Bacterial Ice Nucleation And Frost Protection

Glenn McGourty,
Winegrowing and Plant Science Advisor
UCCE Mendocino and Lake Counties
Dr. Steve Lindow,
Professor, Plant and Microbial Biology
UC Berkeley

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Why Frost Protect?

- All green parts of the vine are susceptible to frost, all during the growing season

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Frost Events

- Temperature drops below 32 degrees F
- Amount of damage is dependent on how long temperatures are below that point—damage starts when temperatures are at 31 degrees for more than half an hour.

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

What happens?

- Ice crystals form between cells and disrupt the cell membranes
- With cell membrane integrity gone, the cell's contents dessicate, cell fails
- Foliage turns color; black in spring, brown in fall

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

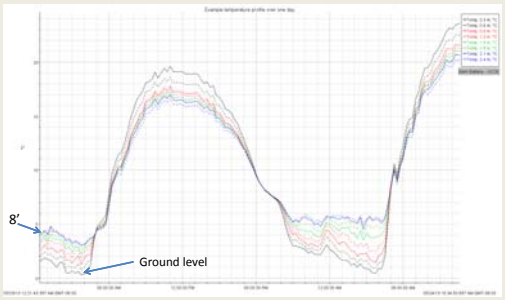
UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Outcome

- Spring frost: loss of fruit, crop—some varieties may bloom from secondary buds, such as Zinfandel, Pinot noir
- Fall frosts: leaves fall off of the vine, sugar accumulation stops. Fruit may also be damaged if temperatures are low enough.

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Temperature at Different Vineyard Elevations During The Day



* Source: Mark Battany, UCCE

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Illustration of Layered Cold Air

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

How elevation affects frost damage

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Soil Water Management

*source: Rhonda Smith

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Frost and Vineyard Floor Management

Vineyard Floor Management	Temperature Change
Bare, Firm, Moist Ground	Warmest
Shredded Cover, Moist	0.5 ºF cooler
Low Cover, Moist Ground	1 to 3 ºF cooler
Dry, Firm Ground	2 ºF cooler
Freshly disked, fluffy	2 to 3 ºF cooler
High cover crop	2 to 4 ºF cooler
High cover crop, restricted air drainage	6 to 8 ºF cooler

Source: Wilbur Reil, Yolo & Solano Tree Crops UC Farm Advisor, retired

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Cover Crops

- Reflect Sunlight
- Evaporate Water
- Reduce Stored Soil Heat
- Colder Minimum
- Ice Nucleating Frost

*Source: Rhonda Smith

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Compromise with cover crops

- Plant in every other row with a cover crop
- Avoid species like bell beans and peas that cannot be mowed closely during frost period - or else disk in, mow short
- Mow everything early, before bud emergence
- If over head sprinklers used as frost protection, then growing cover crops in a frost prone regions becomes much safer

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Why Do Some Shoots Freeze But Not Others?

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Ice Nucleating Bacteria

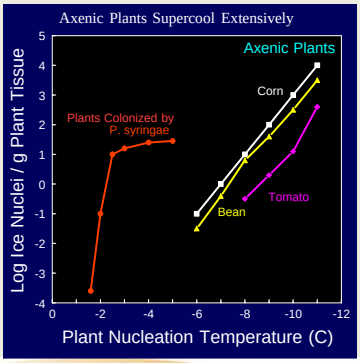


UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Ice Nucleating Bacteria Species

- Pseudomonas syringae
- Erwinia herbicola
- Pseudomonas flourescens
- Pseudomonas viridiflava
- Xanthomonas campestris var. vesicatoria

