


**Hop Production in N.C.**

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and Scott King, Dept. of Soil Science  
NC State University

Photo from J. Davis program © Jeanine Davis & Scott King 2012

### Why is there so much interest in growing hops?



- Started in 2007 when there was a global hops shortage and hops prices rose to historic levels.
- Hops traditionally grown in the Pacific Northwest, but acreages had been reduced over the years.
- The shortage resulted in new interest across the country, especially on the East Coast.

Photo from J. Davis program

### The hops shortage was short-lived, but there are opportunities for farmers in our region!

- Craft breweries (microbreweries)
- Home brewers
- Organic hops
- Fresh hops
- Locally grown hops




Photo from J. Davis program

### Will hops grow here?

- Sure they will!
- Not unusual to find a very old hops plant growing on a NC farm.
- Lots of home brewers produce a few plants for their own use.
- Diseases will challenge us.




Photos from J. Davis program

## Why don't we already have an established hops industry here?

- There was production here a couple hundred years ago.
- Disease and economics caused the industry to gradually move further and further west.
- Now the large commercial production is located where hops grow best-the Pacific Northwest (about 30,000 acres).



Photo from J. Davis program

## That is changing!

- New opportunities.
- Small commercial hop yards scattered across the state.
- Started five to six years ago.



Photos from J. Davis program



## The hop plant (*Humulus lupulus*)



- Long-lived perennial plants (10-50 years).
- Male and female plants. Commercial plants are all female.
- Stems grow each year to be about 25 feet long.
- The stem dies back to the crown each fall.
- Hops yards are established by planting rhizomes.
- Hops are a short-day plant; day length is important.

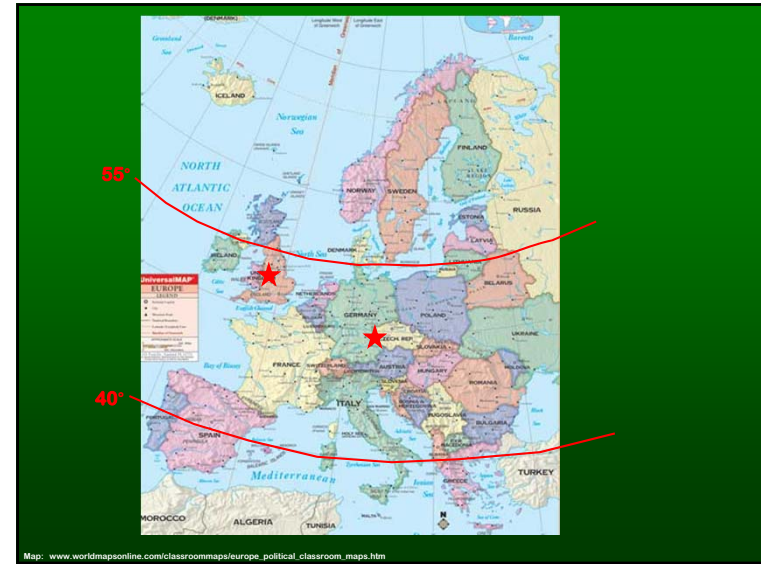
Photo from J. Davis program



## Day Length Concerns

- The photoperiod in NC is barely long enough for hops – they only produce well between latitudes 35°-55° (we're right on the southern edge!)
- They prefer long summer days (15 hours +)
- NC has roughly 14 hours of daylight in mid-June

**This can significantly reduce yields!**

**By how much is not known,  
perhaps as much as 85%!**





## Hop Varieties

- **Aroma types** -usually mature early and adapted to cool climates. Ex: Golding, Fuggle, Willamette, Tettnanger, and Cascade.
- **Bittering types** -higher yielding, higher in alpha acids, vigorous, developed for mechanical harvesting. Ex: Nugget, Chinook, Magnum, Centennial, and Galena.

Photo: Rob Austin      Photo from [blog.mlive.com](http://blog.mlive.com)

## Hop Varieties

- **Noble varieties** –Older European varieties, only grown in their historic regions, known for classic aroma and flavor. Consists of Hallertau, Saaz, Spalt, and Tettnanger. They grow very poorly in NC!
- **Super-Alpha types** –newer, higher yielding, very high in alpha acids and essential oils, more disease resistant. Ex: Newport, Columbus/Zeus, Apollo, and Warrior.

Photo: Rob Austin      Photo from [blog.mlive.com](http://blog.mlive.com)



**Crown puts out lots of shoots**

Once established, they'll start to come up in early March (or even late February!)

Photo from J. Davis program





**Called vines, because no tendrils**

Photo from J. Davis program



**Burrs and cones form**

Photos from J. Davis program



**The mature cone has lupulin (oil) glands containing alpha and beta acids, and essential oils.**

**The amounts and composition of these compounds vary among varieties, plant age, location, and year.**

Photos from J. Davis program

## How to establish a hop yard



Use our research hop yards as examples

Photo from J. Davis program

## Why do we need research hop yards?

- Will hops grow here well enough to be an economically viable crop?
- What varieties should we grow?
- What is the best trellis and management system?
- How should they be fertilized?
- What are the diseases and insects of concern and how do we control them?
- What are the economics of production?
- Will our quality be good enough that brewers will pay a premium for them?



## Field Preparation

Soil sampling and disking (deep tilling ideal)



Feb 20<sup>th</sup>, 2010



Photos from S. King and R. Austin program

## Field Preparation

Liming, bedding (necessary?), and other soil amendments



Mar 10<sup>th</sup>, 2010 in Raleigh



Photos from S. King and R. Austin program

## Trellises

**Hobby or small-scale trellising**

Photos from Battleground Brewers, Red Hill Brewery, and S. King and R. Austin program

## Short Trellis Construction

Can substitute treated lumber with cedar or locust poles for certified organic production

Apr 13<sup>th</sup>, 2010 in Raleigh

Photos from S. King and R. Austin program

## Short Trellis [Top Wire]

High tensile fence wire – a few rows replaced with 3/8" galvanized strand wire just to be safe!

Ground Anchor Screws

May 17<sup>th</sup>, 2010 in Raleigh

Photos from S. King and R. Austin program

## Short Trellis Design - Raleigh

12 ft tall static trellis – allows for ladder stringing and harvesting

Photos from S. King and R. Austin program

## Short Trellis Design - Raleigh

- Installed crank handles to two rows – not much benefit on this shorter design
- Added the 'lasso' line release system to two rows – much more difficult



Photos from S. King and R. Austin program



## Short Trellis [Drip Irrigation]



June 23<sup>rd</sup>, 2010 in Raleigh

Photos from S. King and R. Austin program

## Short Trellis [1<sup>st</sup> Year Growth]



July 27<sup>th</sup>, 2010 in Raleigh



Photos from S. King and R. Austin program

## Short Trellis [2<sup>nd</sup> Year Growth]



July 19<sup>th</sup>, 2011 in Raleigh



Photos from S. King and R. Austin program

## Short Trellis [3<sup>rd</sup> Year Growth]



July 2<sup>nd</sup>, 2012 in Raleigh

Photos from S. King and R. Austin program

## Raleigh Research Hop Yard (Design)

- 10 Varieties
  - 200 total plants
  - 1/4 acre
- Randomized Block
  - Minimize agronomic variability
- Spacing
  - 10 ft row width (10 rows)
  - 3.5 ft between plants
  - 5 ft between varieties
  - Poles spaced ~45ft apart
  - Airflow and equipment
- Selection Criteria
  - Vigor, Yield Potential
  - Pest and Disease Resistance
  - US Production
  - Popular with local craft brewers and home brewers



## Short Trellis Design - Raleigh

- For 1 replication, we double strung the hops to the line in a V arrangement.
- They didn't grow as tall – only half topped out fully, but produced double the average volume per plant!

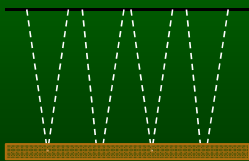


Photo from S. King and R. Austin program



## Another Short Trellis Design – U of MN



16' strings and  
10' netting



Photos by Dr. Charlie Rohwer, U of MN



### Mills River Research Hop Yard Modified traditional 20 foot trellis



Photo from J. Davis program

### Construction of the twenty foot trellis



Photos from J. Davis program

### Top wire can be raised and lowered



Photos from J. Davis program

No ladders, but started to move the anchors by end of season.

### Modifications made in 2012



### Drip-irrigation and weed control



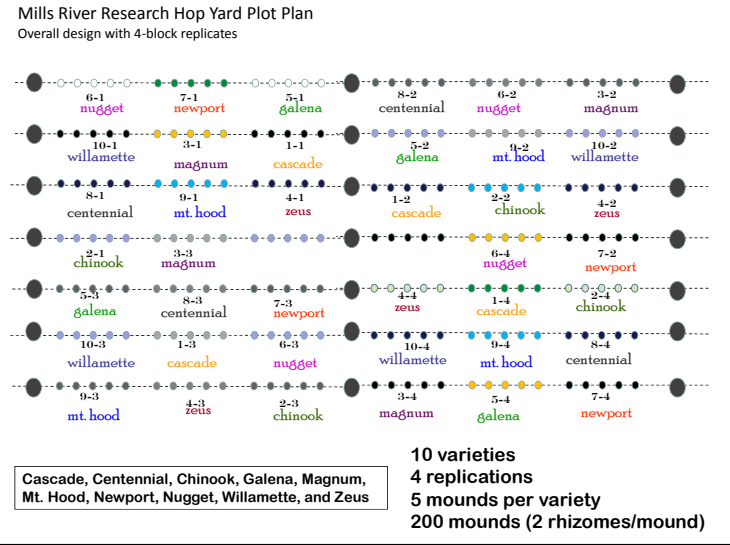
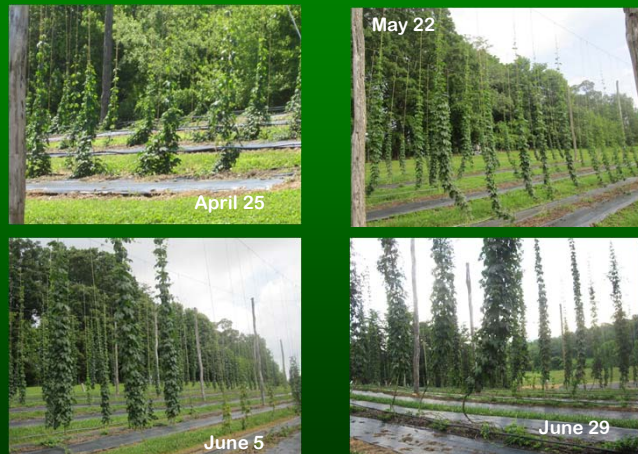
Photos from J. Davis program

### Mills River Tall Trellis 1st Year Growth



Photos from J. Davis program, and Rob Austin

### Mills River Tall Trellis 2nd Year Growth



## Planting hops in early spring



March and April

Photos from J. Davis, S. King, and R. Austin programs

## Putting up strings



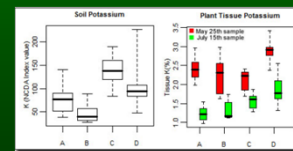
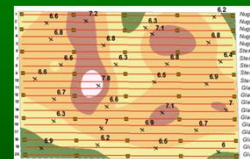
Coir versus sisal twine

Photos from J. Davis program

We can follow many of the recommendations from the Pacific Northwest, but not for soil fertility!



Rob, Scott, and Bill Yarborough, our NCDA agronomist took hundreds of soil tests and plant tissue tests to develop recommendations specifically for our soils.

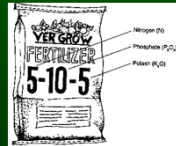


Photos from Scott King and Jeanine Davis

# Nutrient Management for Hops in North Carolina

- Hops are big feeders – require fairly large amounts of N/P/K
- Early spring and early summer – split applications of your N/P/K applications seems appropriate for now.

Nitrogen: 125 lbs/acre (crop specific value)  
 Phosphorus: if soil index is 0: 150 lbs/acre  
 Potassium: if soil index is 0: 150 lbs/acre  
 Sulfur: if soil index is 0: ~ 20 lbs/acre  
 Boron recommend 1 lb/acre  
 Soil pH between 6.0 and 6.5.



Graphic from ces.ncsu.edu

# Soil Test Recommendations

**Timing of Soil Sampling**  
 Analyze soil samples for nutrients in the spring before planting and in the fall after harvest.

**Timing and the Sample Information Form**

Sample No.	Area	Depth	Soil Index	Sample Date	Sample Time	Sample Location	Sample Method
1	1	0-2	0	5/20/12	10:00	1000	Hand
2	1	2-4	0	5/20/12	10:00	1000	Hand
3	1	4-8	0	5/20/12	10:00	1000	Hand

**119 Hops**

**CROP CODES**

Crop Code	Crop Name	Sample No.	Area	Depth	Soil Index	Sample Date	Sample Time	Sample Location	Sample Method
119	Hops	1	1	0-2	0	5/20/12	10:00	1000	Hand

# Soil Test Recommendations

**Soil Test Report**

Recommendations

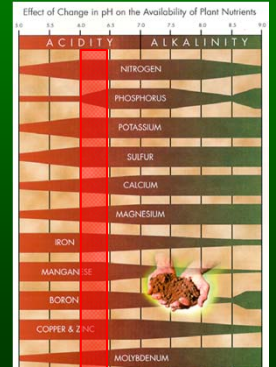
Crop or Year	Lime	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Mg	S	Cu	Zn	B
1st Crop: Hops	0	100-150	50-70	0-20	0	0	0	0	1.0
2nd Crop:									0

Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-Al(1)	Mn-Al(2)	Zn-I	Zn-Al	Cu-I	S-I
0.9	6.6	31	78	59.0	28.0	99	67		130	130	36	26

Field Information: Applied Lime, Recommendations, Test Results

# Nutrient Management - pH

- Soil acidity (pH) very important too!
- Lime recommendations given in soil test results
- pH affects nutrient availability
- pH ideally between 6.0 and 6.5 for hops



## Spring root pruning

- Rhizomes will spread out and take over the yard.
- Mechanically or by hand till around the crowns in very early spring to remove the earliest growth.
- This removes early shoots that may be infected with overwintering powdery and downy mildew spores.
- It also gets rid of the irregular early growth, allowing you to choose from stronger, more vigorous shoots to train up the strings.



Photo from Hop'n Blueberry Farm blog.

## Training and stripping plants



Photos from J. Davis program

## Weed control:

- We know it is important.
- We know it is costly.
- We don't know the economic thresholds.



Photos on left of some NC yards by J. Davis; photo on right from a commercial yard in Yakima Valley from 69.93.14.225/wscprLibraryDocs/Hops.pdf

## These are effective methods



But how much is necessary?

## Diseases that impact us in NC

- Powdery Mildew
- Downy Mildew
- These two fungi caused the collapse of the eastern hops industry in the early 1900s.
- They are still major diseases throughout the industry.
- Our moist climate puts us at a disadvantage.



Photos of local downy mildew from Sue Colucci (bottom) and Jerry Moody (top)

## Powdery Mildew (*Podosphaera macularis*)

- Fungus-race that infects hops is specific to hops.
- Spreads primarily by air-borne spores called conidia.
- High humidity and temperatures between 55° and 90° F favor disease development.
- Once a yard is infected, the disease will usually reoccur.
- Can overwinter on infected rhizomes and then move around on tools and soil.
- Symptoms: in spring new growth will appear white. Later on older leaves, whitish, powdery spots appear on upper or lower leaf surfaces. Sometimes a small blister appears first. Flowers and cones can also be affected.

Information adapted from Oregon State University Extension Disease Online Guide

## Powdery mildew



Photos from Oregon State University Extension Online Disease Guide

## Possible control measures

- Early in the season, remove any infected material and maintain adequate nitrogen.
- Spring prune
- Remove lower growth in mid-season to prevent spread up the bines.
- Serenade and Sonata may give some control (biological controls).
- Many chemical fungicides.
- Consider removing infected plants during winter.



Adapted from Oregon State University Extension Online Disease Guide



## Downy Mildew (*Pseudoperonospora humuli*)

- A fungus-like microorganism specific to hops.
- Develops in wet or foggy weather.
- Overwinters in rhizomes and plant debris in soil.
- Symptoms: In spring, spike-like infected bines arise among normal shoots. The undersides of leaves may be covered by dark purple to black spores. Leaves of all ages are attacked, with brown angular spots. Flower clusters become infected, shrivel, turn brown, dry up, and may fall. Cones also are affected, becoming brown.

Photo and text adapted from Oregon State University Extension Online Disease Guide



Downy  
Mildew

Sporangia on bottom of leaf



Photos from Sue Colucci's Hop Page at WNCVeggies.blogspot.com

## Possible Control Measures

- Remove diseased hills.
- Spring prune.
- Train bines early to prevent them from coming in contact with soil.
- Begin suckering as soon as vines are strung.
- Strip leaves from bines at a height of 4' soon after training to reduce the spread of downy mildew up the canopy.
- Avoid overhead irrigation.
- Sonata may work as biological control.
- There are many chemical fungicides, but there may be resistance.

Adapted from Oregon State University Extension Online Disease Guide

## There are also viruses, wilts, cone blight, and crown rot



Photos from Oregon State University Extension Online Disease Guide

## Products used in Mills River

ACTIVITY DATE	DESCRIPTION	TYPE	RATE PER ACRE
2011.06.10	Dipel 2X - EPA #275-37	I	1 lb.
2011.06.22	Kocide 3000 - EPA #352-862	F	1 lb.
2011.06.22	Tanos - EPA #352-804	F	8 oz.
2011.07.01	Alette WDG - EPA #264-516	F	2.5 lb.
2011.07.01	Malathion 25% WVP - EPA #829-75	I	6 lb.
2011.07.08	Kocide 3000 - EPA #352-862	F	1 lb.
2011.07.08	Malathion 25% WVP - EPA #829-75	I	6 lb.
2011.07.08	Tanos - EPA #352-804	F	8 oz.
2011.07.29	M-Pede - EPA #53219-6	I	175 oz.
2011.08.05	M-Pede - EPA #53219-6	I	175 oz.
2011.08.12	M-Pede - EPA #53219-6	I	175 oz.
2011.08.19	M-Pede - EPA #53219-6	I	175 oz.
2011.08.26	M-Pede - EPA #53219-6	I	175 oz.

Downy Mildew

Spider Mites

Raleigh sprayed an alternating rotation of Tanos and CuSO4 for disease

## Hop Harvesting



Photo from J. Davis program

## Timing of harvest is critical



These were harvested too late.

Photo from J. Davis program

## Timing of harvest is critical

- Most importantly, the lupulin should turn to a bright and bold 'school bus' yellow color
- Cones/lupulin should smell strongly of hops (a resinous, piney, citrusy, or earthy scent depending on variety)
- Cones should be drying and opening up
- When squeezed, the cone should spring back to its initial shape

**Remember: When in doubt, it's generally better to pick a little too early than a little too late!**



### How we harvested in Mills River



Photos from J. Davis program

### Harvesting off Short Trellis

- Only need a ladder to harvest and do not have to cut down the bine.



July 18<sup>th</sup> 2011

Photos from Rob Austin

### How others harvest



Top left: from Blue Mountain Brewery, top right: Willamette Valley Hops; lower left: MOFGA; lower right: Chillidamos Brewing

### Hops are usually dried



Photos from J. Davis program and Rob Austin

## Simple Oast for Drying Hops



Each tray holds about 2-3 lbs of wet hops

Total cost: \$125

Photos from Scott King

## Drying Hops



- Fresh hops are about 75-85% moisture
- Hops should be dried down to about 8-12% If you use heat, be gentle – you don't want to burn off the oils!
- Experience has shown this feels drier than most people would naturally estimate!
- Need to dry sub-sample of fresh-picked hops down to 0% moisture to determine what % moisture you have
- Then calculate what target weight your hop harvest should be at about 10% moisture – don't fear the math!

Source: <http://sroc.cfans.umn.edu/People/Faculty/VinceFritz/Hops/HopDrying/index.htm>

## Drying Hops - Calculations

- Don't like the math? Don't worry, go to this website from the University of MN and plug in your numbers...

<http://sroc.cfans.umn.edu/People/Faculty/VinceFritz/Hops/HopDrying/index.htm>

Special thanks to Dr. Charlie Rohwer of University of Minnesota

## Packaging

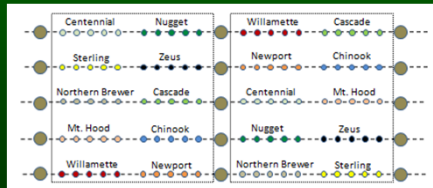


Note: Hop varieties have different storage stabilities, they don't all keep the same!

Photos from J. Davis program and FoodSaver.com

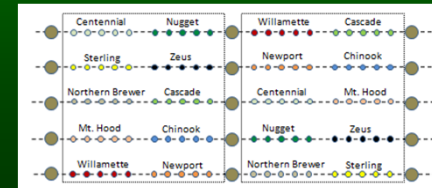
## Yield results - Raleigh Hop Yard

- 10 varieties: Cascade, Centennial, Chinook, Mt. Hood, Northern Brewer, Newport, Nugget, Sterling, Willamette, and Zeus.
- Only 3 varieties really productive in first two years: Zeus, Cascade, and Chinook.
- Five varieties produced nothing! Centennial, Sterling, Mt Hood, Willamette, and Northern Brewer (total ½ lb)



## Variety Results – Mills River Yard

- 10 varieties: Cascade, Centennial, Chinook, Galena, Mt. Hood, Northern Brewer, Magnum, Newport, Nugget, Willamette, and Zeus.
- Only 5 varieties productive in first year: Cascade, Zeus, Galena, Nugget, and Chinook.
- Four varieties produced very little: Centennial, Magnum, Mt Hood, and Willamette (< 3 oz/plant).



## Variety Recommendations

- Variety selection appears to be the single most important factor in hop yard success or failure!
- Some varieties just don't grow well in NC.
- There are over 100 varieties out there and we've only looked at about 15 of them closely.
- All things being equal, we generally recommend you stick with US varieties, newer varieties, and higher alpha-acid varieties.
- There are always exceptions but these seem like the best guidelines we have so far.



## Variety Recommendations

- Thus far, Cascade and Zeus (Columbus) are clearly top performers with Galena, Chinook, and Nugget also acceptable. Subject to change as bines age!
- Zeus gave 1.1 wet lbs/plant in Mills River (year 1), and .9 in one block in Raleigh (year 2).
- If your goal is to sell wet hops to a brewery, it might be best to have one variety with a single harvest date. If your goal is to sell hops to homebrewers, you might want to have several varieties with varying harvest dates.



### Results/Conclusions so far...

- Raising and lowering the top wire works well.
- Hops are labor-intensive!
- Consider your business model before planting (homebrew stores, wet hops to breweries, selling rhizomes, etc. will influence variety selection).
- Need to improve harvest methods.



### Results/Conclusions so far...

- Cone quality appears fine – alpha acids haven't quite reached their potential yet, but bines are young.

NC State University- Soil Science Dept CB #7619- Williams Hall Raleigh, NC 27695-7619		Sample Id: Product Id: Galena Sample Description: Hops	Date Received: Date Collected: 10/24/2011
<b>TEST/METHOD</b>	<b>RESULT</b>	<b>UNITS</b>	
Alpha Acids: 9.6%			
Beta Acids: 5.3%			
H.S.I: 0.216			
NC State University- Soil Science Dept CB #7619- Williams Hall Raleigh, NC 27695-7619		Sample Id: Product Id: Chinook 001 Sample Description: Hops	Date Received: Date Collected: 10/24/2011
<b>TEST/METHOD</b>	<b>RESULT</b>	<b>UNITS</b>	
Alpha Acids: 10.5%			
Beta Acids: 2.8%			
H.S.I: 0.237			
NC State University- Soil Science Dept CB #7619- Williams Hall Raleigh, NC 27695-7619		Sample Id: Product Id: Chinook 002 Sample Description: Hops	Date Received: Date Collected: 10/24/2011
<b>TEST/METHOD</b>	<b>RESULT</b>	<b>UNITS</b>	
Alpha Acids: 11.3%			
Beta Acids: 2.9%			
H.S.I: 0.245			

### Mills River compared to Raleigh

Yields from Raleigh much less than Mills River yard (short vs. tall trellis? soil/climate issues?), need to compare the bottom line.

In 2011 growing season, Raleigh certainly had greater heat and drought pressure compared to Mills River!

	Rain (in)	>90°	>100°
Raleigh	14.7	44	4
Mills River	23.3	8	0

Mills River got almost 9 more inches of rain!

### Who can help you?

- The NC Hops Research group
- Your extension agent
- Current local growers
- The Southern Appalachian Hops Guild
- NCDA lab
- Lots more, but check credentials



Photos from J. Davis program and R. Austin

## Local web resources

**ncherb.org**  
Dr. Jeanine Davis

**Welcome**

My name is Jeanine Davis and I am an associate professor in the Department of Horticultural Science at North Carolina State University. My research and extension programs are dedicated to the development of organic production systems for berries, vegetables, and a wide variety of specialty crops. The purpose of this website is to provide access to up-to-date, practical information on the production of these crops and to keep you informed about the current projects in my program. With the other web links I provide that are listed below, please visit **NC Hops** and visit **NC Mountain Hops** and visit the University of NC CropWatch.

Some of the current projects my staff and I are involved in include working on a regional Ohio production study in which we are evaluating the use of root zone, one of those that will be in the Mountain Horticultural Crops Research Station in Mills River. We are establishing a new crop-based program for the University of Vermont, to help extension agents and other agricultural professionals to begin, and to help them to work. For that project, we are reviewing inventories of forest products buyers and sellers in western NC, providing technical information, and existing non-forest forest products. We are conducting an in-field, multi-stage project to meet berry industry. And we continue to grow a large number of woodland botanicals and ramps under artificial shade and in the field.

**Links to Our Projects and Other Web Sites**

- Early Projects Project** - helpful decision making tools, production information, surveys, and presentations pertaining to early projects.
- NC Mountain Hops** - provides relevant resources for North Carolina farmers.
- NC Mountain Hops** - a support for farmers, entrepreneurs and consumers within the specialty crops market.

<http://nchops.soil.ncsu.edu/>

## Other Resources

**The University of Vermont**  
NW CROPS & SOILS PROGRAM

**Southern Research & Outreach Center**  
Hops

**University of Minnesota**  
Hops

<http://www.uvm.edu/extension/cropsoil/hops>

<http://sroc.cfans.umn.edu/People/Faculty/VinceFritz/Hops/index.htm>

<http://www.gorstvalleyhops.com/>

## A few examples from our young hop industry in NC



Photo from J. Davis program

## Van Burnette Hop n' Blueberry Farm Black Mountain



Photos from J. Davis program

**Stephanie Willis  
Winding River Hops, Canton**



Photos from J. Davis program

**Rita Pelczar and John Wright  
Blue Ridge Hops, Marshall  
certified organic hops**



Photos from J. Davis program

**Julie Jensen  
Echoview Farm, Weaverville**



Photos from J. Davis program

**Howard Covington  
New River Hop Yard – Ashe County**



Photos provided by Howard Covington

**Ben Sunderman  
Cedar Ridge Hops**



Photo from JournalNow.com

**Terry Suitt  
Granville County Hop Yard**



Photos provided by Scott King

**Rick Cockcroft  
Battleground Brew Guild – Guilford County**



Photos provided by Scott King

**Tom and Lauren Holahan  
Holahan Hops – Durham County**



Photos provided by Scott King

## Special Thanks!

- The Golden LEAF Foundation
- North Carolina Department of Agriculture & Consumer Services (NCDA&CS) - Agronomic Services
- USDA



## Let's talk!

