Hop Powdery Mildew: Biology and Management

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Acknowledgement of Collaborators

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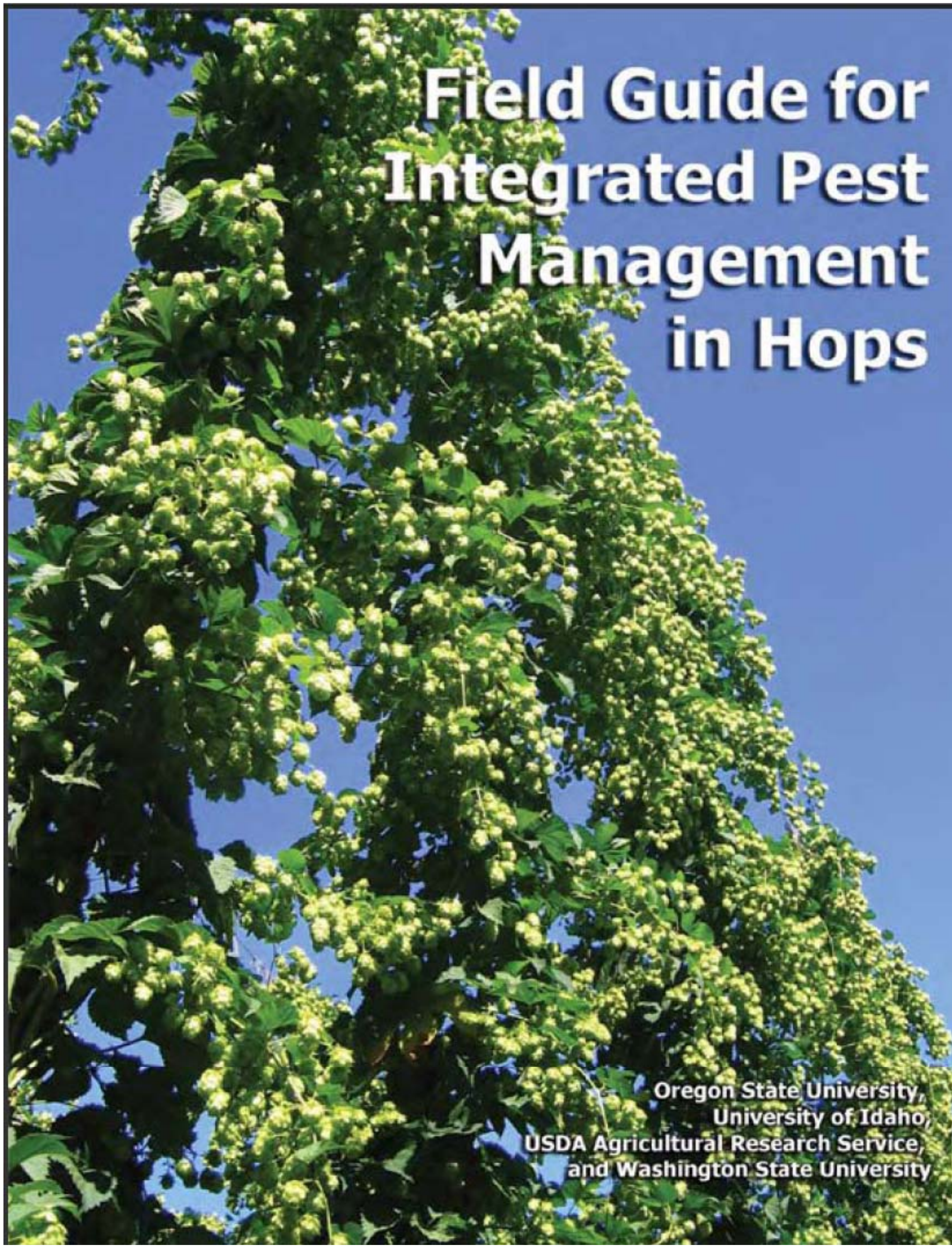
- **WSU:** Ken Eastwell, Gary Grove/Mark Nelson, David James, Steve Kenny, Doug Walsh, & Sally O'Neil
- **UI:** Jim Barbour
- **ARS:** John Henning



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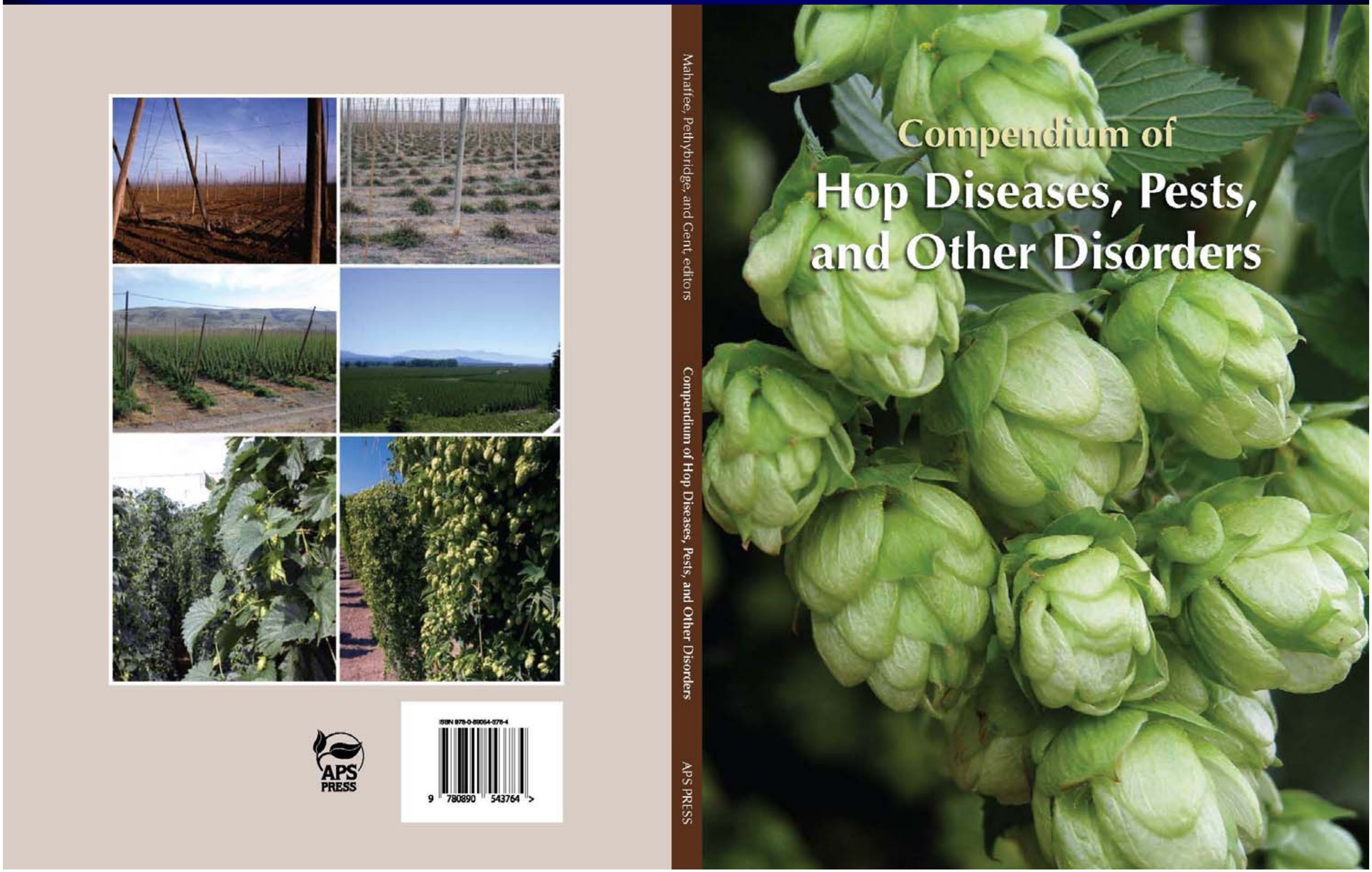
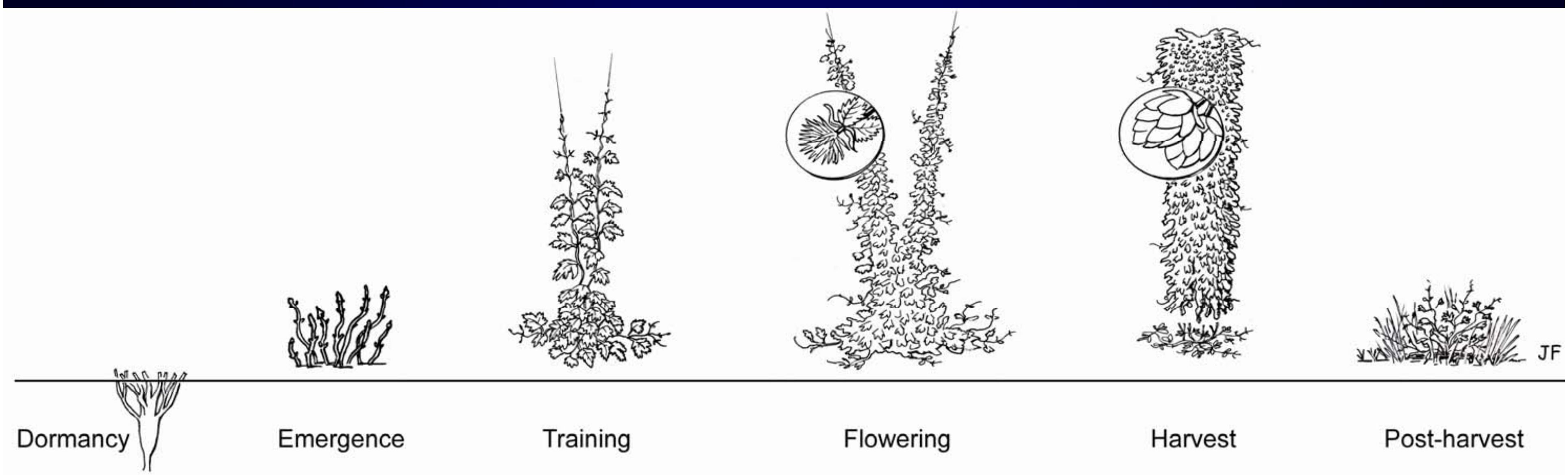


