain of PVY
  - Time of infection
    - Early infection greatest yields loss, late small yield loss

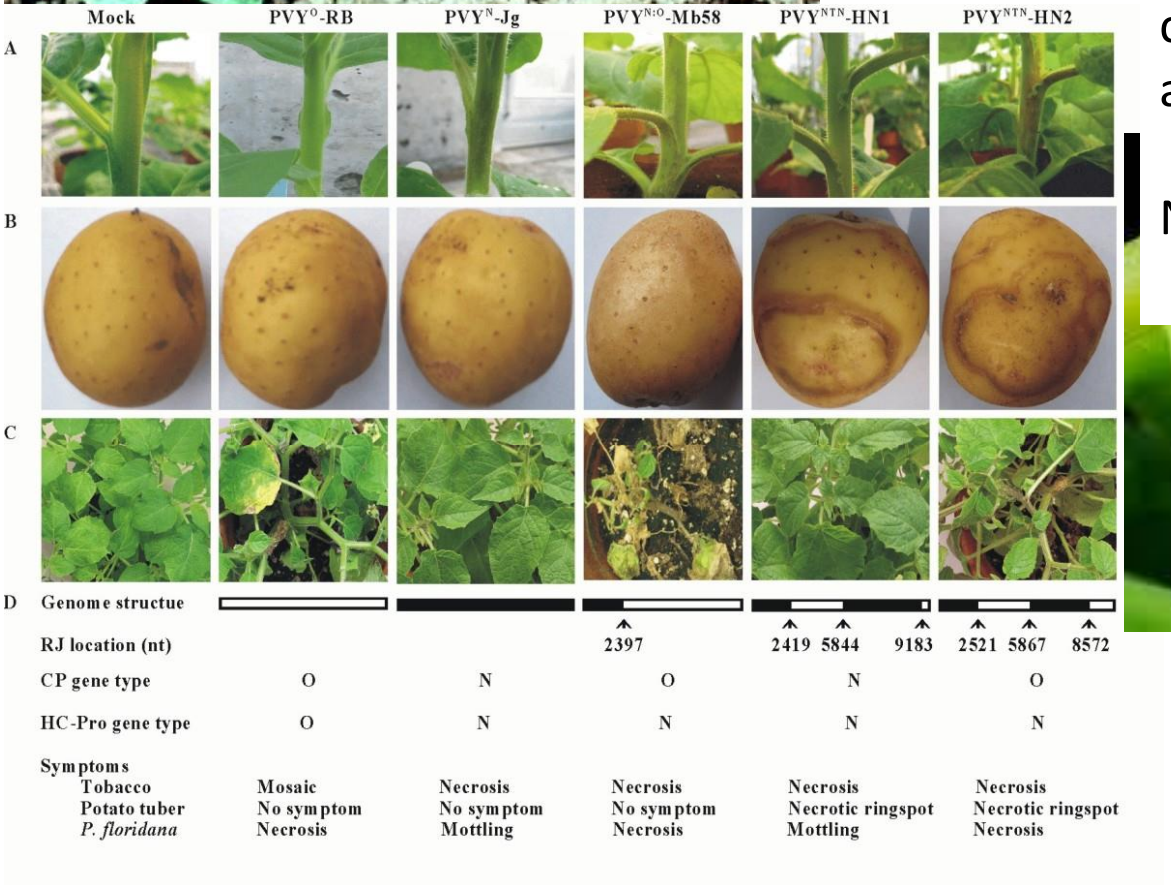
PVY

Currently most important virus in Potato certification programs

In some states 50%+ of lots fail certification

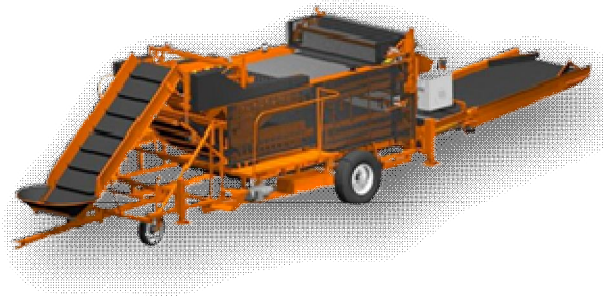
Stylet-borne by both potato colonizing and non-colonizing aphids

New strains



Mechanical Transmission

- Seed cutter- particularly sprouted seed
- Disinfest with quaternary ammonium compound



- Mechanical transmission in field by workers/equipment not considered to be of major importance

Aphid Transmission

- 40-50 species of aphids shown to transmit PVY in non persistent manner.
- Aphid can carry PVY on stylet for 1-17 hours-transmission efficiency drops rapidly with time. At 5 min ~30-40% transmission, at >2 hrs generally less than 1%.

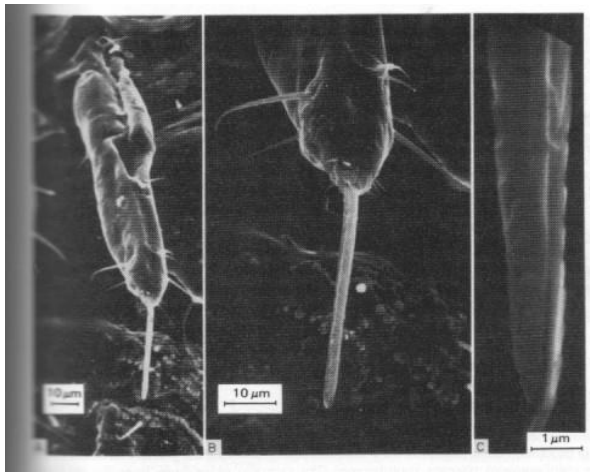
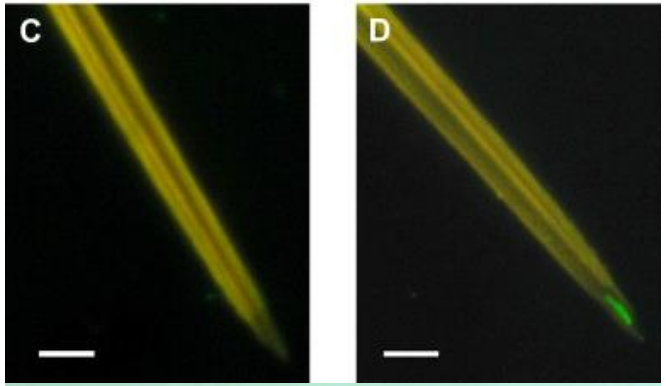


