



THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

Viruses and Viroids Infecting Hops

Melanie L. Lewis Ivey

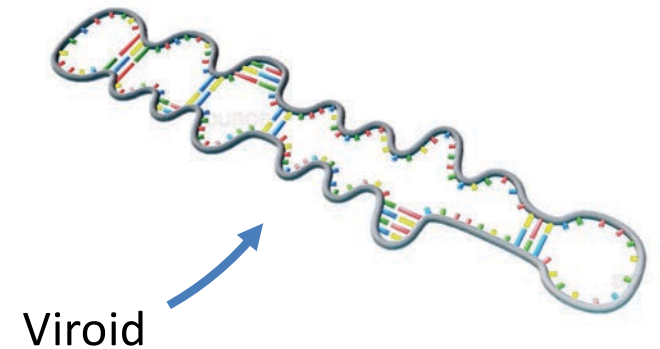
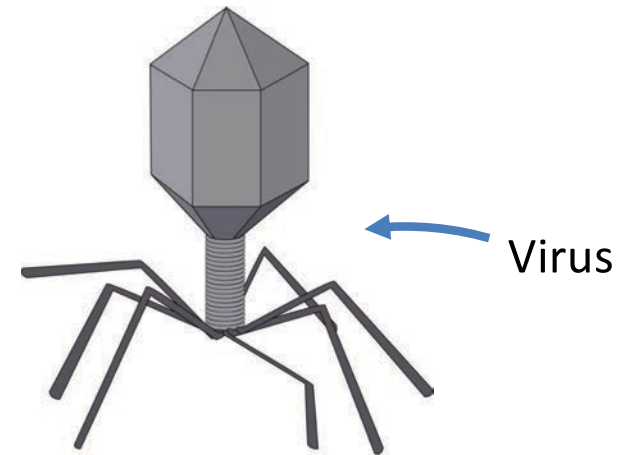
Department of Plant Pathology



Hop Viruses and Viroids

- **Apple mosaic virus**
- **Hop mosaic virus**
- Hop latent virus
- American hop latent virus

- **Hop stunt viroid**
- Hop stunt latent viroid





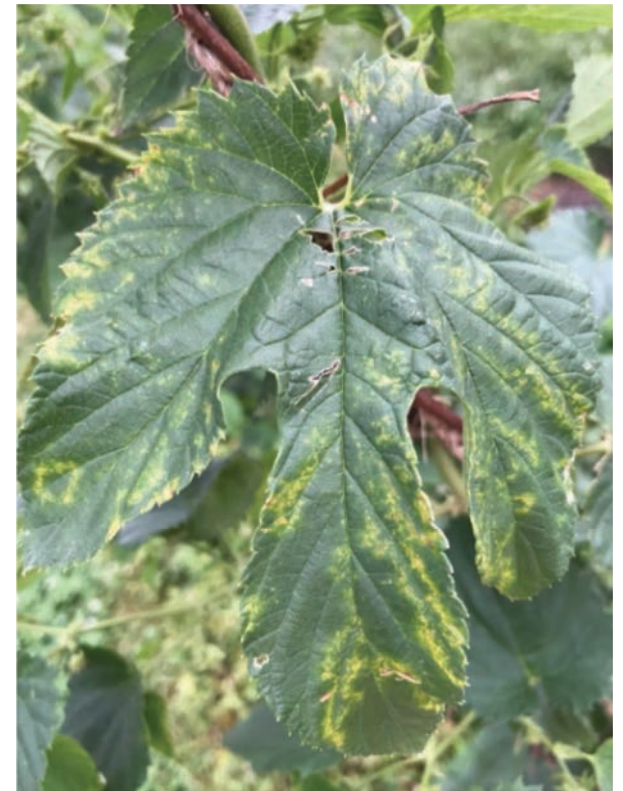
Virus Symptoms

- Vary depending on virus and cultivar
 - Yellowing of leaves
 - Necrotic (brown) rings
 - Chlorotic (yellow) rings
 - Mosaic or mottling
 - Chlorotic speckling



