

# Healthy hop planting stock for Wisconsin

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# Hop planting stock

- Rhizomes
- Plantlets



Picture: The Hop Yard  
via amazon.com

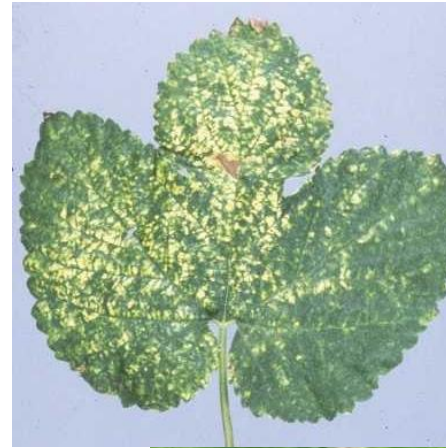


Picture: [www.plantlabs.com](http://www.plantlabs.com)

- Vegetative propagation: pathogens in source plant are also present in propagated plants

# Diseases transmitted in hop planting stock

- Carlaviruses
  - Hop Mosaic Virus (HpMV)
  - Hop Latent Virus (HpLV)
  - American Hop Latent Virus (AHLV)
- Apple Mosaic Virus
- Arabis Mosaic Virus
- Hop Stunt Viroid
- Hop Latent Viroid
- Hop Downy Mildew
- Verticillium wilt



Hop Mosaic Virus,  
cultivar Golding  
<http://www.dpvweb.net>



Apple Mosaic Virus  
Picture: David Gent

# Hop Mosaic Virus

- Many cultivars are tolerant of infection
- Goldings and Chinook are highly sensitive
  - Chinook: 62% yield loss
- Transmission:
  - Hop-damson aphid, potato aphid, green peach aphid
  - Mechanical and plant contact
- Symptoms:
  - Chlorosis (yellowing), mottling and distortion of leaves
  - Stunting, shortened internodes



Picture: C. B. Skotland

# Apple Mosaic Virus

- Previously “Prunus necrotic ringspot virus”
- Transmission:
  - Mechanical (in plant sap)
  - Plant contact, root grafting
- Symptoms
  - Cultivar and strain dependent
  - Expressed in cooler weather
  - Chlorotic (yellowed) or necrotic (dead) rings and arcs
  - Stunting, shortened internodes & sidearms
  - Yield loss (up to 30%)
  - Reduced alpha acids



Picture: David Gent



# Hop Stunt Viroid

- Mechanical transmission
- Stunting; yellowing/speckling and curling of leaves
- Possible association with Fusarium canker
- Yield and quality effects
  - Yield losses of 50-80% (Willamette, Glacier)
  - Brewing acid levels 50-70% lower
  - Shift in ratio of  $\alpha$ : $\beta$ -acids