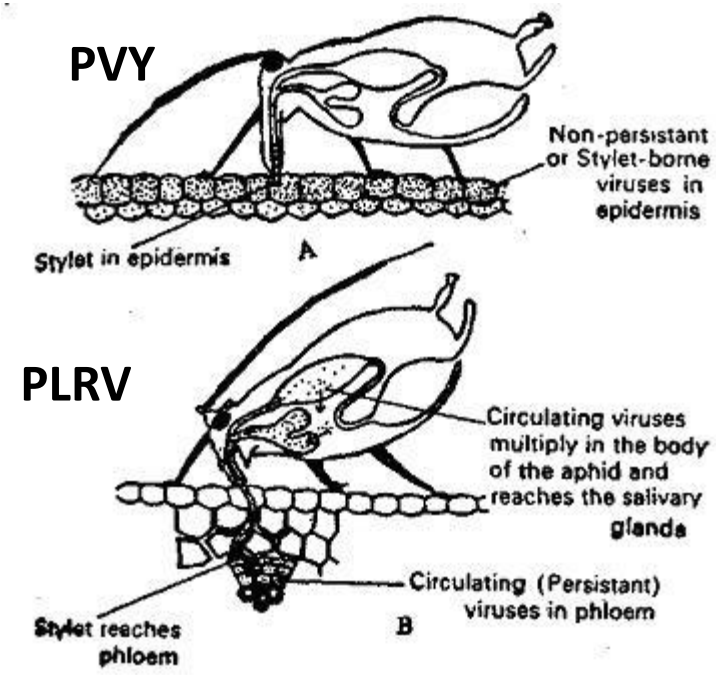
Fig. 11.2 Mouthparts of *Myzus persicae* revealed by scanning electron microscopy. **(A)** Labium with joint area and bristles. Mandibular stylets protrude from the labium. (The aphid was frozen in liquid nitrogen immediately after it had withdrawn its stylets from a leaf.) **(B)** Tip of labium and mandibular stylets at higher magnification. **(C)** Tip of mandibular stylets showing ridges in both stylets, and the overlap of the tip of one stylet. From de Zoeten (1968), with permission.

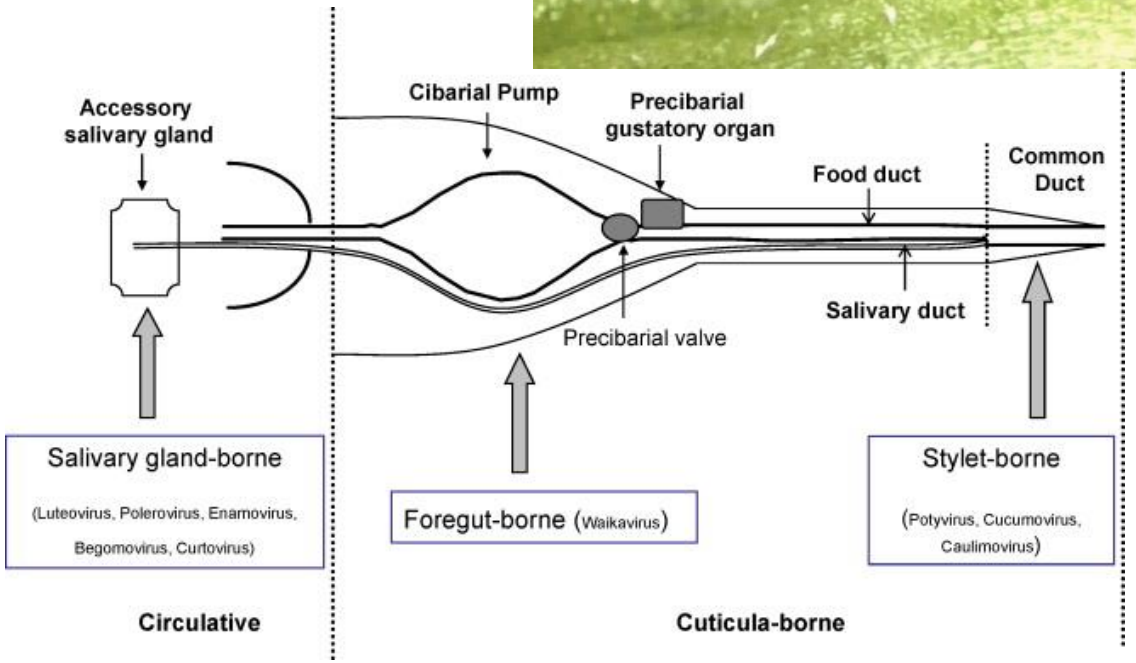
- Potato colonizing aphids- feed and reside on potato
- Non- colonizing aphids moving from other crops (corn, cereal grains, etc) will probe (taste) potato but will move on quickly

Stylet-borne/Non Persistent Viruses

- Transmission in instantaneous as soon as stylet enters cell. This is why insecticides are generally ineffective in reducing transmission of PVY
- Virus carried on stylet tip for 1-2 hours until feeding on another plant then virus is lost. In rare instances virus may be retained for up to ten probes.
- Virus released from stylet tip is associated with salivation







Integrated Management of PVY

No single tool will provide complete control

PVY Management Tools

- PVY free seed- don't plant a problem
- Plant early so infection by non-colonizing aphids from ripening grain or other crops happens with greatest plant maturity possible
- Varieties-Resistance depends on strain

Variety	PVY-O	PVY N-Wi
Yukon Gem	resistant	Very susceptible
Yukon Gold	susceptible	Very susceptible
Ranger Russet	resistant	Moderately susceptible

PVY Management Tools

- Use neonicotinoid insecticide seed treatment or at planting-this will control potato colonizing aphids for ~60 days. Remember this will also control Potato Leaf roll virus ,(PLRV)
  - Admire Pro, Gaucho, Cruiser, Platinum, Belay
- Eliminate overwintering sources before crop emerges or rouge volunteers as seen
  - volunteers/cull piles