Cones Affected by Powdery Mildew


Courtesy WFM

Management Approaches

- **Delay Epidemic**
  - Eliminate overwintering inoculum (flag shoots)
  - Basal foliage removal
  - Delayed spring pruning
- **Reduce Rate of Epidemic**
  - Canopy/foliage management
  - Fertility, irrigation, row spacing/orientation
  - Fungicides
- **Escape Disease**
  - Harvest timing



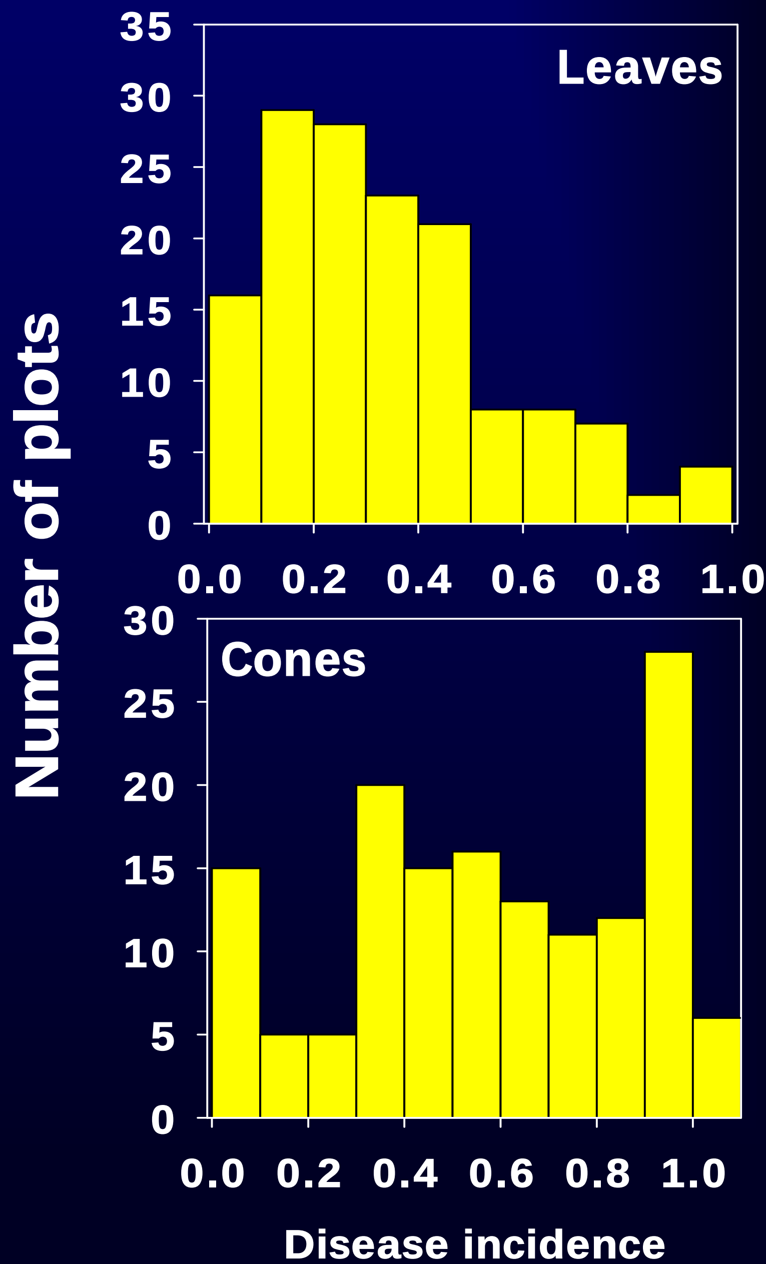
JF
Dormancy
Emergence
Training
Flowering
Harvest
Post-harvest