Photos: David Gent, USDA Agricultural Research Service, Bugwood.org

# Hop Latent Viroid

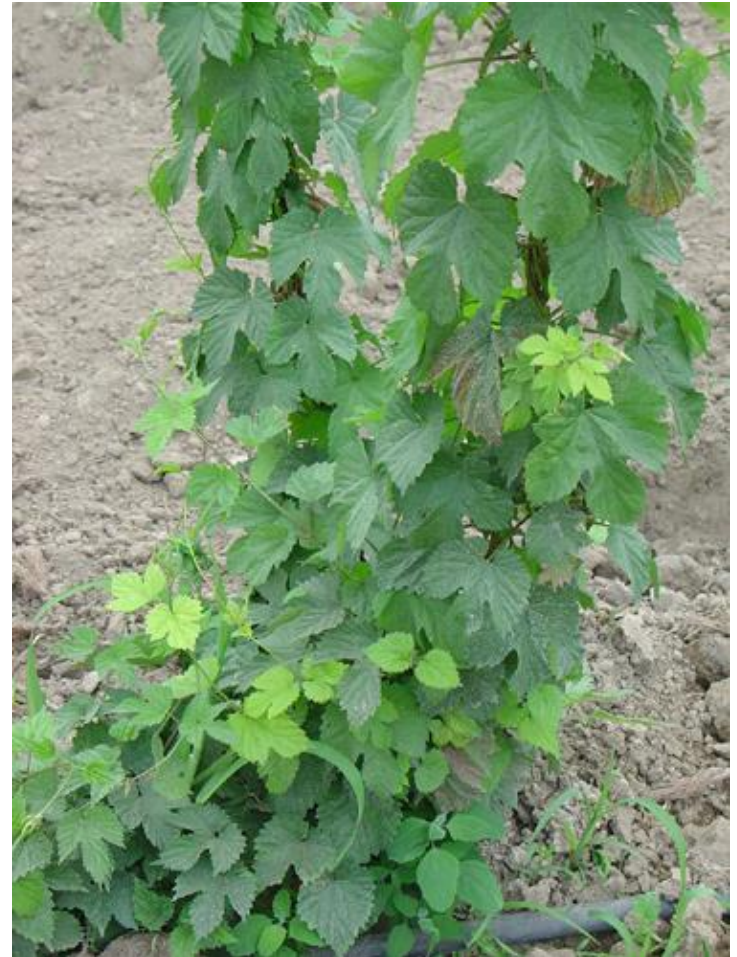
- Mechanical transmission
- Chlorosis, slow growth, fewer laterals
- Yield and quality effects
  - cultivar-dependent; many cultivars appear tolerant
  - Omega – cone yield down 27%,  $\alpha$ -acids down 31%,  $\beta$ -acids higher



Photos: [www.plantmanagementnetwork.org](http://www.plantmanagementnetwork.org)

# Managing diseases spread in planting stock

- Plant clean stock
- Sanitation
  - Work in diseased yards last
  - Sterilize tools (soak in 5-10% bleach for several minutes. Rinse with water.)
- Destroy infected plants

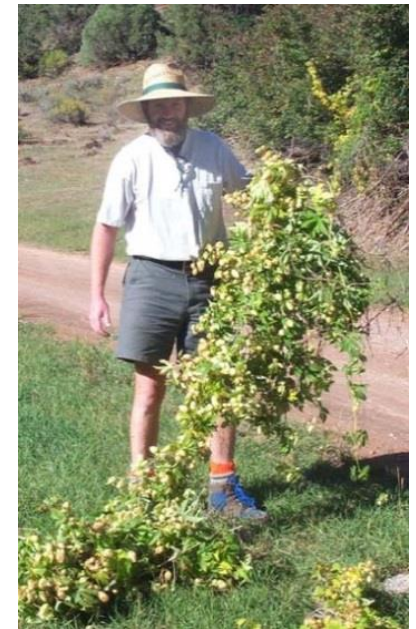


Hop stunt viroid in cultivar Glacier.  
Picture: Ken Eastwell.



# Sources of clean stock

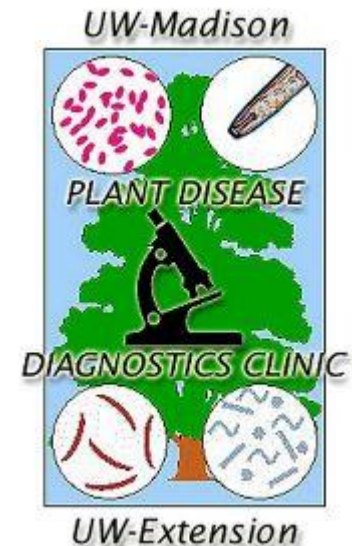
- Clean Plant Center of the Northwest
  - Distributes material in winter (potted plants) and summer (bine cuttings)
  - Subscribe to email list to request material
- USDA National Clonal Germplasm Repository
  - Maintains cultivated and wild hop germplasm
  - Material distributed for research and education
  - Online request form
- Both distribute only small quantities
- No certification system to ensure pathogen-free stock from commercial suppliers



USDA-NCGR  
expedition in 2002 to  
collect native US hops

# University of Wisconsin Clean Hops Program

- Build cultivar collection as local source of clean planting stock
- Develop capacity for pathogen eradication from hop clones
- Offer pathogen testing services for hop samples