Clearfield-Beyond herbicide
Imidazolinone
Volunteer wheat, potato, etc

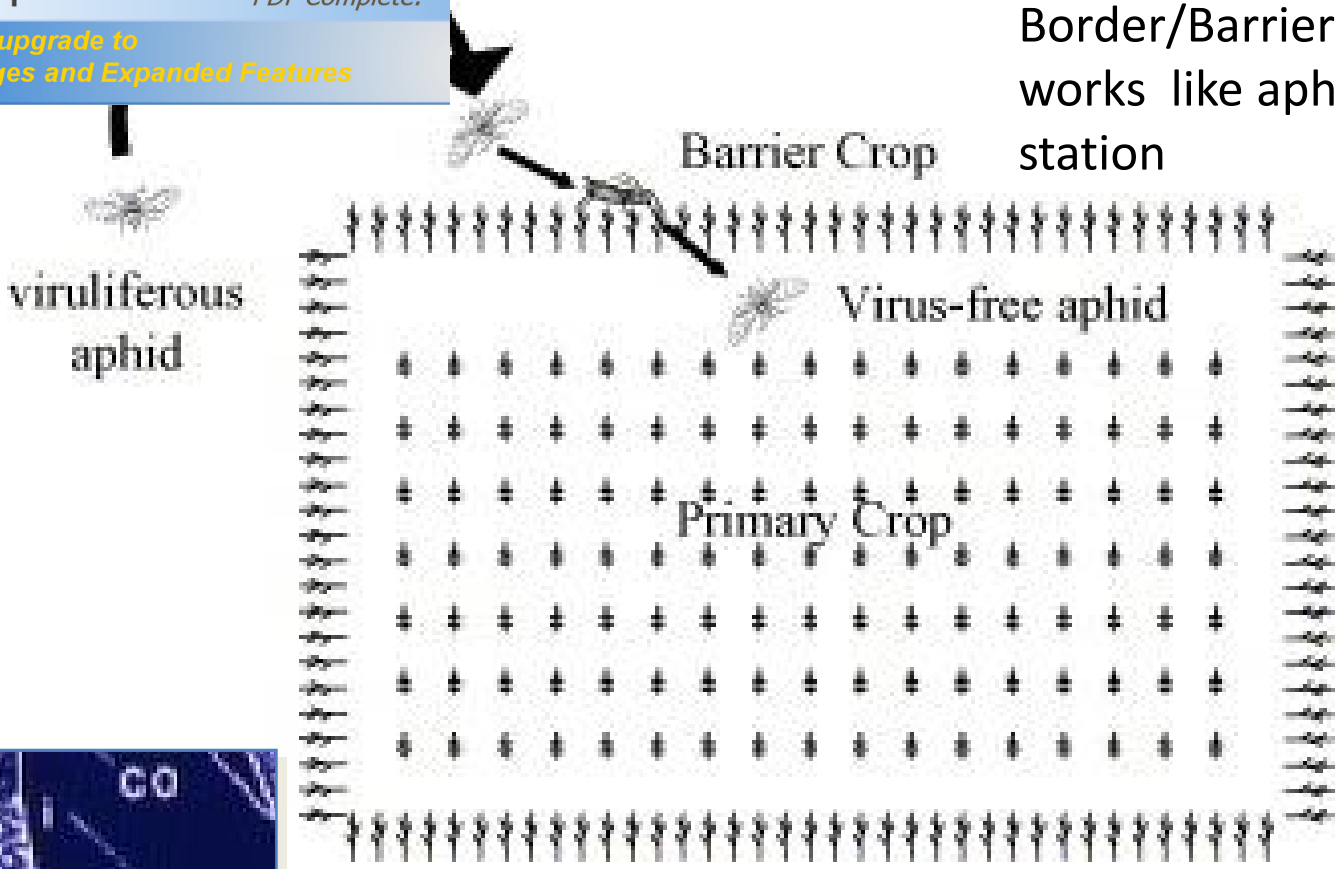
PVY Management Tools

- Control weeds that are PVY and aphid hosts
  - Hairy nightshade
  - Lambsquarter
  - Other Solaneaceous weeds
  - ~120 host plants

PVY Management Tools

- Avoid bare soil on borders. Aphids will look for edges to initially alight.
- Use non-host crop borders-eg. Corn, soybean, pea, winter wheat. This will avoid the breaks that aphids look for- remember roads, etc. This technique has provided 25-65% control

Border/Barrier plant works like aphid cleaning station

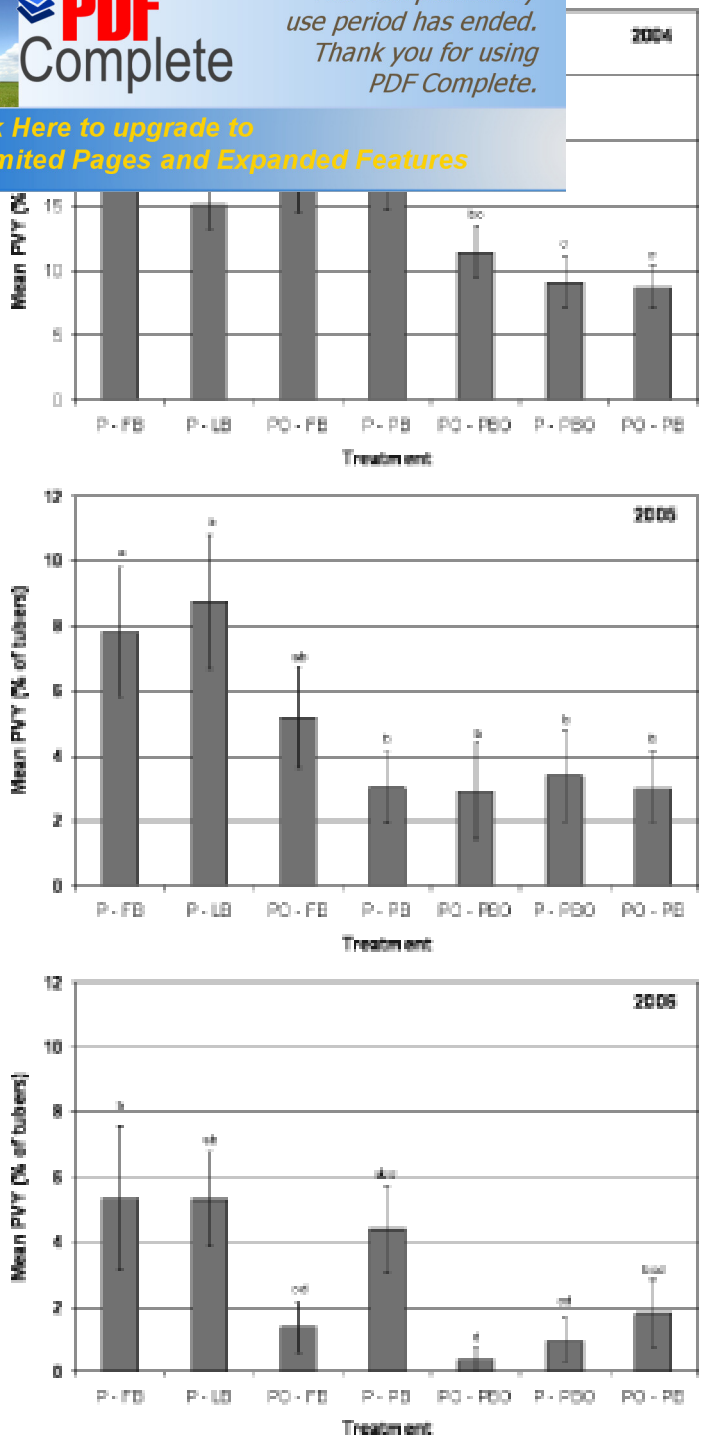


Virus sticks to mouthparts and is wiped off during next probing event

Transmission is instantaneous-too fast for insecticide to kill.