2009 Objectives

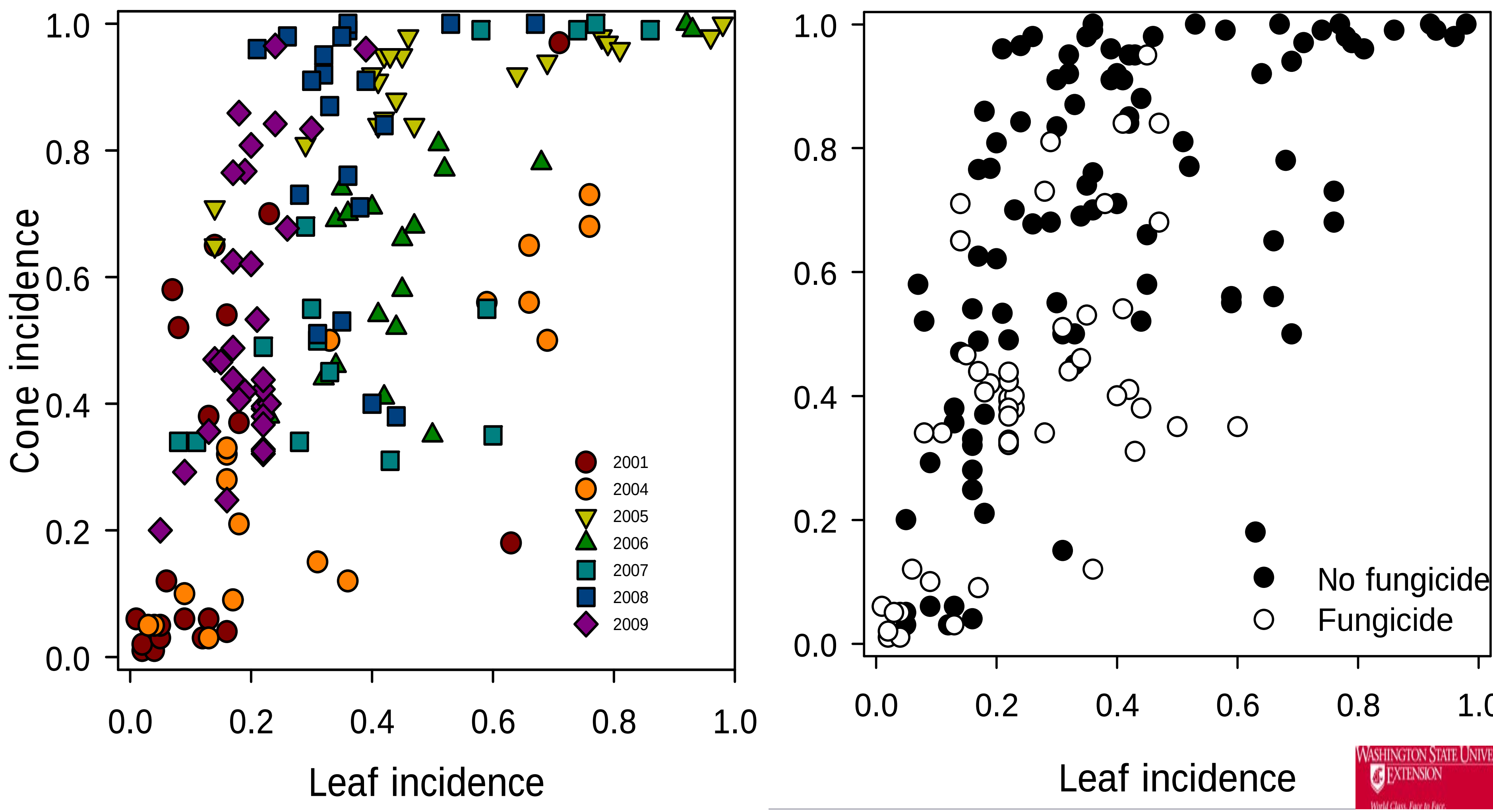
1. Further develop and evaluate preliminary infection model
2. Determine susceptibility of cones to infection at different development stages
3. Quantify crop losses due to powdery mildew when control measures are ceased at different developmental stages

Cone Infection Model

- Developed with data from 12 small plot trials conducted by Mark Nelson, WSU from 2000 to 2008
- 114 treatments evaluated; range of fungicide programs
  - 32 treatments in 2009
- Weather data from nearest AgWeatherNet station (< 1 km)
- Preliminary analysis by Spearman's correlation (*S*)
  - Disease incidence on leaves
  - HOPS risk index
  - Rain
  - Relative humidity
  - Temperature
  - Degree-days
  - Dew point



Association of Disease on Leaves and Cones



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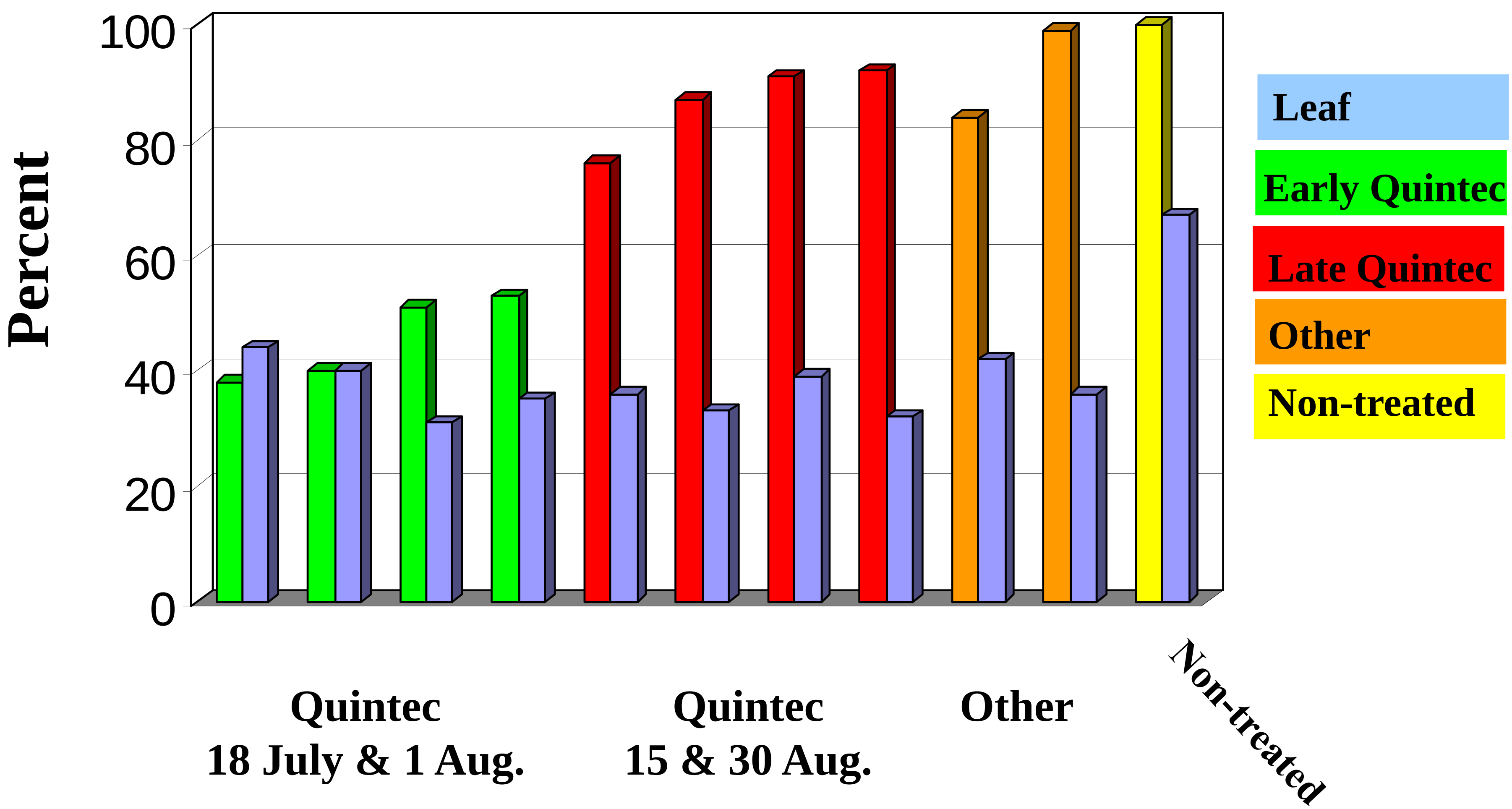
Effect of fungicide timing on hop powdery mildew cv. Zeus – 2008