# Hop cultivar collection at UW-Madison

Cultivar	Source	Greenhouse	Tissue culture
Cascade	USDA-NCGR	Y	Y
Fuggle Tetraploid	USDA-NCGR	Y	Y
Hallertauer Gold	USDA-NCGR		Y
Hallertauer Tradition	USDA-NCGR	Y	Y
Galena	USDA-NCGR	Y	Y
Mt. Hood	USDA-NCGR	Y	Y
Nugget	USDA-NCGR	Y	Y
Perle	NCPN-Hops	Y	
Saazer 38	USDA-NCGR	Y	Y
Tahoma	NCPN-Hops	Y	
Willamette	USDA-NCGR	Y	Y
Yakima Gold	NCPN-Hops	y	Y

# Plans for hop cultivar collection

- Pilot scale plant distribution in 2016 as part of cultivar evaluation (as in 2015)
- Propagate plantlets for distribution to growers
  - First distribution planned for spring 2017
  - Request using online forms (to be developed)
  - Capacity is limited so plant numbers will be small
- Improve greenhouse management
  - Trellising
  - Reduce supplemental lighting?





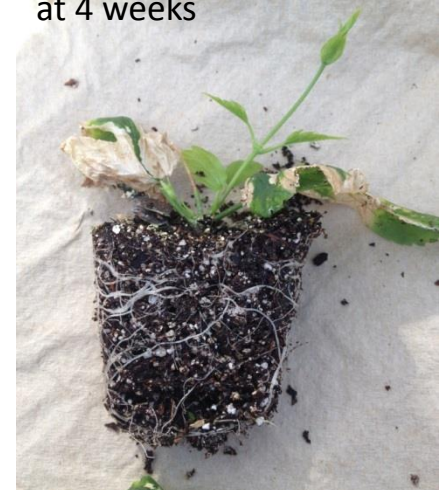
# Greenhouse propagation

- Single node bine cuttings with ~1 inch stem to either side
  - Apply rooting hormone to lower end
    - 10 ppm indole butyric acid/boric acid (IBA/BA) solution, soak for 2 minutes
    - Commercial powders and gels are easy-to-apply alternatives
  - Insert into moist potting media so that nodes are barely covered.
  - Cover with ventilated plastic dome. Avoid direct sunlight.
  - Water gently. Re-cover nodes with soil if exposed.
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- Note that NCPN protocol recommends 1000 ppm IBA/BA solution
  - We observed low propagation rates at 1000 ppm IBA/BA for Brewer's Gold, Crystal, Centennial, Cascade, Willamette, Mt. Hood, Fuggle, Galena

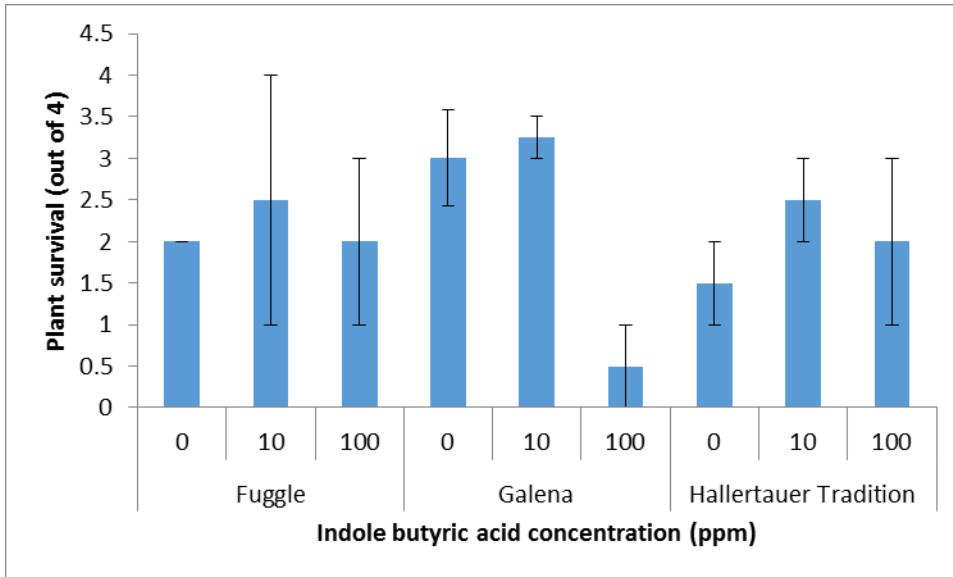


Former student Deena Patterson taking hop cuttings

Successful propagation at 4 weeks



# Rooting hormones for greenhouse propagation



Excess root production on cultivar Cascade after 1000 ppm IBA treatment

- Cultivars vary in sensitivity to rooting hormones
  - Note reduced propagation success for Galena at 100 ppm IBA
- Highly sensitive cultivars may show excessive root production
- We recommend 10 ppm IBA/BA for most varieties

# Dormancy treatments

- Does putting potted hop plants through a dormancy period improve regrowth?
  - Nugget, Fuggle, Galena, Yakima Gold (Propagated in spring 2015)
  - Galena, Willamette (Propagated in fall 2015)
  - Dormancy induced by reducing supplemental light in line with natural photoperiod
  - Plants moved to 4 C cooler at end of October
  - Set of plants moved to normal greenhouse conditions weekly for 12 weeks (ending Jan 25)
  - SMALL SAMPLE SIZE – results are preliminary

# Outcomes of dormancy treatments

- Plants propagated in spring 2015
  - Cold storage as potted plants: 70-100% survival, strong regrowth after up to 10 weeks
  - Cold storage as bare rooted plants (Yakima Gold): 70-100% survival, strong regrowth after up to 9 weeks
- Plants propagated in fall 2015
  - Cold storage as potted plants: survival rate declined after 4 weeks (Willamette) and 7 weeks (Galena)
  - Cold storage as bare rooted plants (Galena): 100% survival after 3 weeks, then 0%



# Preliminary recommendations for propagation cycle

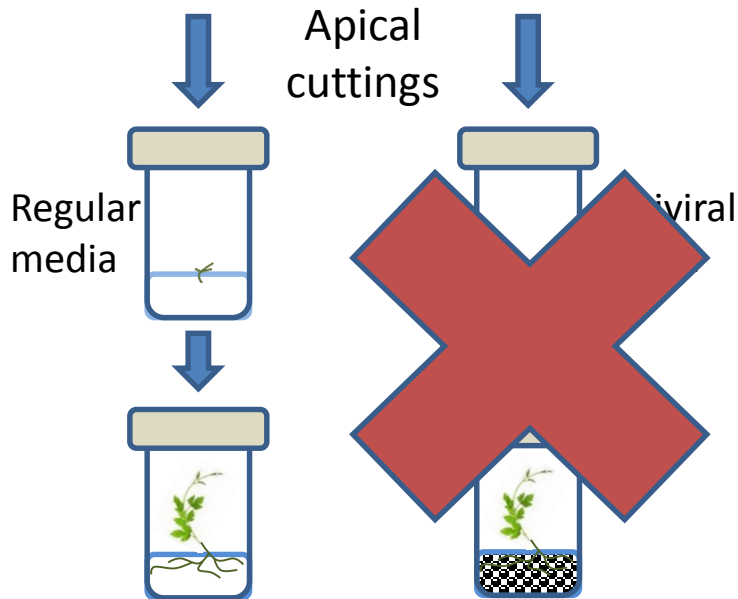
- Propagate in spring, maintain in greenhouse till fall
- Cold storage for 3-4 months should not reduce survival of plants with good root system
  - Keep plants moist, but not soaked
  - Storage as bare-rooted plants may be feasible if root system is well grown
- Later propagation: maintain plants in greenhouse through winter

# Building pathogen eradication capacity

- Meristem culture after heat treatment – USDA-NCGR method
  - Virus less likely to be present in youngest cells
  - Excise cells from growing tip and grow in aseptic culture
- Apical tip culture after growth in antiviral-containing tissue culture media
  - Developed for virus eradication in potato tissue culture
  - Larger cutting increases survival rate
  - Sometimes combined with thermotherapy
  - Easier tissue culture technique, may allow higher capacity due to reduced training needs

# Apical tip culture trials

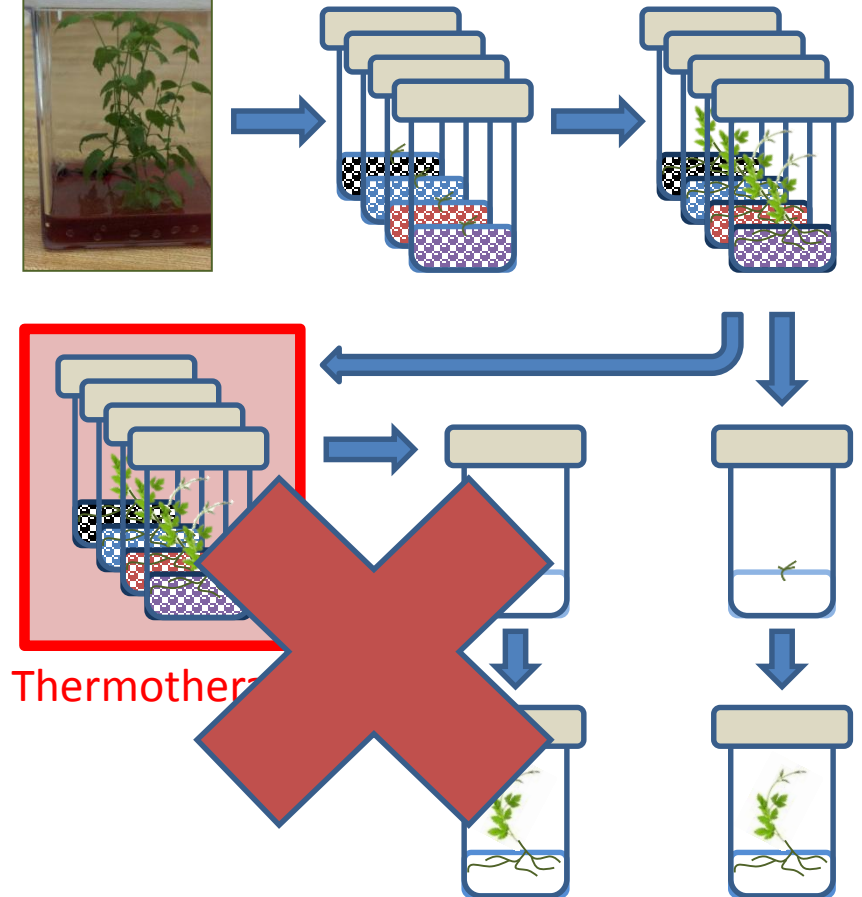
## Start with potted plants



## Start with tissue cultured plants

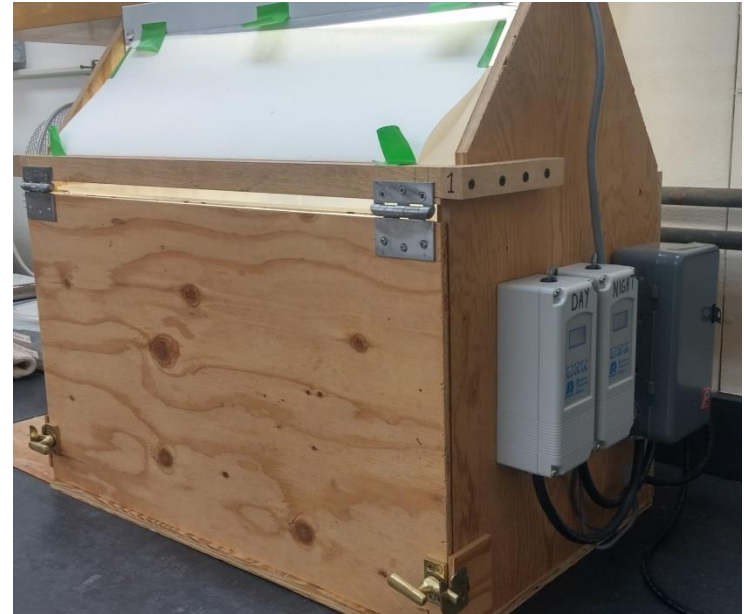


Grow on antiviral-containing media



# Thermotherapy on potted plants

- Brewer's Gold, Centennial
- Infected with:
  - ApMV
  - carlaviruses
- Thermotherapy method following Postman et al (2005):
- 6 week old plants
- 8 hour cycle:
  - 4 hrs lights on, 38 C (100 F)
  - 4 hrs lights off, 30 C (86 F)
- Apical tip culture after 3 weeks





# Tissue culture plants on antivirals

- Crystal, Brewer's Gold, Centennial infected with ApMV, carlaviruses
- Antivirals added to "storage" media (low iron)