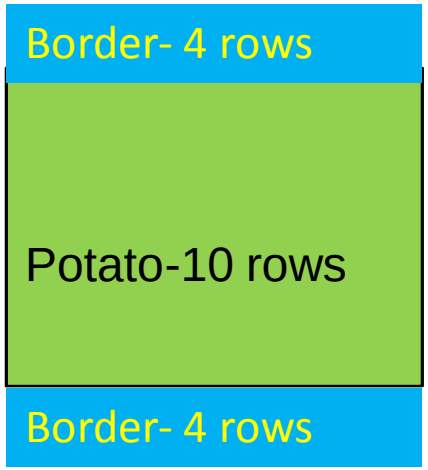
Management Tools

- Mineral Crop Oils
  - Use at 1-3% with emulsifier (0.75-1.25%)
  - Many products-JMS Stylet oil, Aphoil, Glacial spray fluid, Sunco 7E, Ultra-Fine, Organic leaf oil, etc
  - Chemical characteristics
    - SUS (Saybolt Universal Seconds) 60-150
    - VGC (Viscosity Gravity Constant) 0.79-0.819
    - Boiling range 370-420 C
    - Molecular weight 340-380 daltons
    - Unsulfonated residues (USR) 95-100
    - Paraffin-pour point-<0 C
- Have provided 25-70% control
  - Reduce virus acquisition, persistence on stylet (<2 minutes compared to 2 hrs), transmission



P-FB Fallow border
PO-FB potato sprayed with oil, Fallow border
P-PB- potato border
PO-PB potato sprayed with oil potato border
P-LB-low height border
P-POB potato border sprayed with oil
PO-POB potato sprayed with oil + potato sprayed with oil

Crop border and mineral oil sprays used in combination as physical control methods of the aphid-transmitted potato virus Y in potato –Boiteau etal, 2009



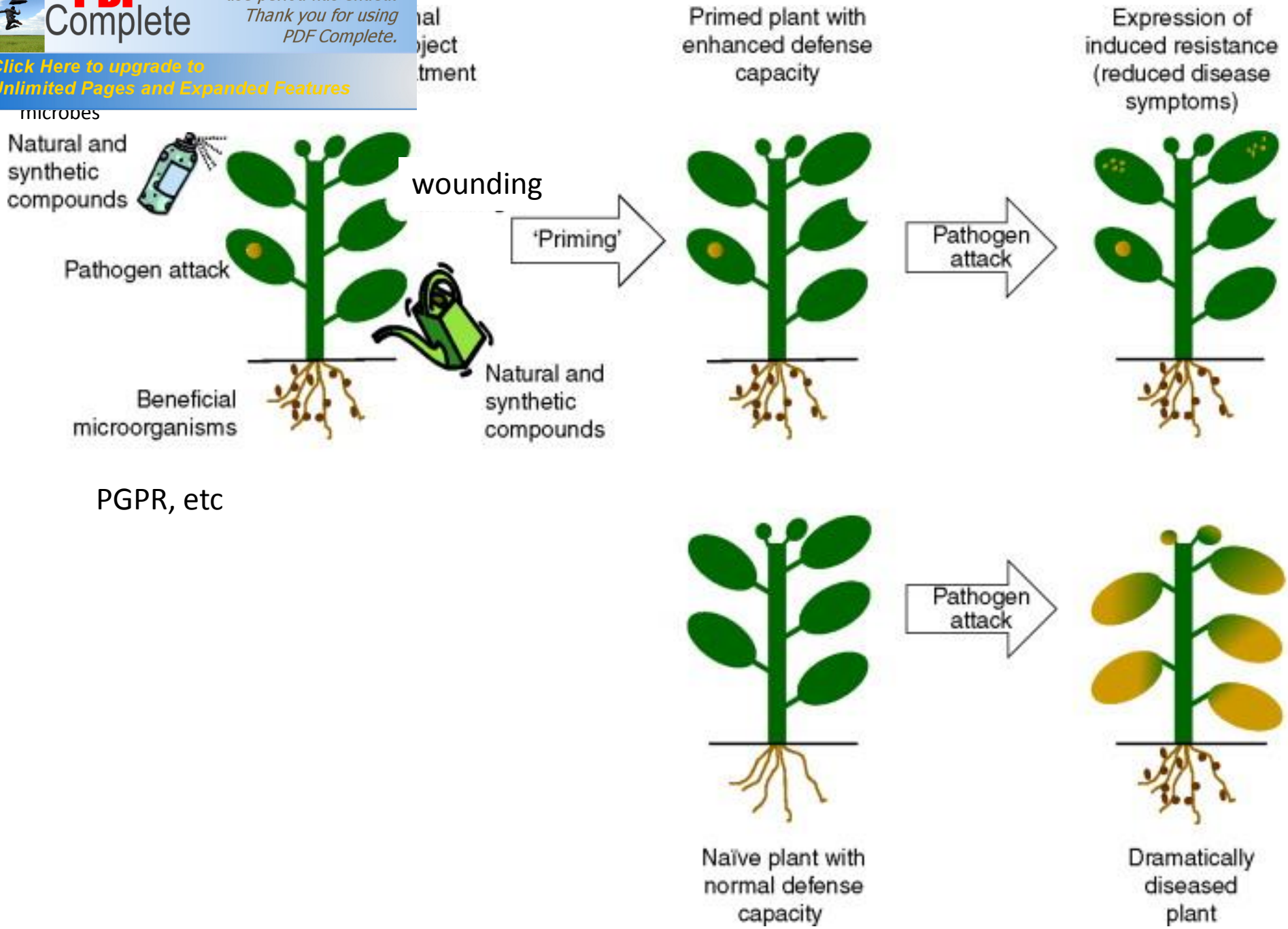
Mineral Oils

- Must have excellent plant coverage
  - Aphids prefer young plant growth- when plant growing rapidly need to apply every 4 days when growth slows every 7 days is sufficient
  - Coverage- higher volume, higher pressures-want coverage of upper and lower leaves
- Phytotoxicity associated with rates >3% most use at 1-2%
- Phytotoxicity with some fungicides (Bravo, Super-Tin, Polyram) apply day before or day after
- Do not apply to wet plants-poor coverage
- Phytotoxicity at high temperatures has been reported- yield drag?

Integrating Rogueing, Stylet oils and Induced Resistance for PVY Management

What is Induced Systemic Resistance?

- Inducible broad-spectrum, systemic host response against a wide-array of potential pathogens. Equivocal to an “immune response”, but without specific antigen-antibody interactions.
- Rapid accumulation of host produced defense compounds (PR proteins and other factors) that act systemically- initial rxn in minutes –usually 3-5 days for max effect.
- Plant is Primed to defend itself for prolonged period (7-20+ days)
- Effective against diseases caused by fungi, bacteria, viruses, nematodes, some insects
- Probably the most common disease control



PGPR, etc

Induced Resistance: A tool in Managing Virus Diseases

Historical Background

- 1961-Ross-TMV/TMV-coined term Systemic Acquired Resistance-SAR
- 1960s-present- Kuc‘ and others- SAR- necrotizing pathogen or chemical, salicylic acid signaling pathway, may involve activation of npr 1 gene, initial reactive oxygen burst and induction of pathogensis-related (PR) proteins
- 1982-Bergstrom- prior inoculation with *Colletotrichum obiculare*, *Pseudomonas lachrymans* or tobacco necrosis virus induce systemic resistance against CMV

PGPR- Viruses

- 1996- Raupach et al. Two strains of PGPR induce ISR in cucumber and tomato against CMV
- Some strains of *Pseudomonas fluorescens, Bacillus pumilis, B. amyloliquefaciens, B subtilis, Kluyvera cryocrescens* rhizobacteria reduced CMV and Tomato Mottle geminivirus infection (50-70%), reduced symptoms and lengthened period from infection to symptom development-Zehender et al, 1999
- *Bacillus globisporus*, *Pseudomonas fluorescens, Streptomyces* gibsonii-30-60% reduction of tobacco necrosis virus local lesions in bean. Shoman, et al 2003
- *Pseudomonas fluorescens- Barley Yellow Dwarf Mosaic- Mysus avenae-Wheat and Barley~50% reduced disease severity. Al Ani et al.2011*

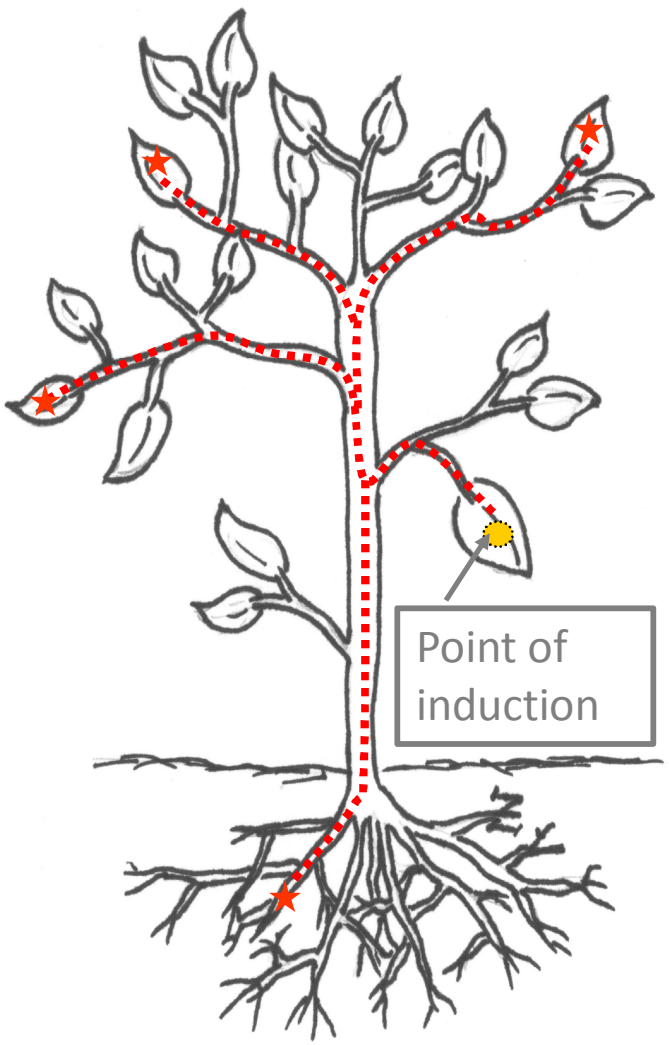
SAR/SIR/ISR

- Induce by necrotizing pathogen, heavy metals, dichloroisonicotinic acid (INA), agents-BABA-Beta DL-3-aminobutyric acid, G(amma)ABA, dipotassium phosphate, phosphorus acid
- Non-necrotizing -Acibenzolar-s-methyl-(Actigard,Bion), salicylic acid, PGPR-Pseudomonas, Bacillus, etc, Bacillus mycoides (BmJ Microbial Fungicide-CERTIS USA), cell wall components of *Pythium nunn* or *P. oligandrum, Trichoderma harzianum, T. viridae*

Bacillus mycoides-BmJ

- Isolated from phyllosphere of sugarbeet with lower incidence of Cercospora leaf spot
- Epiphyte-log 3-4 –Collins, 1999
- Demonstrated 38-91% control of Cercospora leaf spot-statistically equal to best fungicide in 5/9 years-Jacobsen
- Study of spatial and temporal population dynamics showed no correlation for either Bac J or B. subtilis (Bac B) and Cercospora leaf spot severity-no antibiosis or parasitism-Collins, 2001, Collins, et al., 2002
- Equal control at log 2 to log 9/ ml- Collins, 1999
- No control with dead BmJ-Bargabus, et al. 2003, 2004
  - Dead BmJ reduces aphid feeding

/ISR-Foliar Induction



- Protective effects of SAR extend to all plant parts
- Resistance is detectable 2-3 days post induction
- Peaks 5-7 days post induction
- Effective for ~14-20 days or longer
- Suppresses many pathogens: fungi, bacteria, viruses

Virus Disease Control mechanical transmission

Virus	Latent period - days	% symptomatic plants	Virus titer Symptomatic plants
CMV-cucumber			
water	6.7	75	2.37
BmJ	9.0	25	0.49
TMV-tomato			
water	4.8	82	2.35
BmJ	8.3	24	1.1

reenhouse-mechanical transmission

Treatment	% PVY Trial 1	% PVY Trial 2	% PVY Trial 3	% PVY Average
Dead BmJ +PVY	25	50	100	58.3 a
Dead BmJ	0	0	0	0 c
BmJ induction 5 days before inoculation with PVY + BmJ @ 14, 28, and 42 days post inoculation	5	0	75	26.6 b