Impact of Hop Viruses

- Emergence and early growth delayed
- Reduced plant vigour
- Reduce yield
- Minimal change to brewing characteristics



Nebraska Bine Times



Apple Mosaic Virus (APMV)



Hay et al. 2008

- Chlorotic rings and necrotic spots on leaves of cultivar Opal



Apple Mosaic Virus



David Gent, USDA ARS

- Oak-leaf line patterns and chlorotic ring spots on leaves of hop cultivar Willamette



Hop Mosaic Virus (HpMV)



Erin Lizotte, MSU Extension

- Chlorotic mosaic mottling and/or speckling



Hop Mosaic Virus



Hay et al. 2008

- Range of symptoms on leaves of Golding-type hop cultivar



Impact of Hop Viroids

- Emergence and early growth delayed
- Stunting
- Reduced plant vigour
- Reduce yield
- Decrease in alpha-acid content





Viroid Symptoms

- Stunting-temperature dependent
- Speckling along leaf veins
- Reduced lateral branching
- Yellow-green leaves at the base
- Small and sparse cones



Hop Stunt Viroid



- Stunting, yellow-green leaves



Transmission and Spread of Viruses and Viroids

Virus/Viroid	Mechanical	Insect
Apple mosaic virus	X	
Hop mosaic virus	X	X
Hop latent virus	X	X
American hop latent virus	X	X
Hop stunt viroid	X	

*Mechanical=non-insect transmission



Mechanical Transmission and Spread (Non-insect Transmission)

- Requires a wound in the plant tissue
- Movement of plant sap containing virus/viroid particles
 - Propagation
 - Root grafting
 - Pruning (leaf removal)
 - Crowning



Jeanine Davis, NCSU



Insect Transmission and Spread of Hop Viruses

- Damson/Hop aphids are the primary vector for hop viruses
- Transmission is non-persistent





