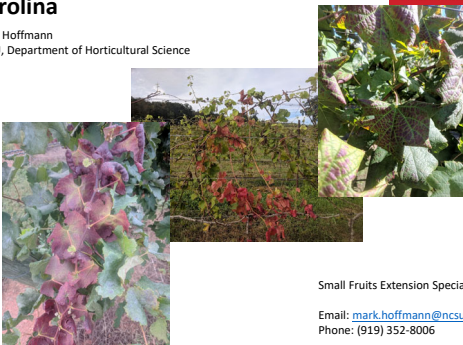


**Grape Virus Diseases in North Carolina**

Mark Hoffmann  
NCSU, Department of Horticultural Science



Small Fruits Extension Specialist  
Email: [mark.hoffmann@ncsu.edu](mailto:mark.hoffmann@ncsu.edu)  
Phone: (919) 352-8006

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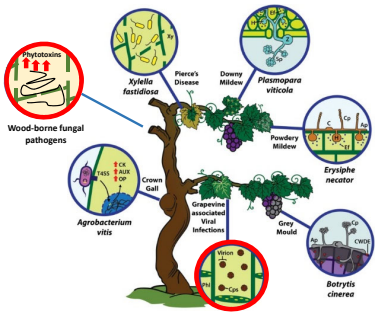
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Phytophthora  
Wood-borne fungal pathogens  
Xylella fastidiosa  
Pierce's Disease  
Downy Mildew  
Plasmopara viticola  
Powdery Mildew  
Erysiphe necator  
Botrytis cinerea  
Grey Mould  
Grapevine associated Viral Infections  
Agrobacterium vitis

Armijo et al. (2016). Grapevine Pathogenic Microorganisms: Understanding Infection Strategies and Host Response Scenarios. Front. Plant Sci. 2016, 7:382.

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**Grapevine Virus Diseases (GVDs)**

Short overview on GVDs  
Update on Virus Survey  
Identification of GVDs  
**NEW ESTABLISHED SERVICES AT NC STATE**  
Current sampling (when and what)

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	Trunk Diseases	Virus Diseases
<i>Type of Pathogen</i>	Fungal	Virus (RNA/DNA)
<i>Lethal to vine</i>	Yes	No
<i>Plant Age</i>	Mature; young (ESCA)	Mature and young
<i>Resistance/Tolerance</i>	Not found	Some native species seems to be more tolerant
<i>Can come with nursery stock?</i>	Yes	Yes
<i>Transmitted?</i>	Open wounds, Rain, Pruning Tools	Insect Vectors
<i>Systemic</i>	No	Yes
<i>Severity in NC</i>	?	?

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**Grape Viruses**  
Actual research data

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Ca. 70 different Grape Viruses are identified  
Ca. 25 associated diseases

Virus	Name
GLRaV 1-10	Grapevine leafroll associated virus 1-10
GRBaV	Grapevine red blotch associated virus
GVA-F	Grapevine virus A-F
GFKV	Grapevine fleck virus
GFLV	Grapevine fanleaf virus
GRSPaV	Grapevine ringspot associated virus
Many many more	

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**Grape Viruses**

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Most grapevine viruses are single stranded RNA viruses

Viruses can not be seen!

**Also called: Virus Particles!!!**

Viruses NEED a cell to be active

Viruses use the cell mechanisms to copy themselves

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**Grape Viruses** **NC STATE UNIVERSITY**

Viruses are often transmitted by insects (so called 'vectors')

Gregerich and Dolja (2006). Introduction to Plant Viruses, the Invisible Foe. The Plant Health Instructor. DOI: 10.1094/PHI-I-2006-0414-01 7

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**Grape Viruses** **NC STATE UNIVERSITY**

Grape Leafroll associated Virus (GLRaV)

Green veins

Rolling edges

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**Grape Viruses** **NC STATE UNIVERSITY**

Grape Leafroll associated Virus (GLRaV)

- Transmitted via Mealybugs
- Please contact Hannah Burrack

[hannah\\_burrack@ncsu.edu](mailto:hannah_burrack@ncsu.edu)

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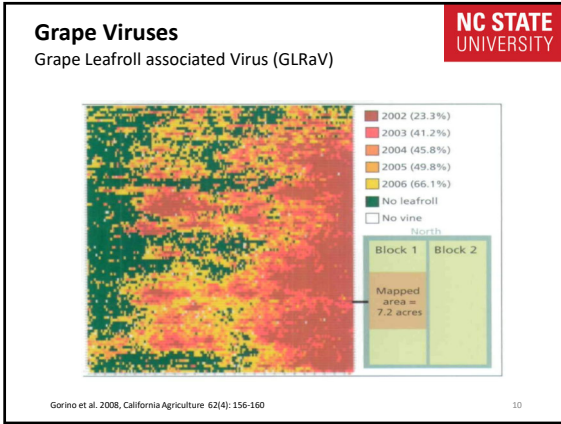
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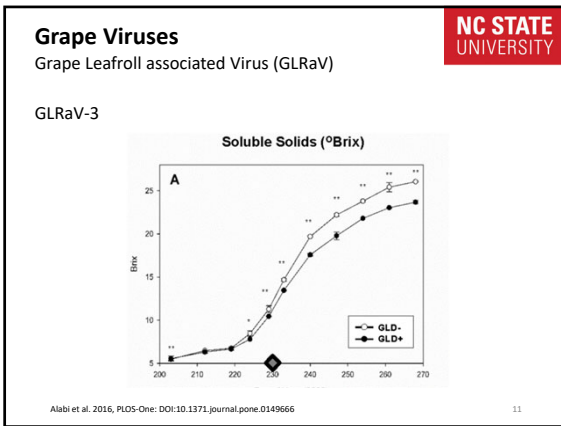
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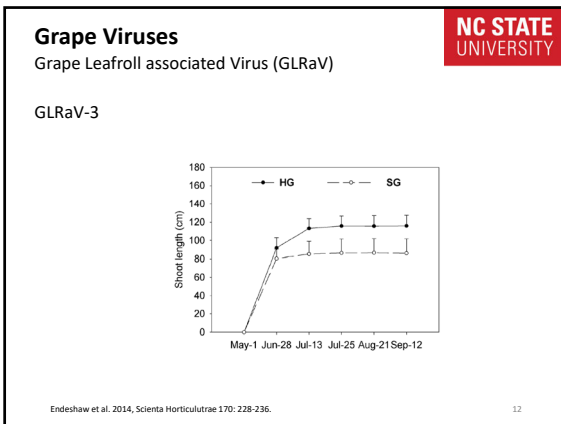
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**Grape Viruses**  
Grape Leafroll associated Virus (GLRaV)

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GLRaV-3

Variable	Treatment means by season <sup>a</sup>					
	2009		2010		2011	
	Non-symptomatic	Symptomatic	Non-symptomatic	Symptomatic	Non-symptomatic	Symptomatic
Yield (kg/vine) <sup>b</sup>	4.70	3.39	4.19	3.52	5.68	4.51
Bunch/Vine (g) <sup>c</sup>	90 <sup>a,c</sup>	79 <sup>a,c</sup>	86 <sup>a,c</sup>	70 <sup>a,b</sup>	116 <sup>a,c</sup>	99 <sup>a,b</sup>
Pruning weight (g/vine) <sup>d</sup>	NA	NA	315.0	279.6	359.3	272.0
TSS (Brix) <sup>e</sup>	24.8 <sup>a,b</sup>	23.3 <sup>a,b</sup>	25.0 <sup>a,b</sup>	23.1 <sup>a,b</sup>	23.5 <sup>a,c</sup>	22.5 <sup>a,b</sup>
Titratable acidity (g/L) <sup>f</sup>	5.4 <sup>a,c</sup>	6.10 <sup>a,c</sup>	6.40 <sup>a,c</sup>	6.76 <sup>a,c</sup>	4.30 <sup>a,c</sup>	4.89 <sup>a,c</sup>
pH <sup>f</sup>	3.65 <sup>a,c</sup>	3.58 <sup>a,b</sup>	3.54 <sup>a,c</sup>	3.53 <sup>a,b</sup>	3.65 <sup>a,c</sup>	3.55 <sup>a,b</sup>

<sup>a</sup>Data represents means of raw data from 12 pairs of non-symptomatic (uninfected) and symptomatic (GLD-affected) vines for 2009 and 2010 seasons and eight pairs of vines for the 2011 season due to new infections of four non-symptomatic vines as determined by RT-PCR.  
<sup>b</sup>Data represents means of raw data from fruit triplicates taken from fruit lots from non-symptomatic and symptomatic vines at commercial harvest.  
<sup>c</sup>Means followed by an asterisk (\*) differ statistically ( $p \leq 0.05$ ) and alphabetical letters were used to separate means for each significant treatment effect comparison. Significant season effects ( $p \leq 0.05$ ) were obtained for all variables except yield and pruning wood weight but no significant "Treatment x Season" effects were found in all cases. NA, data not taken.  
doi:10.1371/journal.pone.0149666.t001

Alabi et al. 2016, PLOS-One: DOI:10.1371/journal.pone.0149666 13

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**Grape Viruses**  
Grape Red Blotch associated Virus (GLRaV)

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Red veins

No rolling edges

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**Grape Viruses**  
Grape Red Blotch associated Virus (GLRaV)

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Three-cornered alfalfa hopper (*Spissistilus festinus*).



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**Really important point:  
K Deficiency/Trunk Disease/Leafroll?**



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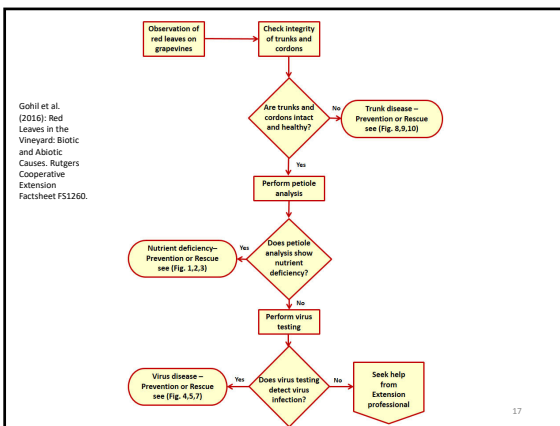
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**Research**

**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

**Objectives:**

(1) Survey of North Carolina Vineyard (2018-2020).  
(2) Develop Virus Testing Capacity in the Southeast

Hannah Burrack:  
Insect monitoring 2018 (Pierces/Red Blotch)

In 2019: Hannah and I work together on a survey

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**Viruses**

**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

**We mainly work on the Virus site of things**

Project Team:

- Maher Al Rwahnih (UC Davis, Foundation Plant Services)
- Christie Almeyda (NCSU, Micropropagation and Repository Unit)
- Win Talton (NCSU, Molecular Scientist)
- Mizuho Nita (VT, Plant Pathologist)
- Emma Volk (NCSU, Research Technician)
- **Mark Hoffmann (NCSU, Viticulture Specialist)**

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**Viruses**


**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

**NC State Micropropagation and Repository Unit in Raleigh**

*Director:* Christie Almeyda (NCSU, Micropropagation and Repository Unit)



- Is part of the National Clean Plant Network (NCPN)
- Is one out of only four centers NATIONWIDE with berry and grape responsibilities
- Keeps plant stock and has virus testing capacity for berries (and now also for grapes!!)

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**Viruses**


**UCDAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

**NC State Micropropagation and Repository Unit in Raleigh**

*Director:* Christie Almeyda (NCSU, Micropropagation and Repository Unit)



- The NC Grape and Wine Council has funded a project in 2018 to develop grape virus testing capacity at the MPRU, led by Dr. M Hoffmann
- As part of this project, we also conducted a preliminary survey

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**Viruses**

**UCDAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

Grape Virus Survey North Carolina 2018

23

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**Viruses**

**UCDAVIS**  
UNIVERSITY OF CALIFORNIA

**NC STATE**  
UNIVERSITY

**VT VIRGINIA**  
TECH.

Have to be sterile in the field  
Virus titer has to be high  
**Sampling window: after harvest until leaves turning  
(2-3 week window each year)  
(late October/early November)**

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**Grape Virus Survey North Carolina** **NC STATE UNIVERSITY**

Most grapevine viruses are single stranded RNA viruses

Common	Name
GLRaV-2	Grapevine leafroll associated virus 2
GLRaV-3	Grapevine leafroll associated virus 3
GLRaV-4	Grapevine leafroll associated virus 4
GLRaV-7	Grapevine leafroll associated virus 7
<b>GRBV</b>	<b>Grape Red Blotch Virus</b>
GVA	Grapevine Virus A
GVB	Grapevine Virus B
Other disease:	Xylella (Pierces Disease)

DNA

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**Virus Survey 2018** **NC STATE UNIVERSITY**

Nine vineyards in the Upper Hiwassee Highlands AVA, Yadkin Valley AVA and Crest of the Blue Ridge Henderson Co. AVA.

When? October 2018

What? Symptomatic and non-symptomatic vines

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**Virus Survey 2019** **NC STATE UNIVERSITY**

Focus on Yadkin Valley AVA

Sampled first week of November 2019

Samples are currently processed

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### Grape Viruses

Survey data 2018



GLRaV-2	GLRaV-3	GLRaV-4	GLRaV-7	GRBV	GVA	GVB	TMSV	Xylella
1%*	22 %	0 %	0 %	23 %	0 %	0 %	0 %	7 %

**Grapevine Leafroll associated Virus – 3: 22%**  
**Grape Red Blotch Virus: 23%**

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### Grape Viruses

Sampling: preliminary method


**1st Step:** Contact the EXTENSION AGENT and send pictures of the area/plant you want to sample!

**2nd Step:** Contact the Plant Disease and Insect Clinic (PDIC) in Raleigh and inform them before sampling and when to expect the sample

<https://projects.ncsu.edu/cals/plantpath/extension/clinic/>

FILL OUT THE ONLINE FORM at the PDIC and upload your pictures as well!

**THEN:** Collect samples. SAMPLES need to be shipped **AT THE SAME DAY** and **OVER NIGHT** and **ON ICE!** **DO NOT SHIP ON THURSDAY OR FRIDAY**



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### Grape Viruses

Sampling: preliminary method



Merlot

**Sample a whole symptomatic shoot**


Try only to touch the shoot where you have detached it from the cordon, but nowhere else!

Put the branch directly into a large **NEW!** plastic bag

Only **ONE** branch per BAG! No exception

Close the bag immediately after sampling.

Ship it right away



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**Grape Viruses**  
Sampling: preliminary method



Cab franc

- Sample a whole symptomatic shoot
- Try only to touch the shoot where you have detached it from the cordon, but nowhere else!
- Put the branch directly into a large NEW! plastic bag
- Only ONE branch per BAG! No exception
- Close the bag immediately after sampling.
- Ship it right away

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**Grape Viruses**  
Sampling: preliminary method



<https://projects.ncsu.edu/cals/plantpath/extension/clinic/submit-sample.html>

FILL OUT ONLINE FORM FIRST

<b>Address for US Postal Service, UPS &amp; FedEx:</b> Plant Disease and Insect Clinic Campus Box 7211 100 Derieux Place 1227 Gardner Hall North Carolina State University Raleigh, NC 27695-7211	<b>State Courier Address:</b> Plant Disease and Insect Clinic Campus Box 7211 NCSU Raleigh, NC STATE COURIER: 53-61-21
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**Grape Viruses**  
Sampling: preliminary method



<https://projects.ncsu.edu/cals/plantpath/extension/clinic/submit-sample.html>

FILL OUT ONLINE FORM FIRST

Fee Structure for in state samples from farmers:

Sample Processing (RNA extraction and quality control): \$ 50/sample  
Virus Testing (qPCR method in three replicates): \$15/sample

EXAMPLE COSTS:

Sample Processing (RNA extraction and quality control): \$ 50/sample  
Virus Testing (qPCR method in three replicates): \$15/virus

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**Grape Viruses**  
Sampling: preliminary method

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<https://projects.ncsu.edu/cals/plantpath/extension/clinic/submit-sample.html>

FILL OUT ONLINE FORM FIRST

EXAMPLE COSTS:

Two blocks, testing of two vines per block → **four samples**

Overnight shipping and material: Ca. \$100  
Sample Processing: \$50 \* 4 = \$200  
Virus Testing for current suite (8 viruses) \$15 \* 8 \* 4 = \$480

**TOTAL for four samples: ca. \$780**

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**Grape Viruses**  
What to do if you have them?

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**First: Don't panic!**

Mature Vineyards:

- VECTOR CONTROL ([www.smallfruits.org](http://www.smallfruits.org))
- Monitor spread of symptoms
- Replace vines gradually!

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**Grape Viruses**  
What to do if you have them?

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Young plantings/replants

- VECTOR CONTROL ([www.smallfruits.org](http://www.smallfruits.org))
- Monitor spread of symptoms
- Treat every vine as if it would be infected
- If a young vine shows any symptoms, you need to replace it!
- Symptoms can show even **three years** after planting

**PLANTING MATERIAL:**

- Order early (min one year before planting)
- Reject bad planting material, even if it means a one year delay!
- Order 15% more than you need
- Cut open grafting unions and inspect BEFORE planting!
- Develop relationship with nursery
- Ask for disease control protocols!!!

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**Grape Viruses Resources**

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[Plant Disease and Insect Clinic:](https://projects.ncsu.edu/cals/plantpath/extension/clinic/submit-sample.html)  
<https://projects.ncsu.edu/cals/plantpath/extension/clinic/submit-sample.html>

**IPM Guide (VectorControl):**  
<https://smallfruits.org/>

**This talk and other resources:**  
<https://grapes.ces.ncsu.edu/>  
<https://smallfruits.cals.ncsu.edu/> ('Grower Resources')

**Lodi Winegrowers Association (CA)**  
<https://www.lodigrowers.com/>

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**Team**

**NC STATE UNIVERSITY**



Xiaonan Shi MS Student PI    Mark Hoffmann PI    Tekan Rana PhD Student    Amanda Lay MS Student    Emma Volk Res. Technician    Rania Hassan Lab Manager/ Pathology Assay    Owen Washam Outreach Assistant

Not in picture: Hannah Fetzer (root systems), Caleb Brownfield (greenhouse)

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**Thank you!**

**NC STATE UNIVERSITY**

**Thank you for your attention**

NCSU  
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Raleigh, 27695 NC

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cell (919) 352 8006  
Email: [mark.hoffmann@ncsu.edu](mailto:mark.hoffmann@ncsu.edu)  
<https://smallfruits.cals.ncsu.edu>



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