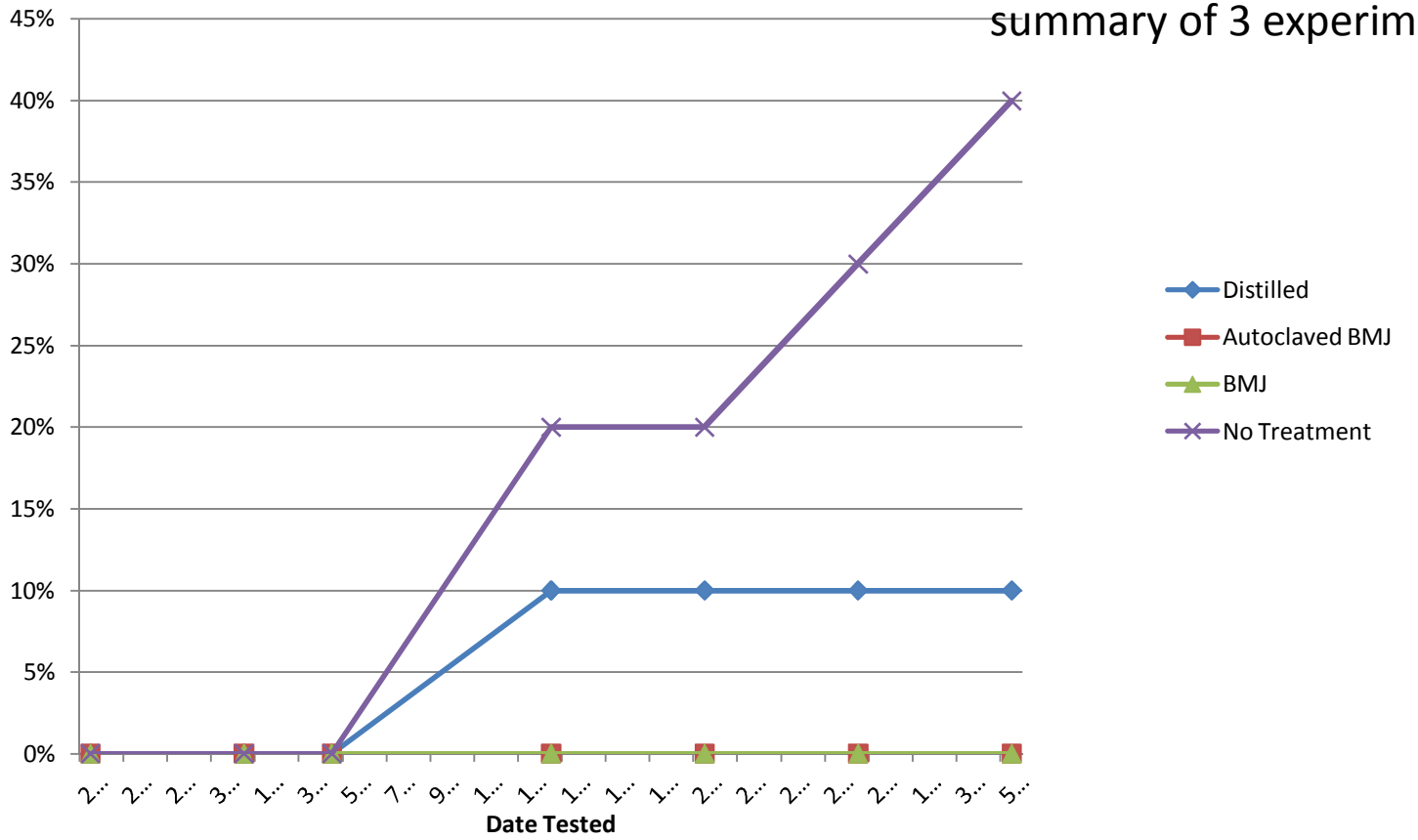
Note variability in results but consistent reduction

Greenhouse PVY Aphid Transmission March-May

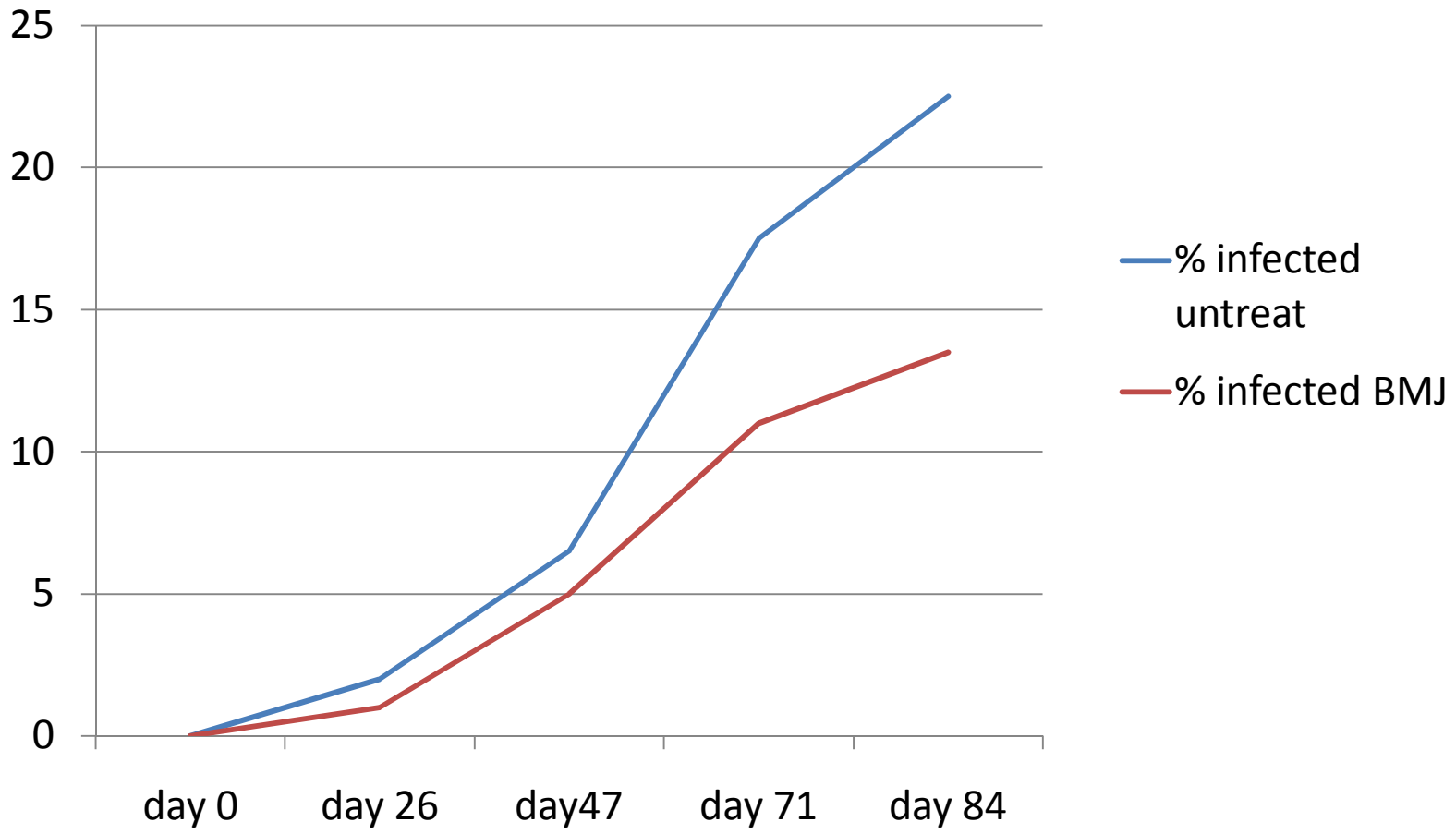
Aphid Transmission of PVY

Transferred 10 green peach Aphid/ plant from PVY infected potato- 20 replications summary of 3 experiments

% infection ELISA



tion of Russet Norkotah potatoes at different times planted at Hermiston, OR. either induced with BmJ at emergence then every 14 days compared to non- induced potatoes. Data are statistically different at day 71 and day 84 @P<0.05.