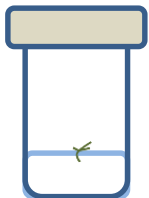
			Plant growth on antivirals	
Ribavirin (15 mg/L)	DHT (50 mg/L)	ASA (1.8 mg/L)	Crystal	Brewer's Gold/ Centennial
+			Stunted	Small, but active growth
+	+		Stunted	Small, but active growth
+		+	Very stunted	Small, but active growth
	+		Small, but active growth	Small, but active growth

# Apical tip culture trials

## Start with potted plants



Apical cuttings



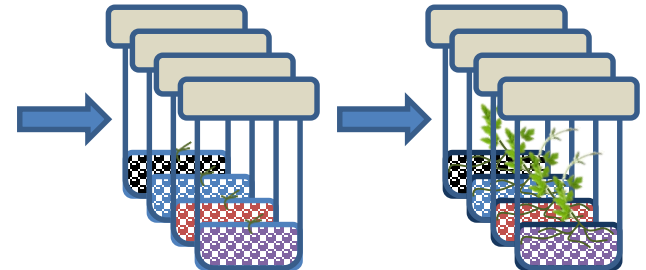
3 Brewers Gold plants to test

Next steps:  
Trial meristem culture of heat-treated plants  
Compare efficiency with apical tip culture (assuming successful virus eradication)

## Start with tissue cultured plants

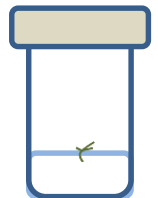


Grow on antiviral-containing media



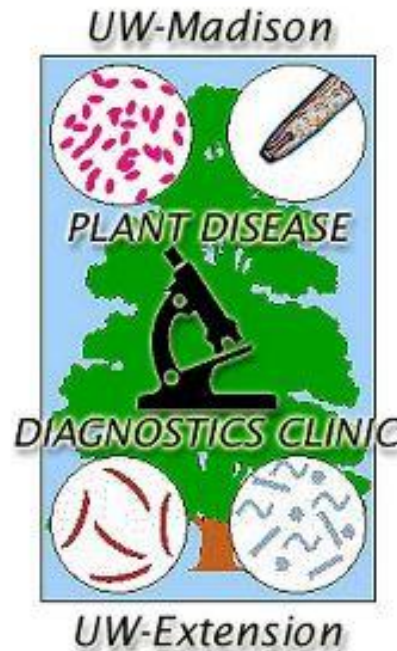
11 Centennial, 7 Brewers Gold plants to test

Apical cuttings



# Hop testing services

- Plant Disease Diagnostic Clinic at UW-Madison  
<http://labs.russell.wisc.edu/pddc/>
- Testing services for
  - Carlaviruses
  - Apple mosaic virus
  - Arabis mosaic virus
  - Downy mildew
  - Powdery mildew
  - Verticillium wilt



See brochure  
or website for  
details on  
sample  
submission  
and pricing.

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QUESTIONS?