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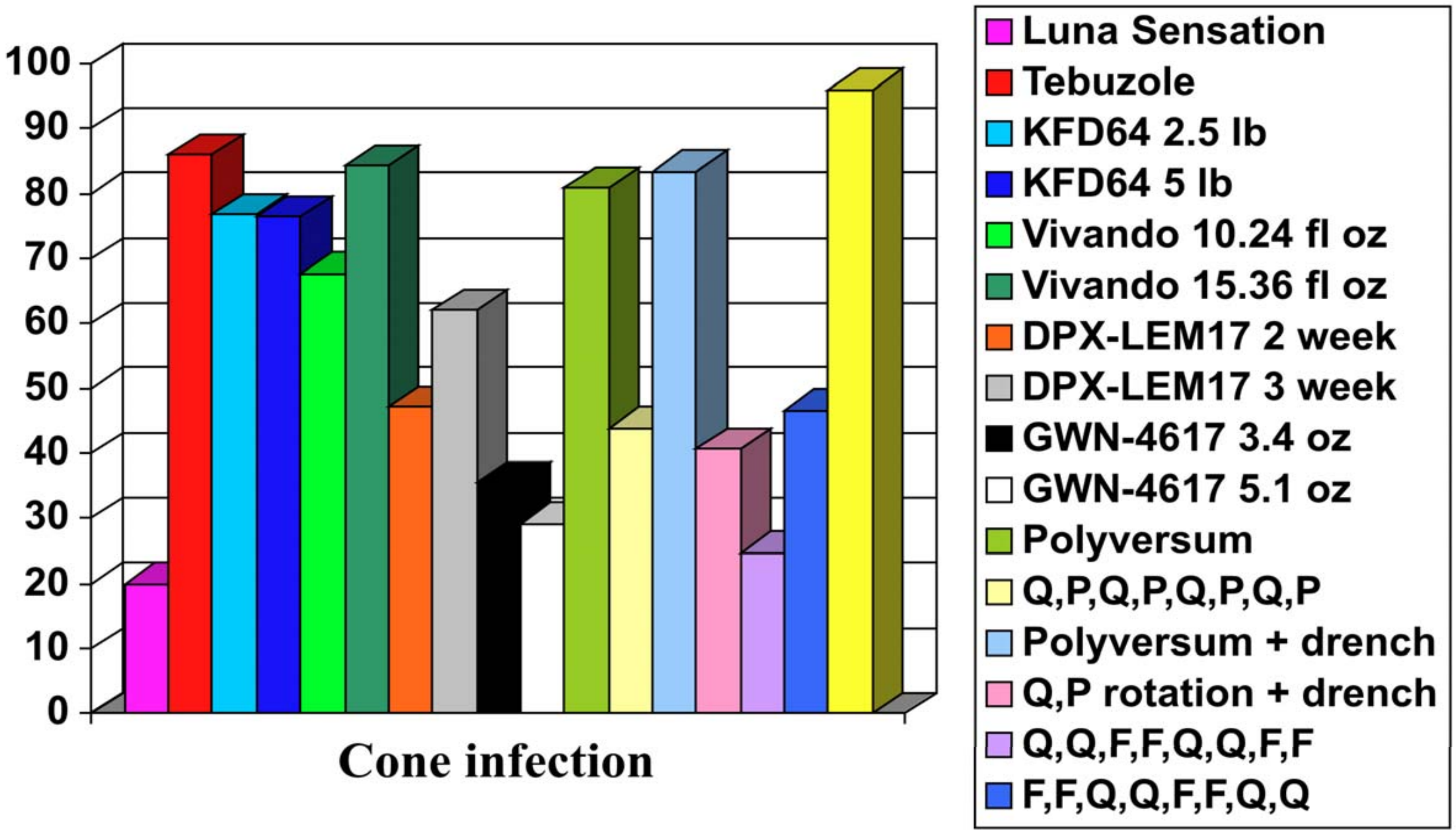
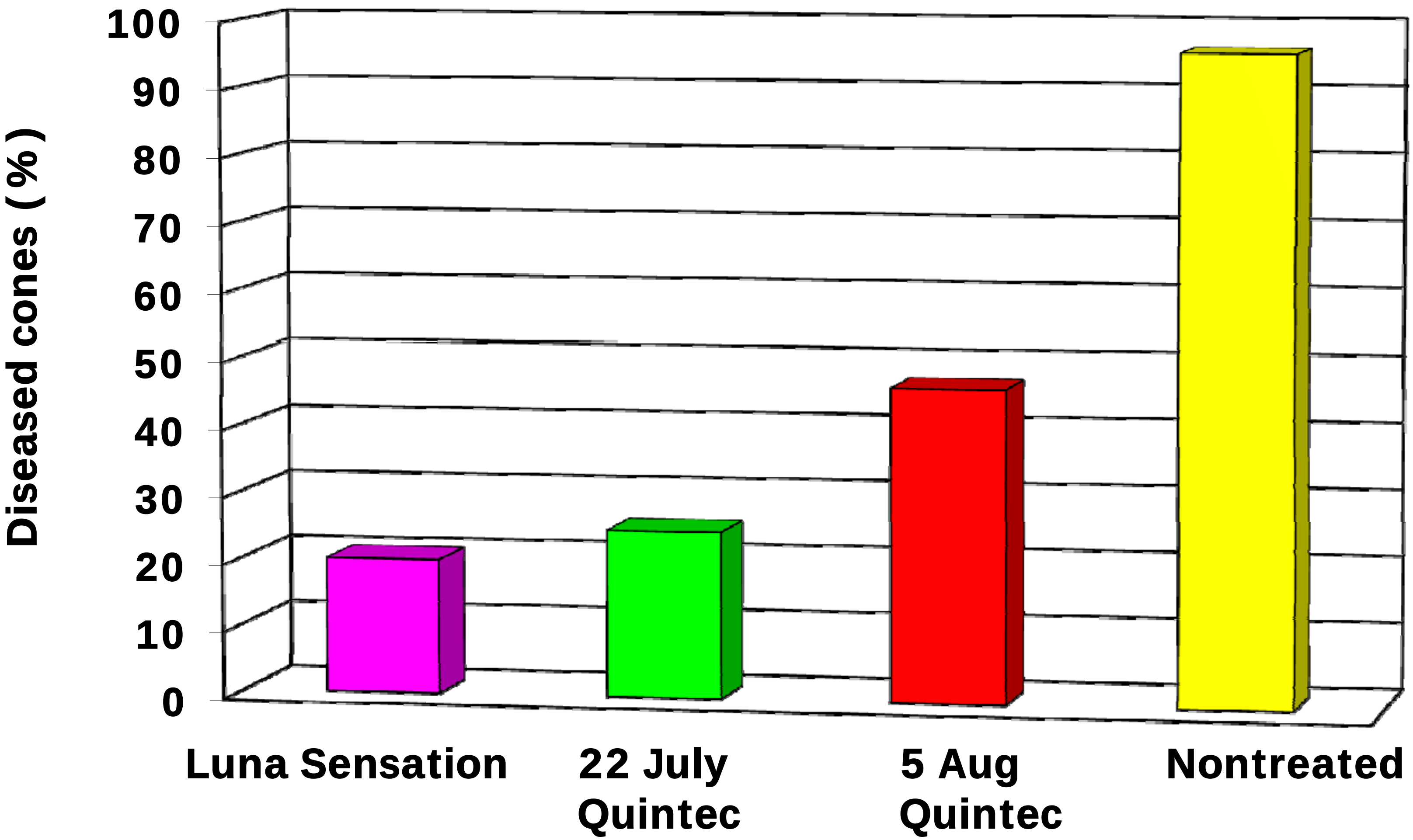
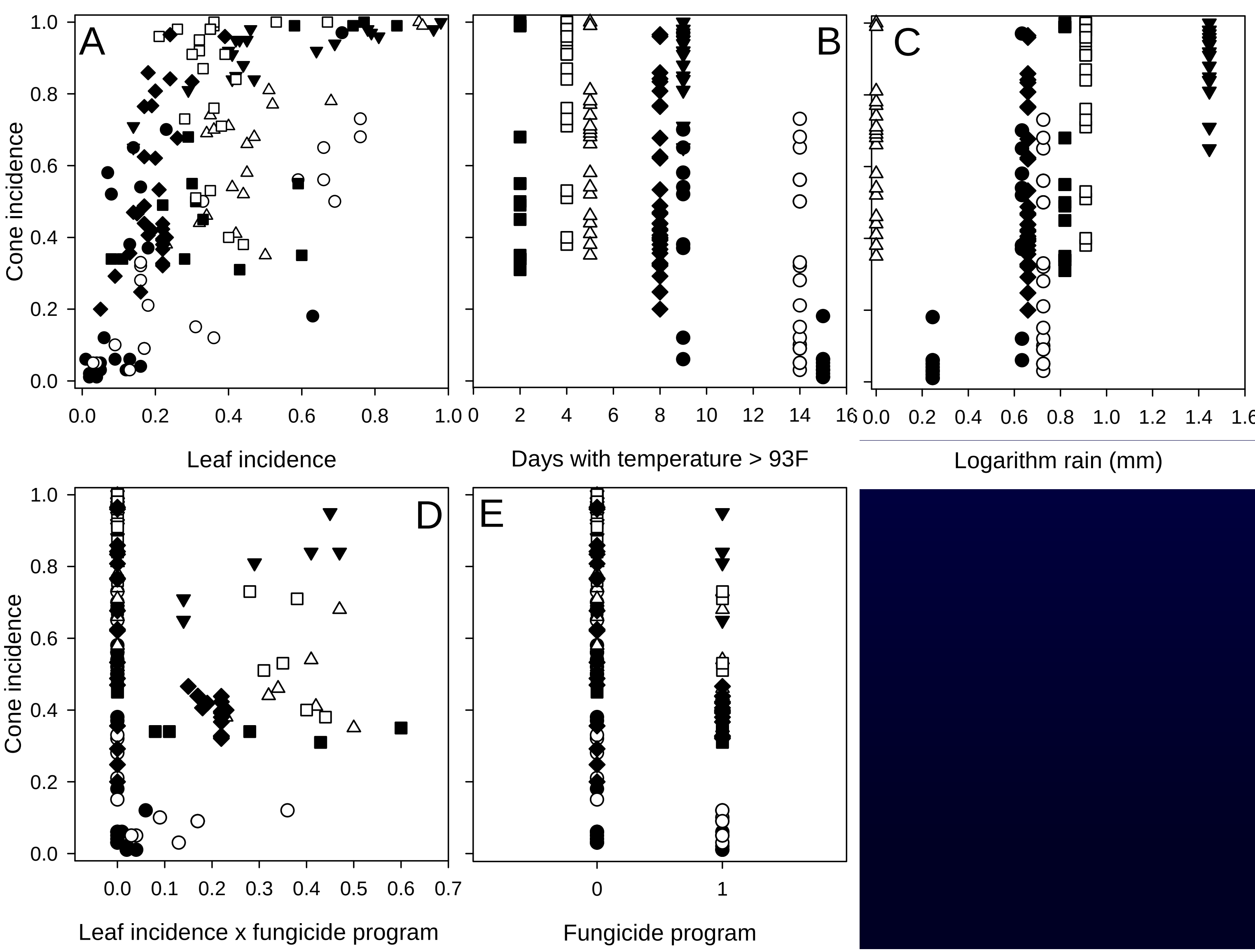
Effect of fungicide timing on hop powdery mildew cv. Galena2009



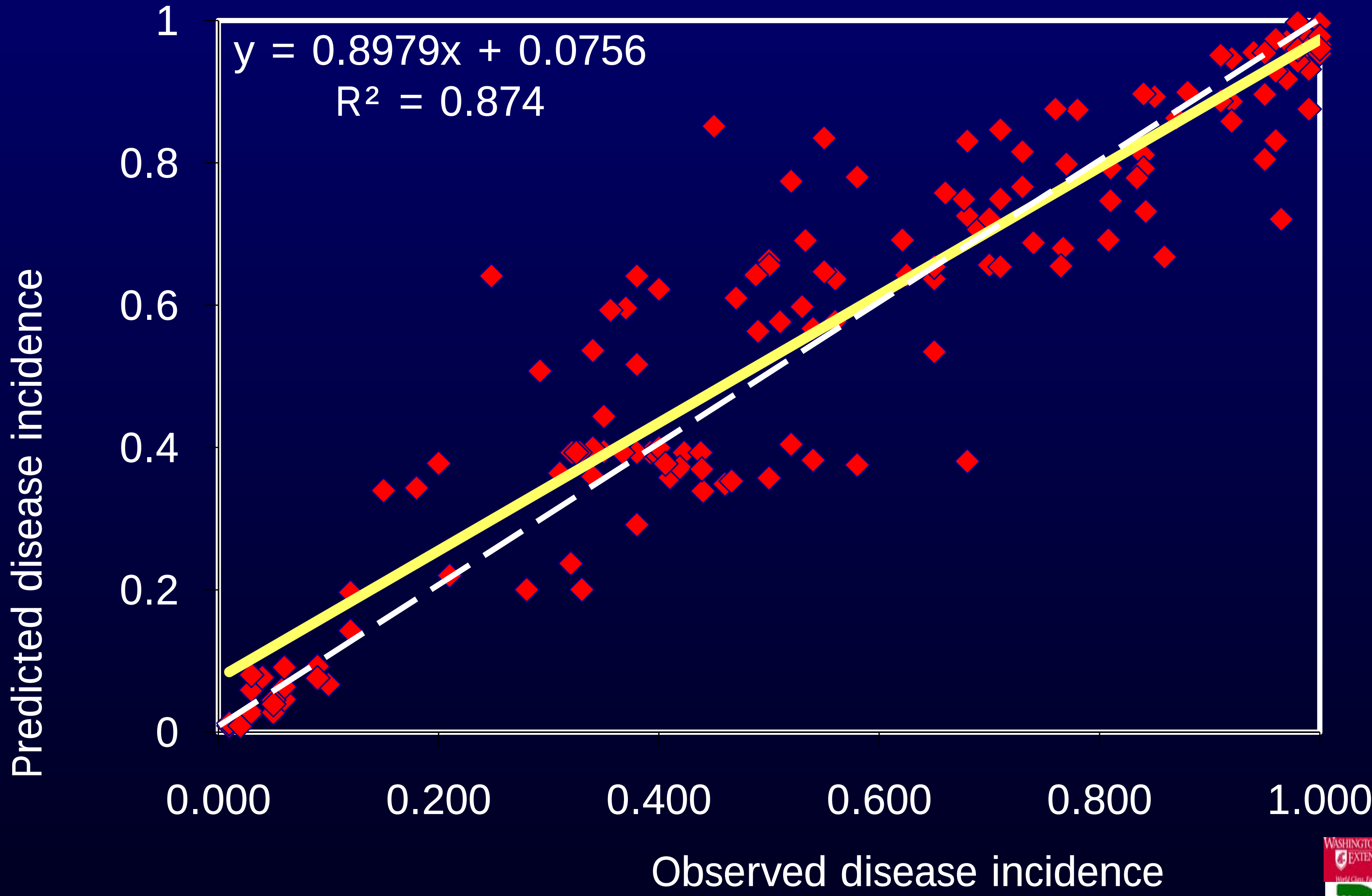
Effect of fungicide timing on hop powdery mildew cv. Galena2009