Wingless Damson hop aphid



Winged Damson hop aphid

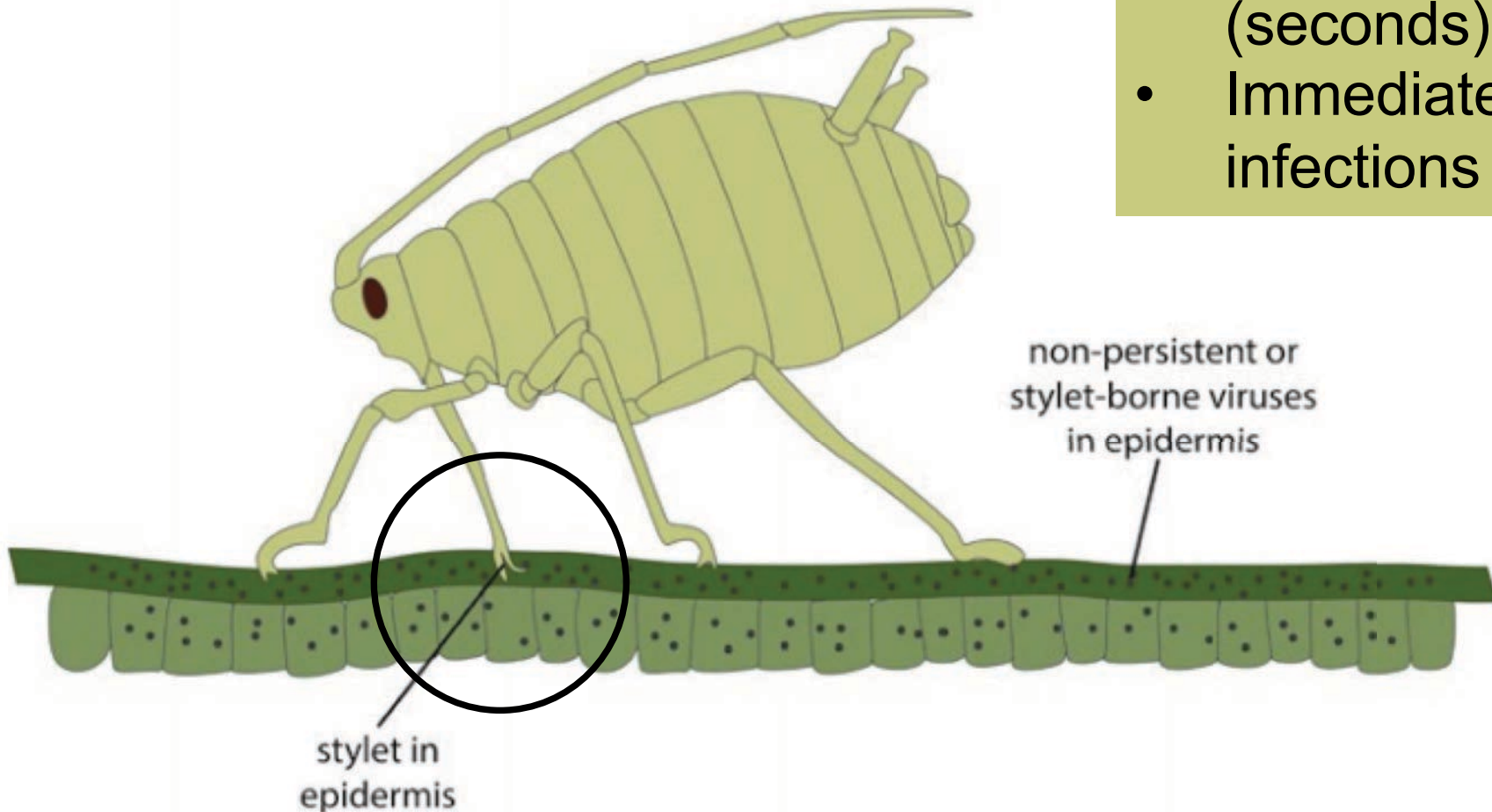


Sooty mold





- During feeding
- Rapid transfer (seconds)
- Immediate infections



Non-persistent virus transmission



Hop Virus and Viroid Disease Management

- Plant clean stock material
- Early detection and rapid response
- Good sanitation practices (propagation and field)
- Reduce aphid populations to reduce rate of secondary transmission within a hop yard



What is a “Clean Plant”?

- Foundational or Generation 1 (G1) plant line or cultivar
 - Tested for and found free of economically important plant pathogens
 - Maintained under controlled conditions to prevent reinfection
- Not guaranteed to be free of ALL pathogens



National Clean Plant Network for Hops

- Clean Plant Center Northwest (CPCNW)
 - Virus and viroid tested
 - 18 months (non-infected) to 3 years (infected)
 - Unrooted green shoots \$25





Hops

Hop Screen (11 tests)

Pathogen	Symbol	Format
Alfalfa mosaic virus	AMV	ELISA
Apple mosaic virus	ApMV	ELISA
Arabis mosaic virus	ArMV	ELISA
Carlavirus group test (American hop latent virus, Hop latent virus, Hop mosaic virus)	Carla	PCR
Cherry leaf roll virus	CLRV	ELISA
<i>Phytophthora</i>	Phyt	ELISA
Prunus necrotic ringspot virus	PNRSV	ELISA
Strawberry latent ringspot virus	SLRSV	ELISA
Tobacco ringspot virus	TRSV	ELISA
Tomato bushy stunt virus		
Tomato ringspot virus		

1st sample: \$372
Additional samples: \$60



- Washington State University Virus Diagnostic Lab
 - Complete virus panel
 - *American hop latent virus*
 - *Apple mosaic virus*
 - *Apple fruit crinkle viroid*
 - *Arabis mosaic virus*
 - *Cherry leaf roll virus*
 - *Hop latent viroid*
 - *Hop latent virus*
 - *Hop mosaic virus*
 - *Hop stunt viroid*
 - *Tobacco ringspot virus*