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension



UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Ice Nucleating Bacteria

\+ -

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Ice Nucleating Bacteria

\+ -

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

The Secret To Snowmaking: Freeze Dried *Pseudomonas syringae*

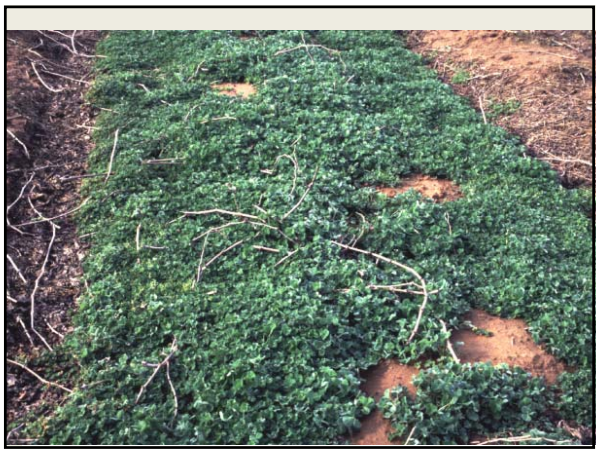
Snow at 27° F vs. 15° F from sprayed water

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Total bacterial populations on various cover crop species

Treatment	Bacteria recovered Log (cells/g)
Fine Fescue	8.26 a
Crimson Clover	8.02 a
Vetch	7.76 ab
Burr Clover	7.12 bc
Subclover	6.86 cd
Pea	5.84 ef
Grape	About 4.0

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension



USE OF COPPER AND STYLET OIL TO CONTROL ICE NUCLEATING BACTERIA AS A FROST PROTECTION STRATEGY IN A NORTHERN CALIFORNIA VINEYARD

UTILISATION DU CUIVRE ET DE L'HUILE DE PARAFFINE POUR DIMINUER LA NUCLEATION DE LA GLACE ET PROTEGER DU GEL UN VIGNOBLE EN CALIFORNIE DU NORD

Glenn McGourty, Winegrowing and Plant Science Advisor
UCCE
Mendocino and Lake Counties

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Experimental Design

- 3 chemical treatments: copper, copper + Stylet (paraffinic oil); control
- 2 vineyard floor treatments: cover crop; clean tillage
- 3 replications
- 18 plots total, 1.5 ha area for the trial, each subplot = 85 m²

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Treatments and Samples

- Cupric hydroxide: 2.1 kg/ha
- Stylet (paraffinic) oil: 6.0 l/ ha
- Spray volume: 300 l/ ha
- Applications on 4/11, 4/19, 4/26
- 20 shoots or leaves sampled per plot
- Plot sampled 4/14, 4/22, 4/30

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Lab Procedure

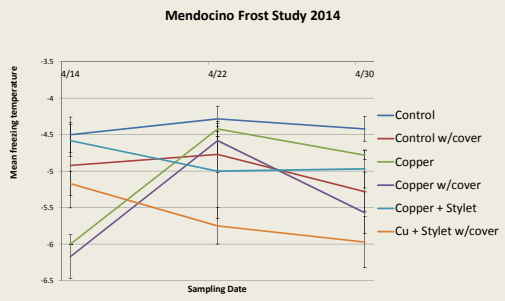
- Detached leaves placed in test tubes, chilled in ethanol bath to determine the freezing point
- Leaves washed with phosphate buffering solution, then the liquid plated on TSA media in petri dishes