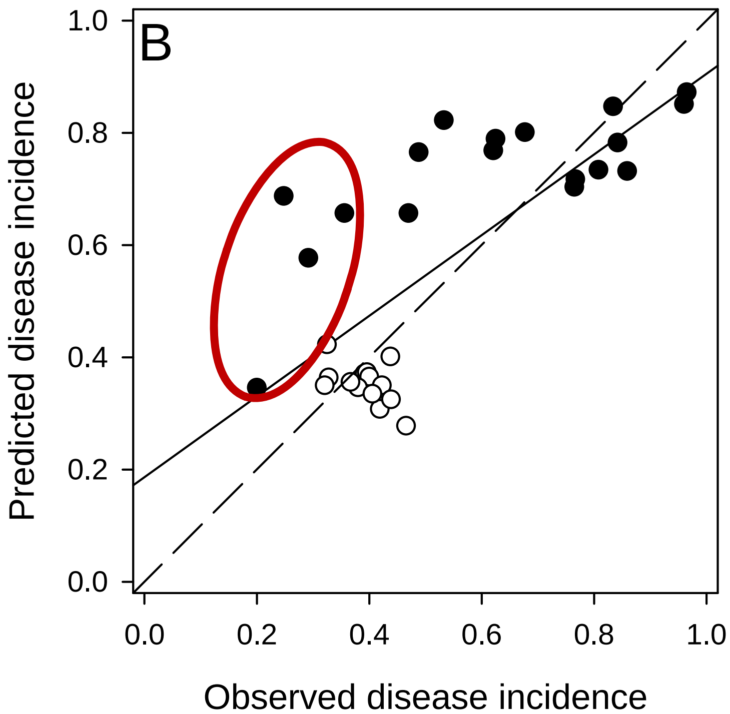
Association of Cone Infection with Weather and Disease Factors

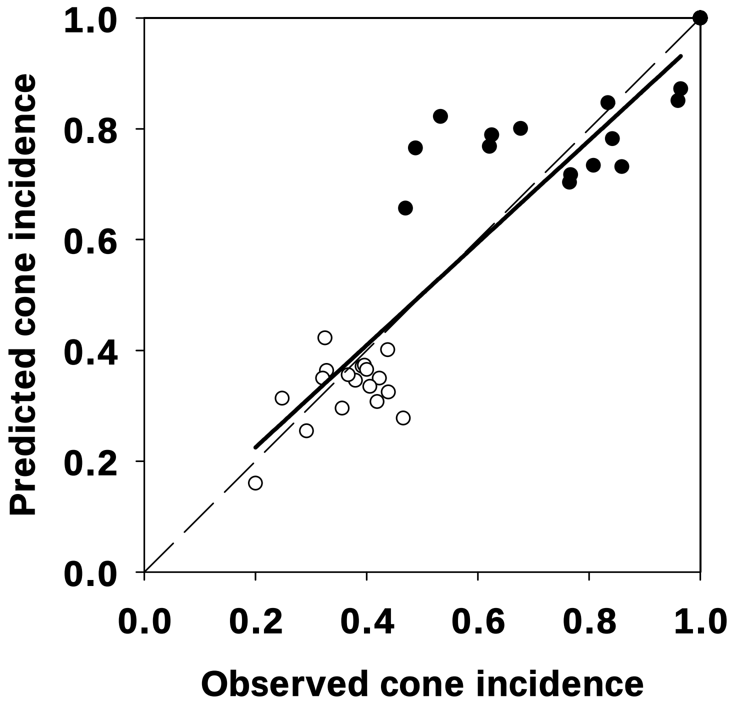


Model Evaluation—Small Plots



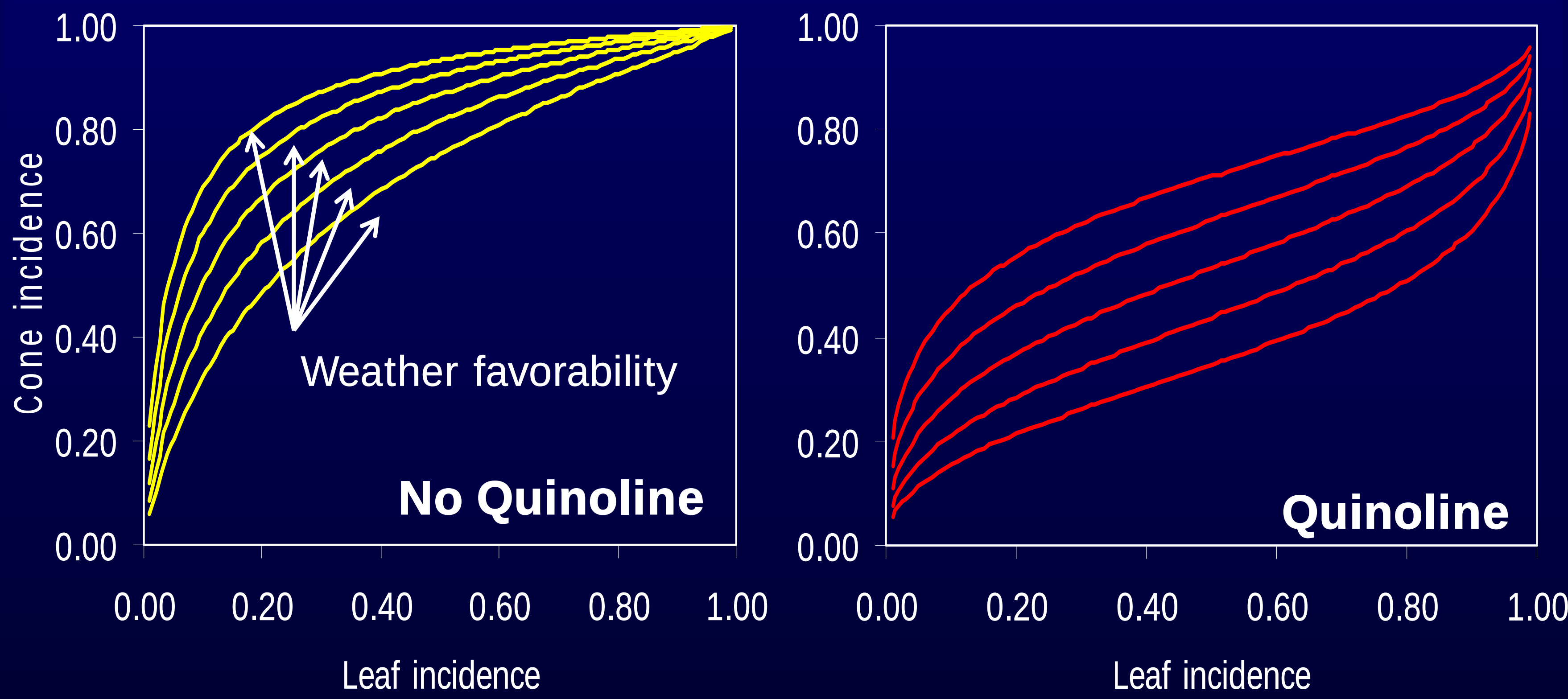
Cone Infection Model: Validation





- 2009 validation:
  - Model with 2001 to 2008 data: R^2=0.55
  - 22 July Quintec, Luna Sensation, QWN-4617
- Revised fungicide effect
  - R^2=0.76

Disease Model Predictions



- Model predicts significant disease reduction from highly effective fungicides during critical cone development stage

Model Risk Factors

Predictors/Risk Factors

1. Mid-July leaf incidence (+)
2. Rain from 30 July to harvest (+)
3. Days temp. at least 93F 30 July to harvest (-)
4. Quinoline or similarly efficacious fungicide during 22 July to 10 August (-)
5. Interaction of fungicide and disease incidence (-)
6. *In commercial yards, last fungicide application date correction factor*

Conclusions

- Critical cone susceptibility period not defined precisely, but very important for disease prediction and management
- Several factors can be managed to reduce disease risk:
  - Disease levels on leaves
  - Fungicide timing
  - Last spray date