Diseases controlled by BmJ

- Viruses
  - Cucumber Mosaic-cucumber
  - Tobacco Mosaic-tomato
  - Squash vein yellowing virus-watermelon
  - Potato virus Y-both aphid and mechanical transmission
  - Wheat Streak Mosaic mechanical and mite transmission
  - Both reduced infection and reduced virus titer

tegrated PVY Management Plots
Norkotah-Mazzama Borders

0 Hermiston PVY Trial

4 replications- 50 plants each

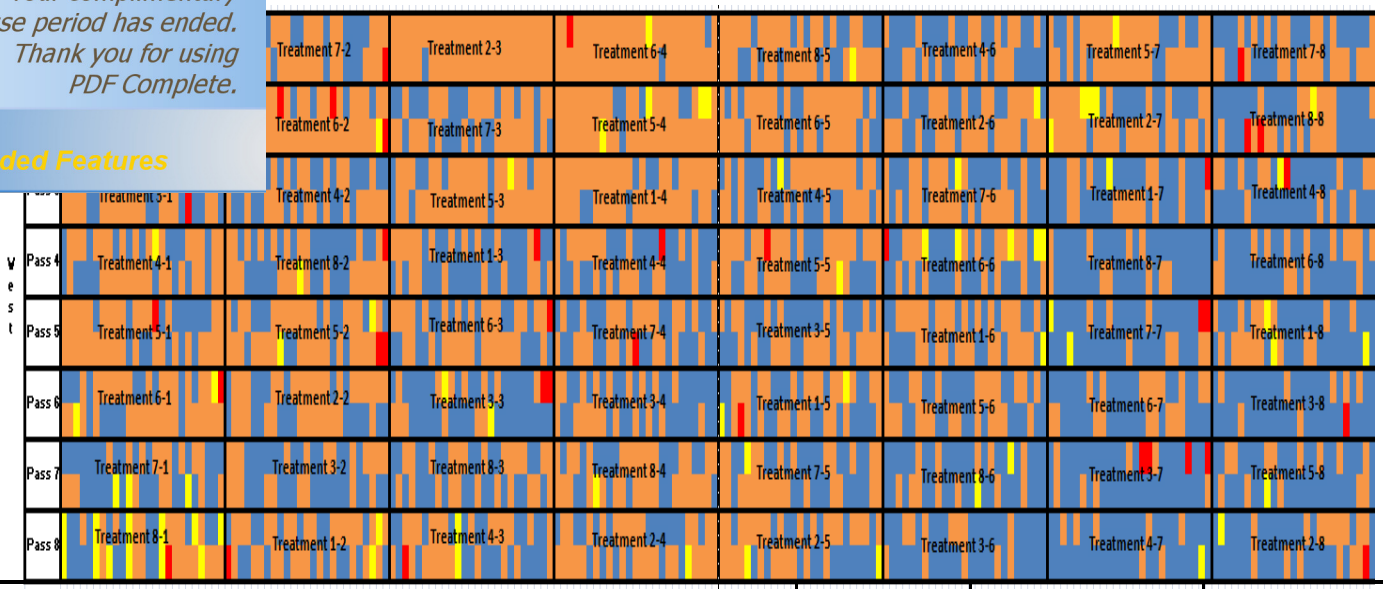
Treatment	% PVY total including winter test
BmJ WP 2.0 oz/A 14 days emergence to harvest	3.5
BmJ WP 2.0 oz/A 14 days emergence to harvest- rogue out infected plants	1.5
Admire Pro 8.7 oz @ plant +BmJ WP 2.0 oz/A 14 days emergence to harvest @ 60 days post emergence Assail 1.7 oz, 67 days Fulfill 5.5 oz, 75 days Beleaf 2.8 oz, 87 days Leverage 3.8 oz-rogue out infected plants	3.0
Admire Pro 8.7 oz @ plant @ 60 days post emergence Assail 1.7 oz, 67 days Fulfill 5.5 oz, 75 days Beleaf 2.8 oz, 87 days Leverage 3.8 oz-rogue out infected plants	4.5
Untreated	10.0
Flsd 0.05	5.86

011 Hermiston PVY Trial

	% PVY total Field	% PVY Total Field + winter test	Yield CWT/A
BmJ WP 2.0 oz/A 14 days emergence to harvest	4.0	10.4	278 a
BmJ WP 2.0 oz/A 14 days emergence to harvest-rogue out infected plants	2.0	4.7	250 a
Admire Pro 8.7 oz @ plant +BmJ WP 2.0 oz/A 14 days emergence to harvest @ 60 days post emergence Assail 1.7 oz, 67 days Fulfill 5.5 oz, 75 days Beleaf 2.8 oz, 87 days Leverage 3.8 oz-rogue out infected plants	5.0	6.3	241 ab
Admire Pro 8.7 oz @ plant @ 60 days post emergence Assail 1.7 oz, 67 days Fulfill 5.5 oz, 75 days Beleaf 2.8 oz, 87 days Leverage 3.8 oz-rogue out infected plants	7.0	7.6	215 b
Untreated	8.0	10.0	238 ab
Flsd 0.05	2.5	5.3	

Healthy

PVY+



#	Hermiston 2012 Treatments	BmJ	Aph Oil	No gap insecticide
1	UTC			
2	BmJ Microbial Fungicide @ 2 oz /A applied @ a 12 day interval from emergence till vine kill (~9/1/12-13)	x		
3	JMS Stylet Oil at 1.5% applied every 4 days from emergence till vine-kill		x	
4	BmJ, JMS Stylet Oil- rates and timing as above	x	x	
5	No- gap insecticide (Movento 5 oz/A@60 days, Fulfill 5.5oz/A @ 72 days, Movento 5 oz/A @84 days and Beleaf 2.8 oz /A@96 days post planting)			x
6	BmJ, No-gap insecticide and timing as above	x		x
7	JMS Stylet Oil, No-gap insecticide- rates and timing as above		x	x
8	BmJ, JMS Stylet Oil, No-gap insecticide- rates and timing as above	x	x	x

2012 Hermiston, OR- PVY Plots

		% PVY infection August 1, 2012	8 rep % PVY Winter test	4 rep % PVY Winter test
1	UTC	17.5	57.8 abc	51.5 a
2	BmJ Microbial Fungicide @ 2 oz /A applied @ a 12 day interval from emergence till vine kill (~9/1/12-13)	11.5	66.4 a	53.5 a
3	Stylet oil at 4% applied every 4 days from emergence till vine-kill	4.5	35.4 d	18.7 b
4	BmJ, Stylet oil- rates and timing as above	7	45.0 dc	27.2 ab
5	No- gap insecticide (Movento 5 oz/A@60 days, Fulfill 5.5oz/A @ 72 days, Movento 5 oz/A @84 days and Beleaf 2.8 oz /A@96 days post planting)	22	65.4 a	49.7 a
6	BmJ, No-gap insecticide	15	65.3 a	36.3 ab
7	Stylet oil, No-gap insecticide	7.5	48.9 abcd	40.2 ab
8	BmJ, Stylet oil, No-gap insecticide	8.0	45.7bcd	27.3 ab
	Flsd 0.05	3.8	19.9	26.5

2012 Hermiston, OR- PVY Plots

ermiston PVY Potatoes by Market Class						
		ls	4-8 oz	8-12 oz	Over 12 oz	Combined Weight for 4-12 oz Classes
1.	19.7 a	.57 a	74.94 a	22.99 a-b	3.72 a-b	101.64 a
2.	19.87 a	.51 a	62.44 b-c	22.39 a-b	3.91 a-b	88.74 a-b
3.	21.85 a	.68 a	65.74 a-c	20.28 a-b	3.49 a-b	89.52 a-b
4.	21.88 a	.48 a	56.39 c	14.96 b	1.46 b	72.81 b
5.	19.39 a	.61 a	69.03 a-b	31.15 a	5.13 a	105.30 a
6.	19.44 a	.70 a	65.14 a-c	27.46 a	4.74 a-b	97.33 a
7.	19.79 a	.46 a	68.4 a-b	20.75 a-b	4.08 a-b	93.23 a-b
8.	22.33 a	.93 a	70.60 a-b	21.01 a-b	3.03 a-b	94.63 a

histon Small Roguing Plot % PVY infection 8/8/13

Treatment	Not Rogued	Rogued
Untreated	6.84	4.03
BmJ 12 day interval from emergence	6.51	2.85 *
BmJ + JMS Stylet oil + no gap insecticide from emergence	1.82 **	1.29 **

ÅDiffer from untreated unrogued @ P=0.1
ÅDiffer from untreated unrogued @ P=0.05

Data including winter test results from large scale non rogued plot (very low infection in August) will be available in February 2014.

induced resistance reduce virus?

- No data from biological systems yet
- In Arabiopsis mutant / cauliflower mosaic virus studies with mutants Love, et al., 2007 showed salicylic acid pathway involved in delayed symptoms and severity and alternative oxidase. Ethylene/Jasmonic acid deficient mutants show reduce long distance spread. Lewsey et al., 2009 showed **RNA silencing** and salicylic acid mediated defense to **restrict virus replication** and movement. **Jasmonic acid may have direct effect on aphid vector**.
- Data using salicylic acid, Acibenzolar-s-methyl-(Actigard,Bion)/ CMV TMV in tobacco, squash, Arabidopsis show **reduced virus movement-cell to cell (delay symptom development) and systemic movement.** IR involves mitochondrial enzyme alternate oxidase and RNA dependent RNA polymerase.
  - Mayers, et al 2005 : Madhusudham, et al., 2008

Conclusion

- IR shown to delay symptom onset and reduce infection, disease severity, virus titer, virus movement or symptom severity for a wide range of viruses . Viruses where some level of control has been noted include; cucumber mosaic virus (CMV), tobacco mosaic virus(TMV), potato virus Y(PVY), tomato mottle virus, cauliflower mosaic virus, barley yellow dwarf mosaic virus and tobacco necrosis virus.
- Control levels are generally in the range of 30-80% and that the mode of action or efficacy differs remarkably by biological control agent and plant species.
- May have direct effect on aphid vectors

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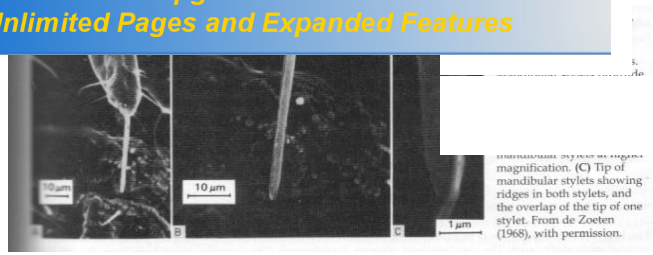

magnification. (C) Tip of mandibular stylets showing ridges in both stylets, and the overlap of the tip of one stylet. From de Zoeten (1968), with permission.

PVY/PVA

- Consider crop/oil borders-"aphid stylet cleaning stations"
- Control volunteers and Hairy nightshade (a good host for virus and green peach aphid)
- Use oils -start just before cereal crops begin to turn
- When registered use induce resistance from emergence till harvest
- Start foliar applied aphid insecticide program 60-70 days after planting treatments with group 4A materials (Admire, Cruiser, etc)
  - Non colonizing aphids like Bird Cherry- Oat aphids move from grain as crop ripens-late June-July
  - Mineral crop oils- oil reduces aphid acquisition and transmission of virus- need coverage, 5-7 day intervals, can use with insecticides
- Use "soft materials" Fullfill, Beleaf, Movento, neonicotinoid-4A materials – use till vine kill (no green vine tissue)- follow insecticide resistance management suggestions

Reducing PVY Risk

- Disease-free seed
  - Seed growers-100% testing nuclear and G1 (tuber unit)
  - Rogueing
- Crop Borders
- Systemic insecticides at planting
- Roguing symptomatic plants
- Stylet oils, Induced systemic resistance
- No gap insecticide program- feeding deterrents, “soft insecticides” thru vine kill
- Early Vine-kill
- Volunteer potato control

DU TO LAB GROUP

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- Dr. Oliver Neher
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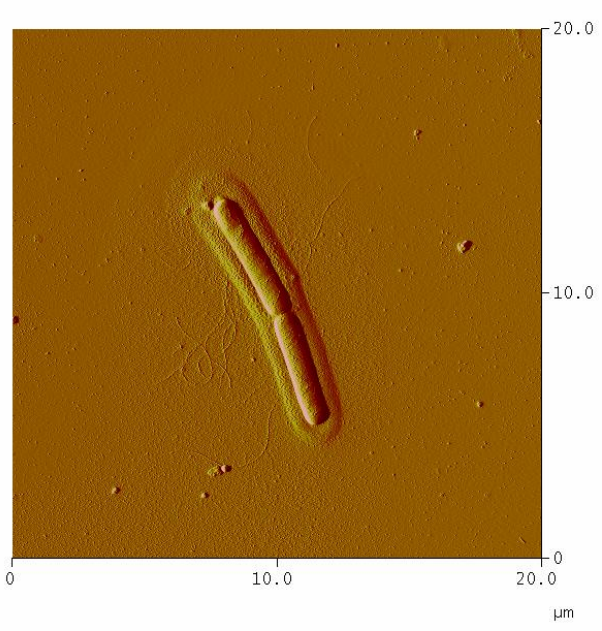

u &Happy Trails