1 sample: \$66.53

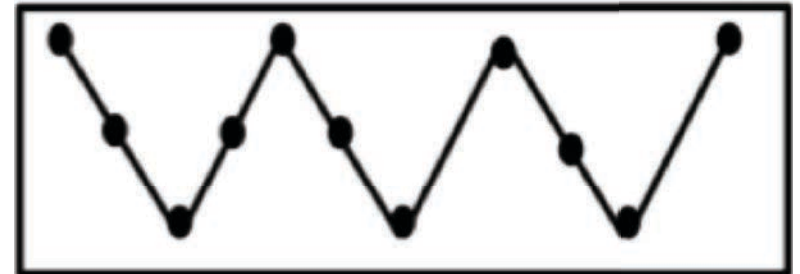
10 samples: \$144.20

- 5-6 leaves per sample
- Collect in spring, trifoliate stage



Scouting for Early Detection

- Scout yards regularly
 - At least once a week
- Walk in zig-zag pattern
- Inspect from the ground to the top
- Look at bottom and top of leaves and the entire cone
- Note any patterns





To Rogue or Not to Rogue?

- Things to consider before deciding to rogue
 - Plants are often asymptomatic
 - Removal of all the plant is difficult
 - Decline for viruses is slow (but accumulative)
 - Total number of symptomatic plants
- **Viroid infected plants should be removed**



Aphid Control

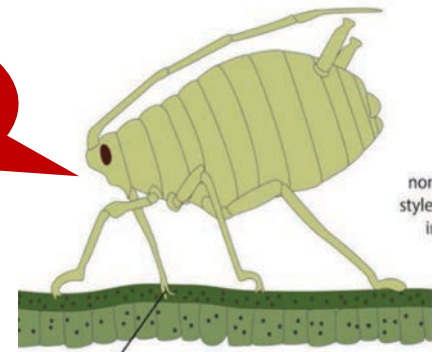
- Remove alternate hosts
 - Overwintering on *Prunus* species
 - Flowering weeds (in season habitat)
- Monitoring program
 - Begin when daytime temperatures $>58-60$ F
 - Limit populations early



Aphid Control

- Limit the spread of viruses only (not introduction of viruses)
- Monitoring and early applications are critical
- Insecticides, but avoid broad spectrum insecticides
- Beneficial insects or biocontrol products

Remember
me?





Sanitation Practices

- Handle healthy plants first
- Wear clean clothing
- Use clean tools (free of dirt, sap and plant debris)
 - Use soap and water and scrub brush
- Remove pruning material from the yard immediately
- Use sanitizers





Equipment Sanitation

- Tools must be free of dirt and plant debris
- Do all healthy (asymptomatic) plants first
- Sanitize between plants
 - Lysol
 - 10% chlorox
 - 20% skim milk
 - KleenGrow
 - Virkon S
 - GreenShield

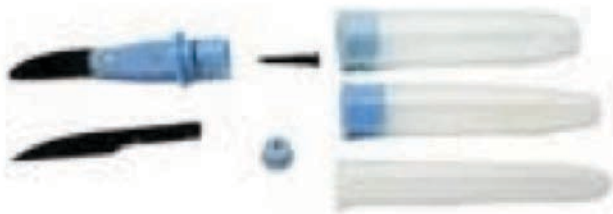




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Sanitizer Delivery Aids



Menno Knife
Royal Brinkman, The Netherlands
royal@brinkman.com



Metallo-GermoKnife
metallotools.nl/



**Felco19 Shears with
spray device**
FelcoSA Switzerland
felcostore.com/pruners



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Questions and Discussion

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Hop Powdery Mildew

- Officially confirmed in Ohio in 2018
- Infects shoots, leaves, cones





- *Podosphaera macularis*
- Mating type 1-1 (MAT1-1)
 - Overwinters in crown buds as fungal strands only