2009 Objectives

1. Further develop and evaluate preliminary infection model
2. Determine susceptibility of cones to infection at different development stages
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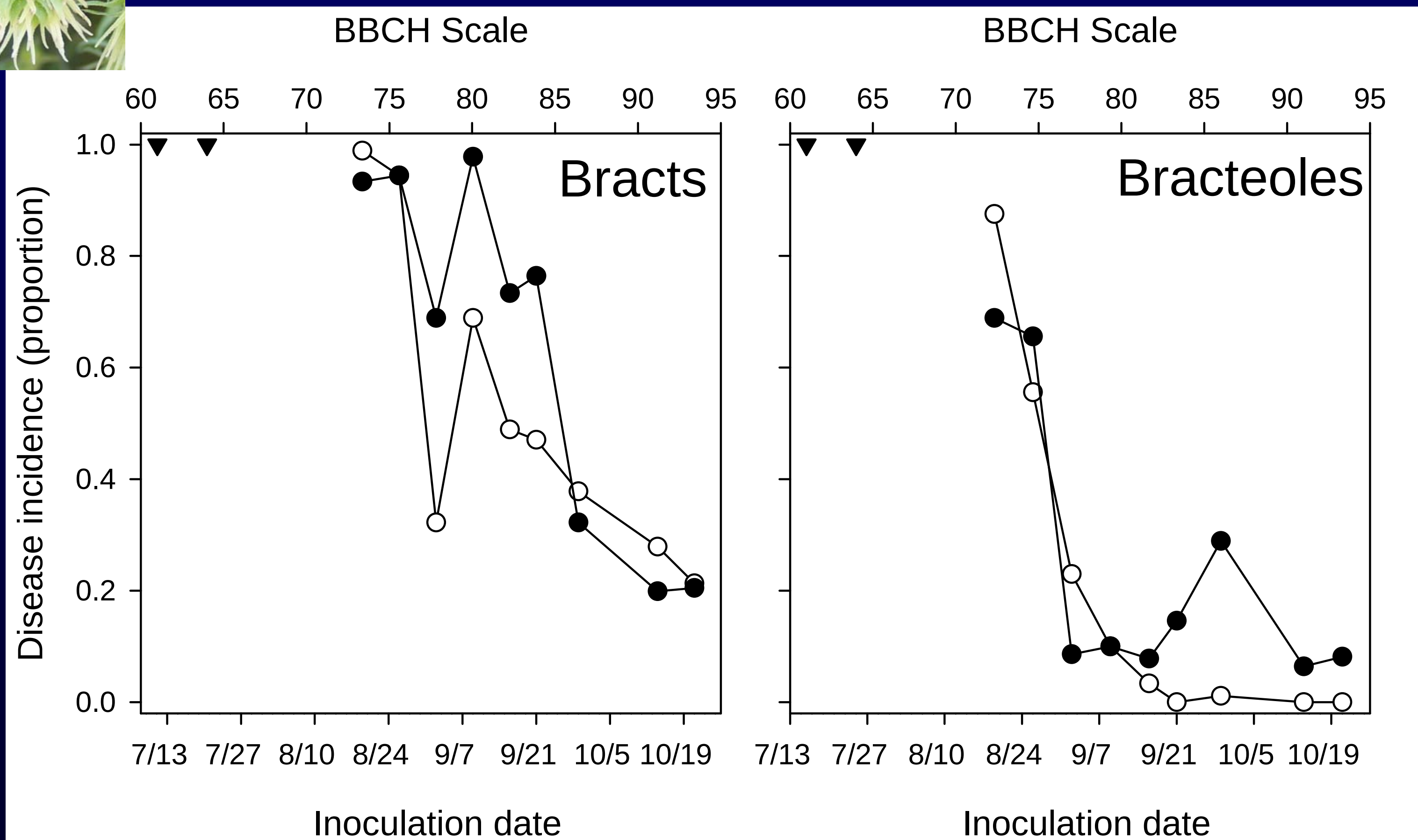
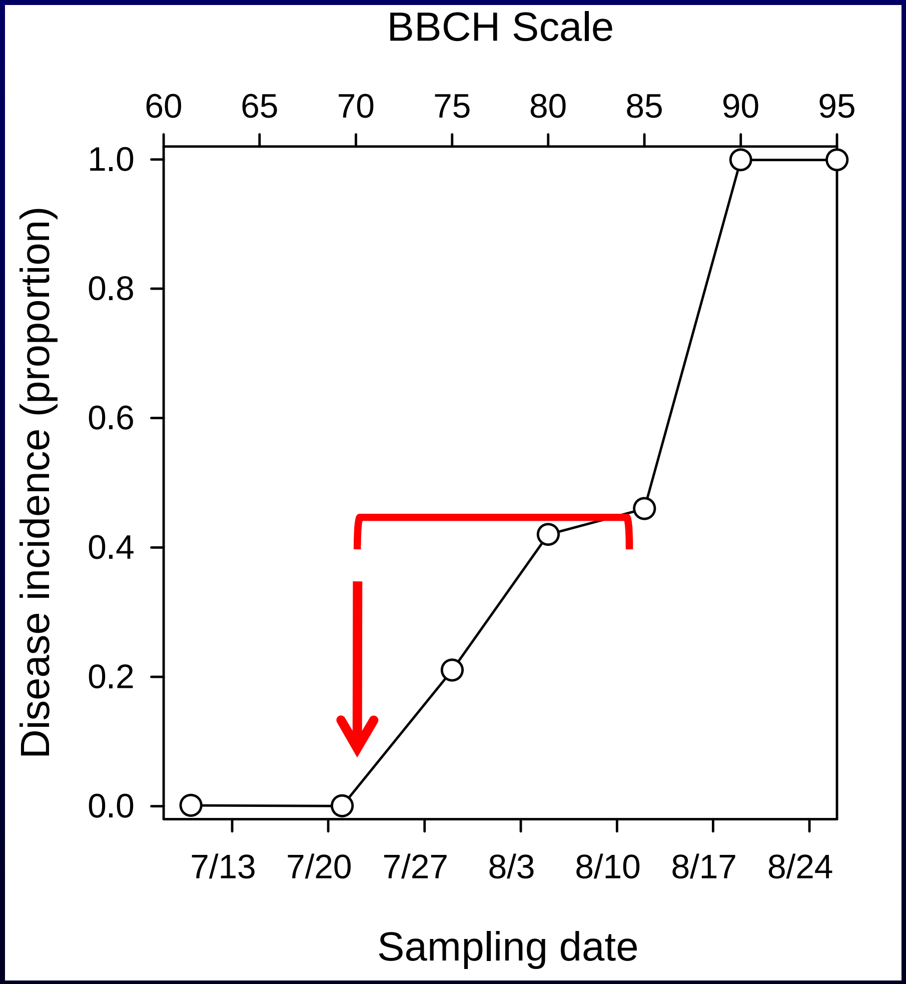
Cone Susceptibility

- **Field and greenhouse produced cones**


Cone Juvenile Susceptibility



Disease Spread Among Cones?



- Exponential (logistic) increase of powdery mildew on cones
- Strongly suggests secondary spread among cones

Conclusions

- Cone susceptibility appears to decrease with maturity
- Bracts appear to retain some degree of susceptibility
- Pattern of disease increase on cones suggests secondary spread between cones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Crop Loss from Powdery Mildew

- **Commercial CTZ**
  - Applications of Quintec or Pristine ending:
    - 15 July (Quintec)
    - 29 July (Quintec)
    - 12 August (Pristine)
    - 27 August (Pristine)

- **WSU experimental Galena**
  - Non-treated, Flint/Quintec rotation or blocking program ending:
    - 13 July
    - 27 July
    - 10 August
    - 24 August

  - Disease incidence (leaves and cones), yield, alpha acid, HSI, and cone quality rated by a hop merchant

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Powdery Mildew Yield Loss: CTZ

Last spray date	Diseased cones (%)	Yield (kg/plant) Cones	Yield (kg/plant) Alpha	Bittering acids (%) Alpha	Bittering acids (%) Beta	Bittering acids (%) HSI
July 15 (Quintec)	80.0a	2.91	0.86	13.30	4.75	0.27
July 29 (Quintec)	62.9b	3.14	0.89	12.76	4.69	0.27
Aug 12 (Pristine)	58.8b	2.83	0.82	13.57	4.98	0.27
Aug 27 (Pristine)	62.9b	2.91	0.86	13.54	5.04	0.27
P-value	0.02	0.54	0.95	0.69	0.70	0.98

Harvested 14 September

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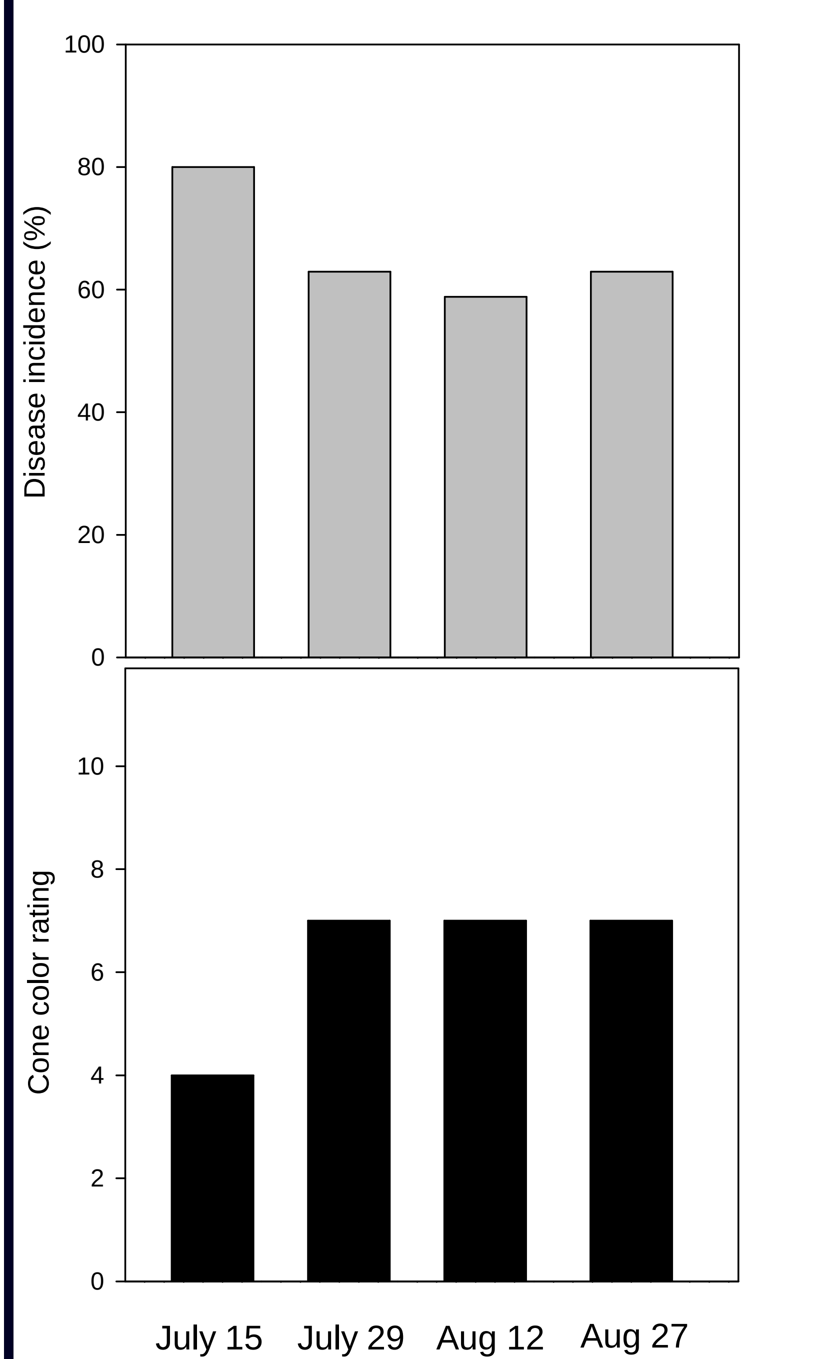
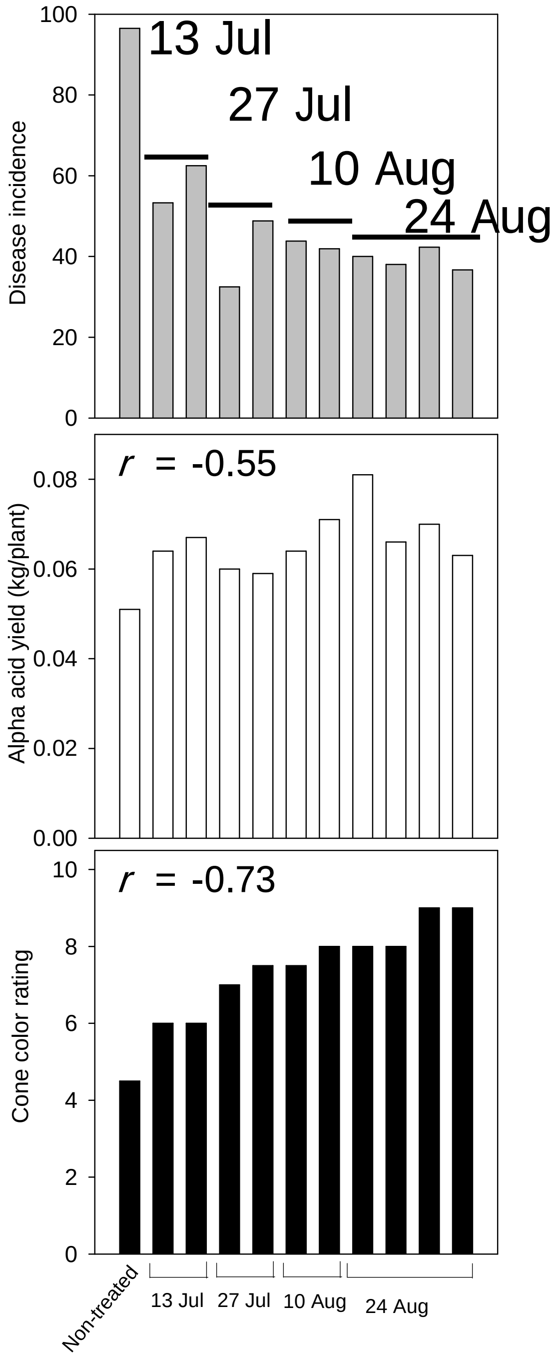


Late Season Disease Control

Commercial yard

- Disease reduction from treatments through 29 July
  - Associated with improved cone color
- No effect on yield, aroma, bittering acids and storage index



Late Season Disease Control

Experimental plots

- Disease reduction from treatments through 27 July
  - Trend for higher yield with later treatments
  - Cone color improved with late treatments
  - No effect on bittering acids, storage index or aroma between fungicide treated

Summary

- **Crop Loss**
  - Fungicide applications through end of July important for disease control
  - Later applications associated with higher yield and cone quality under high disease pressure
  - No quantifiable effect on yield or quality under low disease pressure in 2009

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Summary

- **Cone infection model development**
  - Prediction of cone infections based on late season: disease levels on leaves, temperature, rain, fungicide timing, and last spray date
  - Large affect from highly effective fungicides applied during critical cone developmental stages
- **Cone susceptibility**
  - Juvenille susceptibility of bracts and bracteoles
  - Bracts appear to remain infective at some level at harvest maturity

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