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

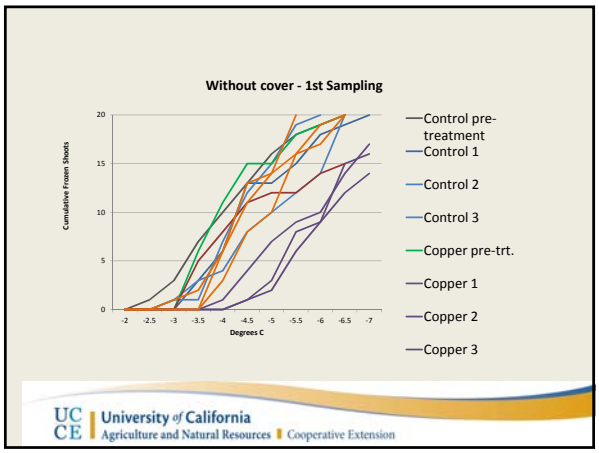
Results

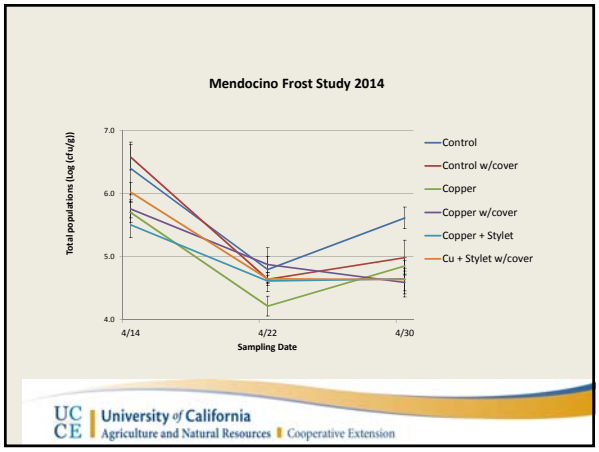
- It did not freeze in the vineyard
- In the laboratory, significant differences seen between treatments, with copper treated leaves and shoots having the lowest freezing points

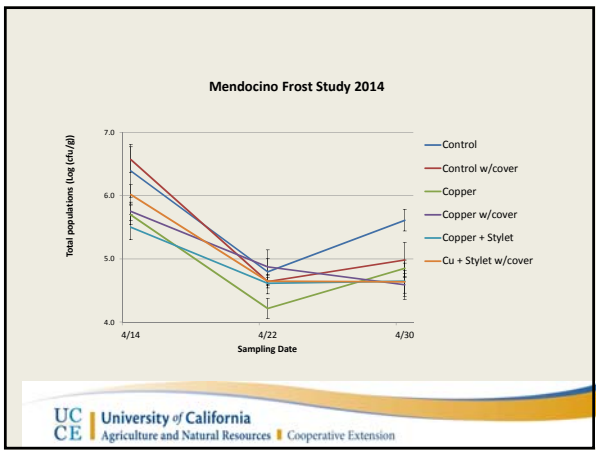
UC CE | University of California Agriculture and Natural Resources | Cooperative Extension



UC CE | University of California Agriculture and Natural Resources | Cooperative Extension


Without cover - 1st Sampling
Cumulative Frozen Shoots
20
15
10
5
0
-2
-2.5
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
-7
Degrees C
Control pre-treatment
Control 1
Control 2
Control 3
Copper pre-trt.
Copper 1
Copper 2
Copper 3
UC CE
University of California
Agriculture and Natural Resources
Cooperative Extension


Mendocino Frost Study 2014
Total populations (Log (cfu/g))
7.0
6.0
5.0
4.0
4/14
4/22
4/30
Sampling Date
Control
Control w/cover
Copper
Copper w/cover
Copper + Stylet
Cu + Stylet w/cover
UC CE
University of California
Agriculture and Natural Resources
Cooperative Extension


Mendocino Frost Study 2014
Total populations (Log (cfu/g))
7.0
6.0
5.0
4.0
4/14
4/22
4/30
Sampling Date
Control
Control w/cover
Copper
Copper w/cover
Copper + Stylet
Cu + Stylet w/cover
UC CE
University of California
Agriculture and Natural Resources
Cooperative Extension

Conclusions

- **Copper alone proved to be most effective at lowering freezing temperature**
- **Not much difference between vegetation/no vegetation**
- **It doesn't appear that grape leaves support the growth of ice nucleating bacteria**
- **Copper can protect vines from freezing**

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

What is Next?

- Larger field scale trials in vineyards with no frost protection
- More work on bacterial dispersion in the vineyard environment
- Evaluation of A506, a strain of Erwinia herbicola that can colonize cover crops and perhaps vines, but doesn't nucleate frost

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

Thanks for Your Attention!

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension