Non-Antibiotic Control of Fire Blight for Organic Orchards

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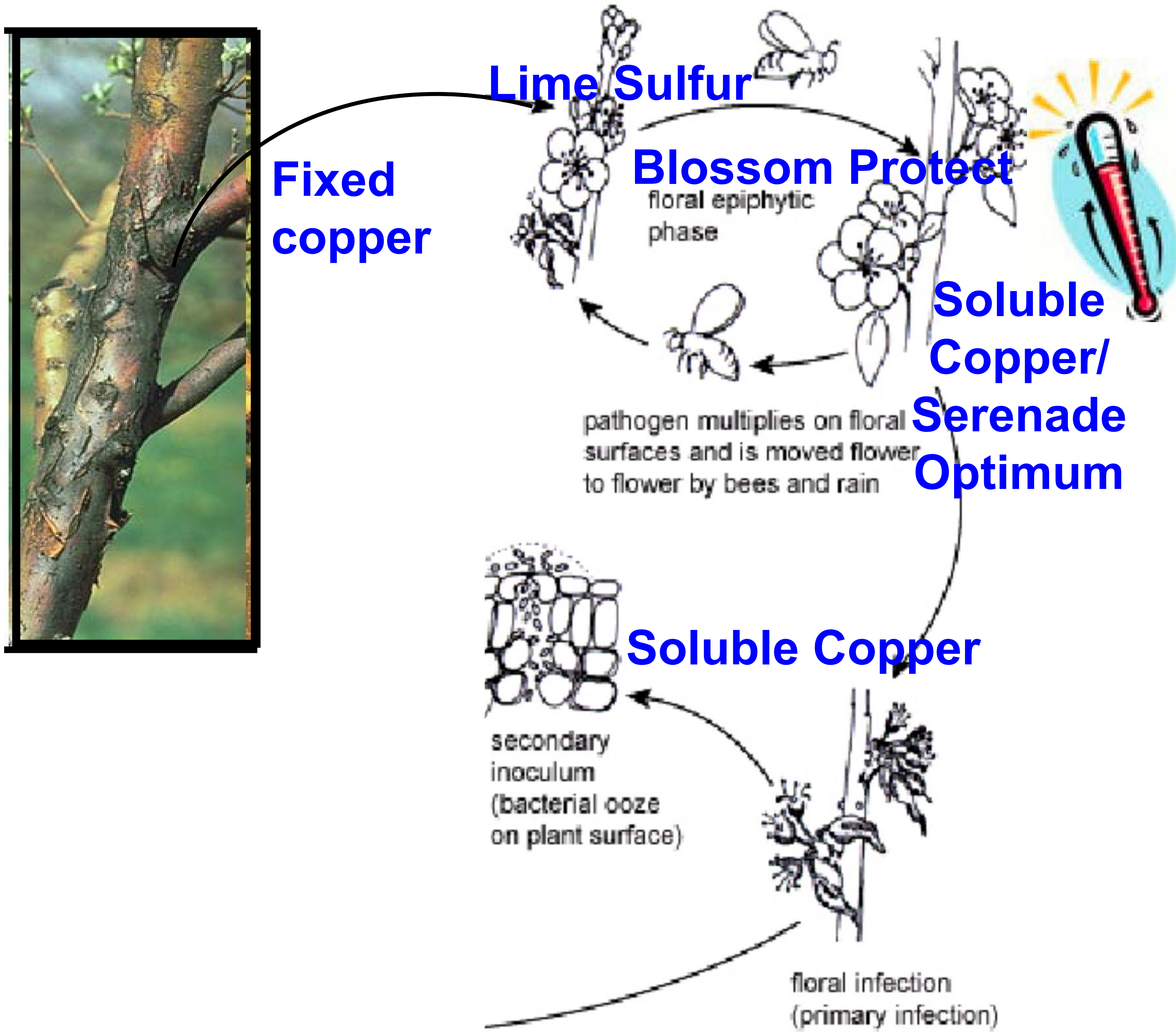
Context

- Organic growers have been allowed to use antibiotics to control fire blight in apples and pears prior to the NOP and since its establishment in 2002.
- Recently, the National Organic Standards Board (NOSB) voted to remove the allowed antibiotics (oxytetracycline and streptomycin) from the Allowed List of Synthetic Materials and have them expire from use in October 2014.
- A USDA-NIFA Organic Research and Education grant for organic non-antibiotic fire blight control is underway to develop alternatives, involving researchers in Oregon (Ken Johnson), Washington (Tim Smith), and California (Rachel Elkins). Support for testing of alternatives has come from other sources as well.
- Significant progress has been made in the availability of new control materials and understanding how they work, and how to integrate them into an effective control program.

This presentation shows results on non-antibiotic fire blight control compliant with the National Organic Program. Growers are encouraged to test such approaches in 2014, the last year in which antibiotics are available as a fallback option. The data were generated in the Pacific Northwest, and applicability to other regions is uncertain. Thus, growers in other regions are especially encouraged to test these ideas and products. The main issues are material efficacy and their potential to mark fruit (russetting).

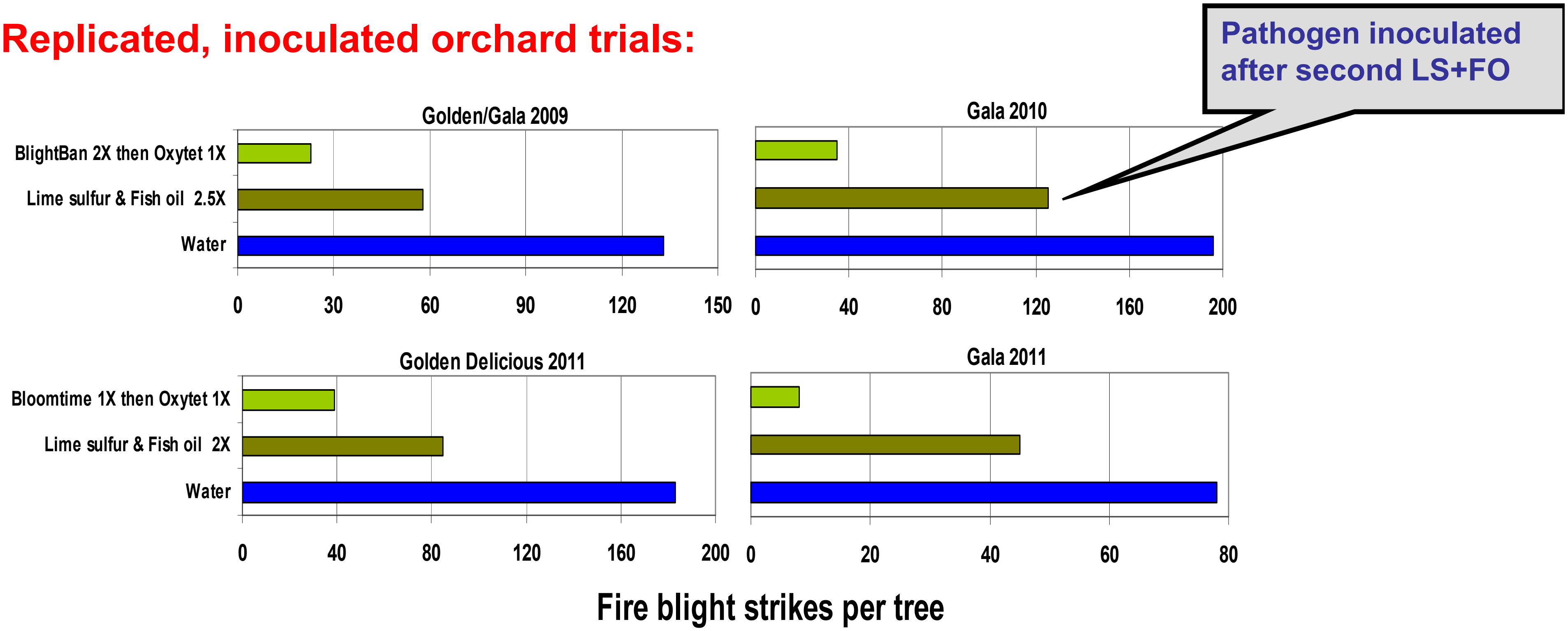
In the following slide, the fire blight disease cycle is outlined, along with the non-antibiotic control materials appropriate at each stage of crop development. Non-antibiotic control will be easier to accomplish in apples because it is less susceptible than pear to fire blight and because apple growers typically will be using lime sulfur as a fruit crop load thinning agent. With resect to fire blight, lime sulfur, which is sprayed in early bloom, has proven to be toxic to the pathogen as well as effective in reducing the number of flowers and thus, the number of potential infection sites. Ideally, treatment with biological materials should begin after the completion of lime sulfur sprays (i.e., at ~80% flowers open), as it is also toxic to living biocontrol agents.

One soluble copper, Cueva® copper soap, is currently registered, OMRI-approved and available. Others may become available in the near future.


Fixed
copper
Lime Sulfur
Blossom Protect
floral epiphytic
phase
Soluble
Copper/
Serenade
Optimum
pathogen multiplies on floral
surfaces and is moved flower
to flower by bees and rain
Soluble Copper
secondary
inoculum
(bacterial ooze
on plant surface)
floral infection
(primary infection)

Q: How does bloom thinning effect fire blight control?

Replicated, inoculated orchard trials:

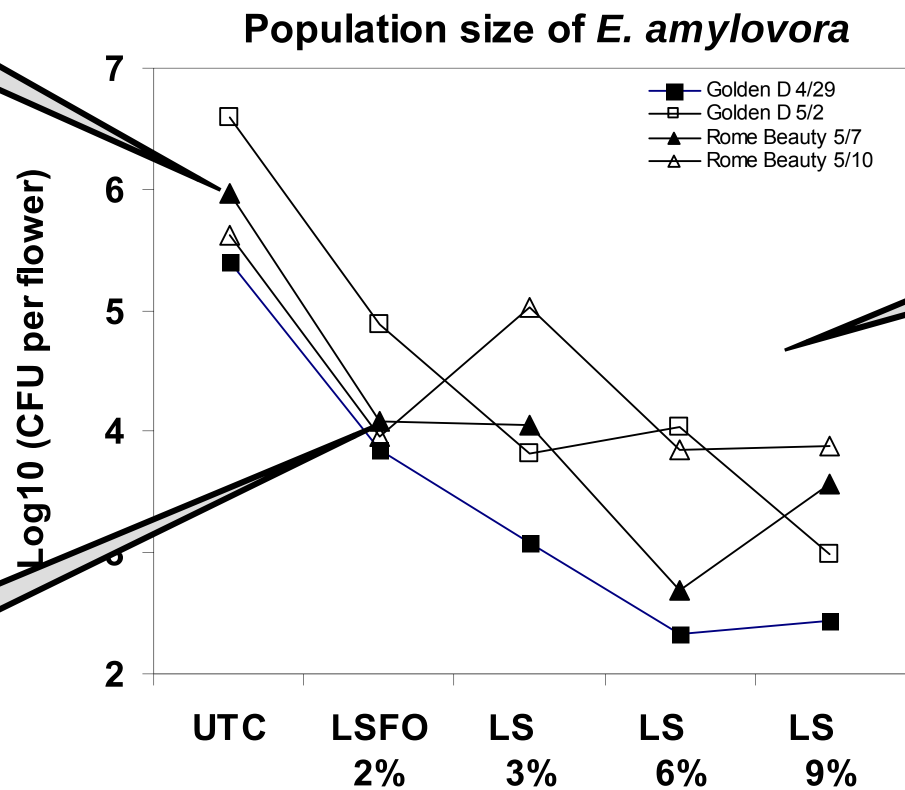


Conclusion: Lime sulfur treatments result in fewer flowers to infect

Q: How does bloom thinning effect the fire blight pathogen?

Lime sulfur directly suppresses epiphytic pathogen populations

One million cells per flower



Pathogen inoculated before lime sulfur

Ten thousand cells per flower

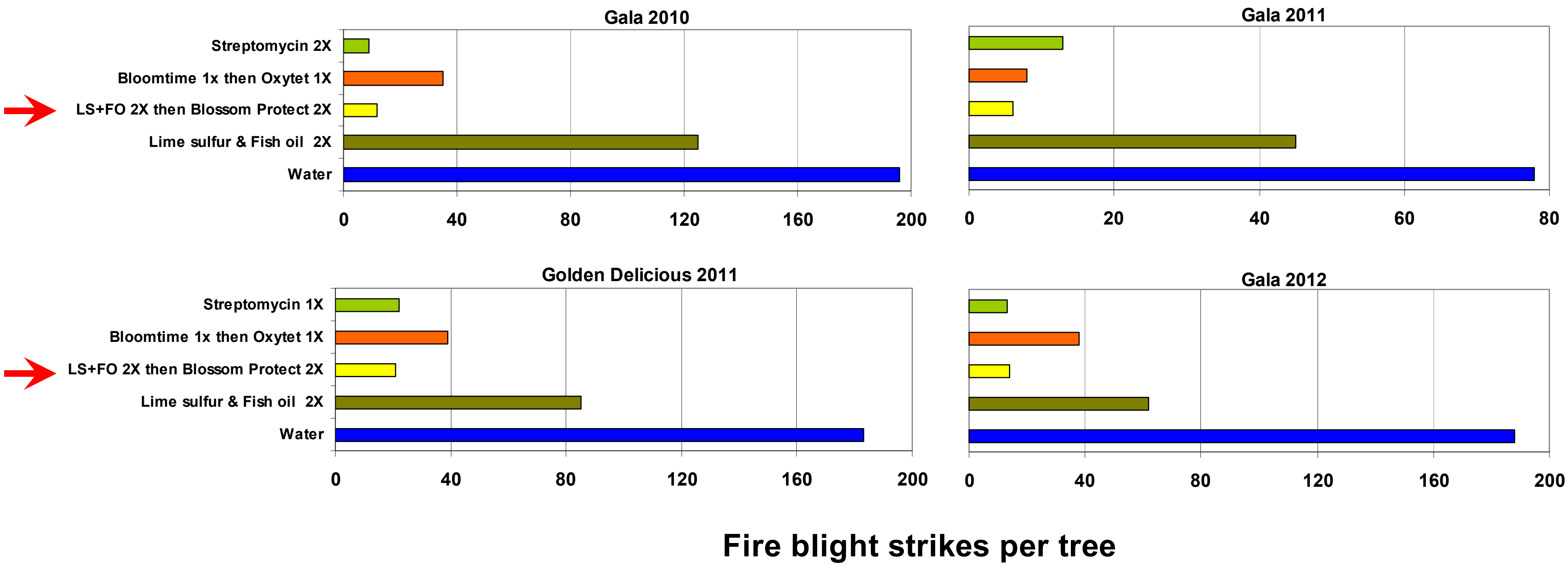
Conclusion: Lime sulfur is bactericidal

Between 100,000 (10^5) and 1 million (10^6) cells of the fire blight pathogen are needed on a flower to achieve an infection. But bees or splashing raindrops introduce much smaller numbers of pathogen cells to the flowers. Consequently, to infect the flower, the pathogen must multiply on the floral stigmas to attain a large number of cells. Infection occurs when pathogen cells (in large numbers) are washed by rain or dew down the style into the floral cup where they enter the developing fruitlet via the openings from which nectar is secreted.

Heat regulates the speed of pathogen multiplication on stigmas and its movement from flower to flower by bees. Thus, temperature-based models (e.g., CougarBlight) are used to assess infection risk. Antibiotics are powerful enough to use when a model indicates risk is high (large pathogen populations on stigmas). With non-antibiotic control relying more on biological materials, control programs will need to be initiated before high risk has developed. That is, a biological material (e.g., the yeast material Blossom Protect ®) will need to be sprayed at least once in the specific developmental window of 80% to full bloom regardless of model information.

An example of fire blight control on apple from two lime sulfur thinning sprays (20% and 70% bloom) followed by two Blossom Protect treatments (80% and full bloom) is shown in the next slide. This treatment (yellow bar) provided control equal to the streptomycin standard (green bar) in four orchard trials.

Integrated control ✓
Lime sulfur plus fish oil ✓
Followed by Blossom Protect yeast product ✓



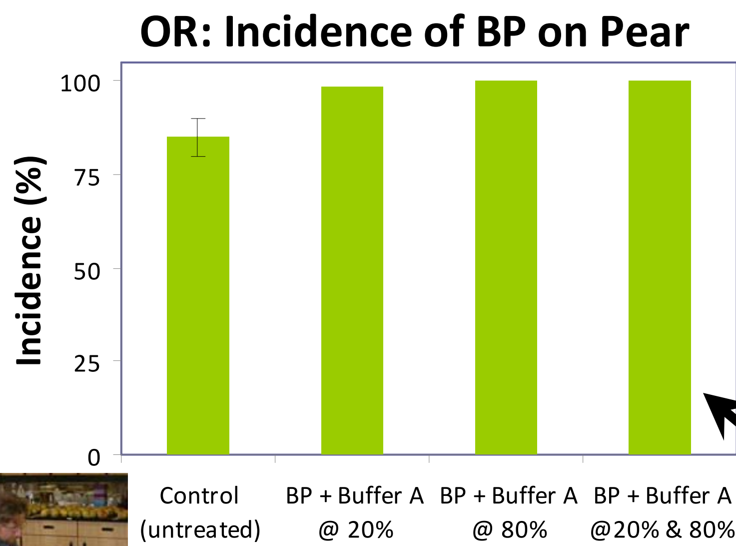
Blossom Protect® is the yeast *Aureobasidium pullulans.* Years ago, this organism was identified as a common colonizer of tree fruit blossoms by several research groups. It grows on flowers and is spread flower-to-flower by insects. Therefore, after spraying, the protection the yeast provides can improve over time.

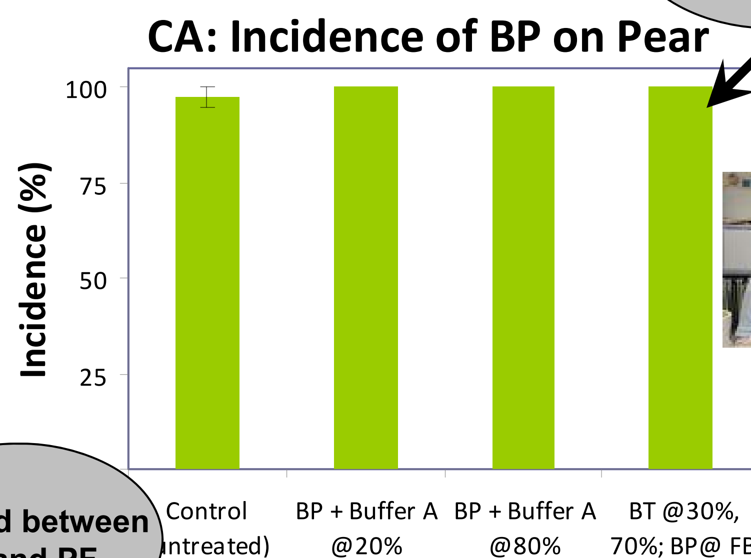
During bloom, *Aureobasidium pullulans* frequently colonizes flowers not treated directly with Blossom Protect (next slide) and is an <u>excellent</u> colonizer of both the stigmas and the nectary (2^{nd} slide ahead).

In Europe, however, where Blossom Protect was developed, there have been instances where multiple sprays of the yeast has caused increased russetting (fruit marking), which remains a concern. In the drier fruit-producing regions, this has not been problem to date. Nonetheless, to insure against russeting, it may be that a control material applied after Blossom Protect not only needs to suppress the fire blight pathogen but also needs to suppress a possibility of 'over-colonization' of young fruit by *Aureobasidium pullulans.* This sequencing of materials is discussed further below.

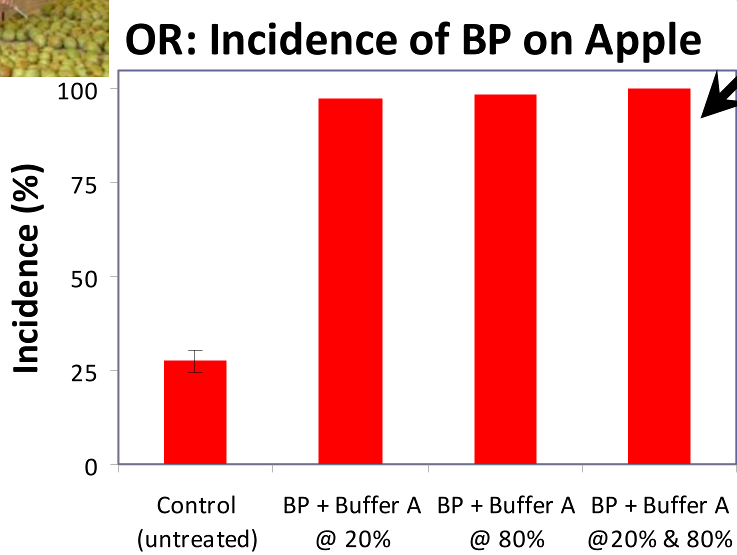
Blossom Protect is an excellent colonizer of flowers

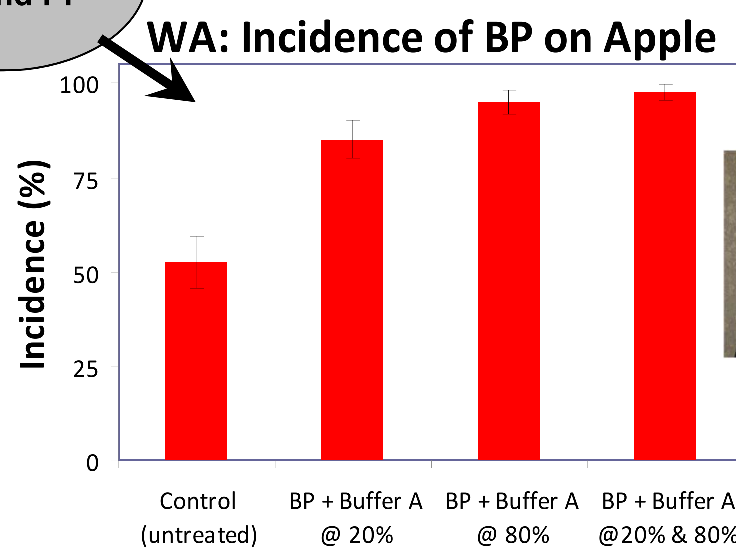
Sampled mid-June

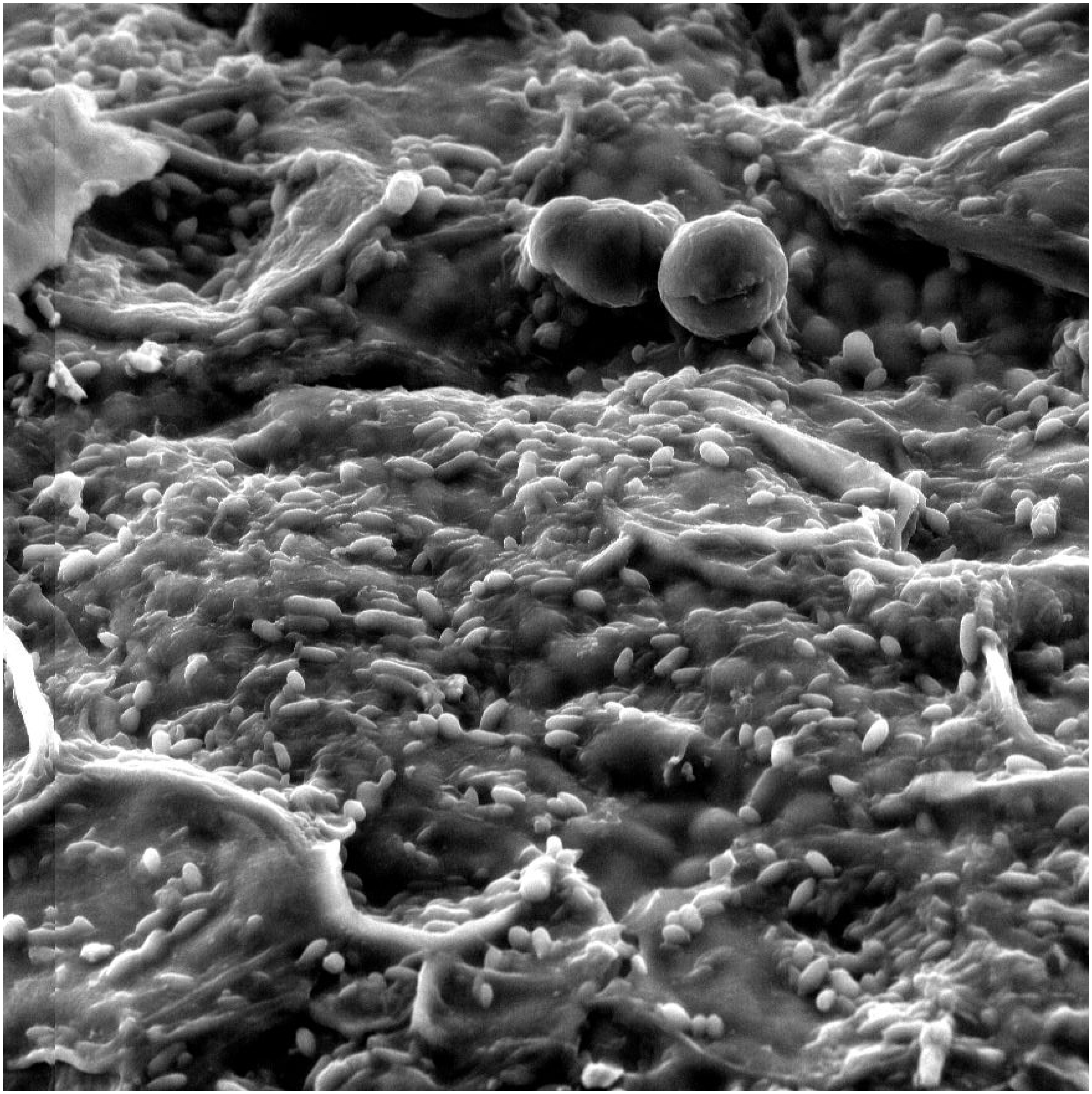




Sampled between FB and PF







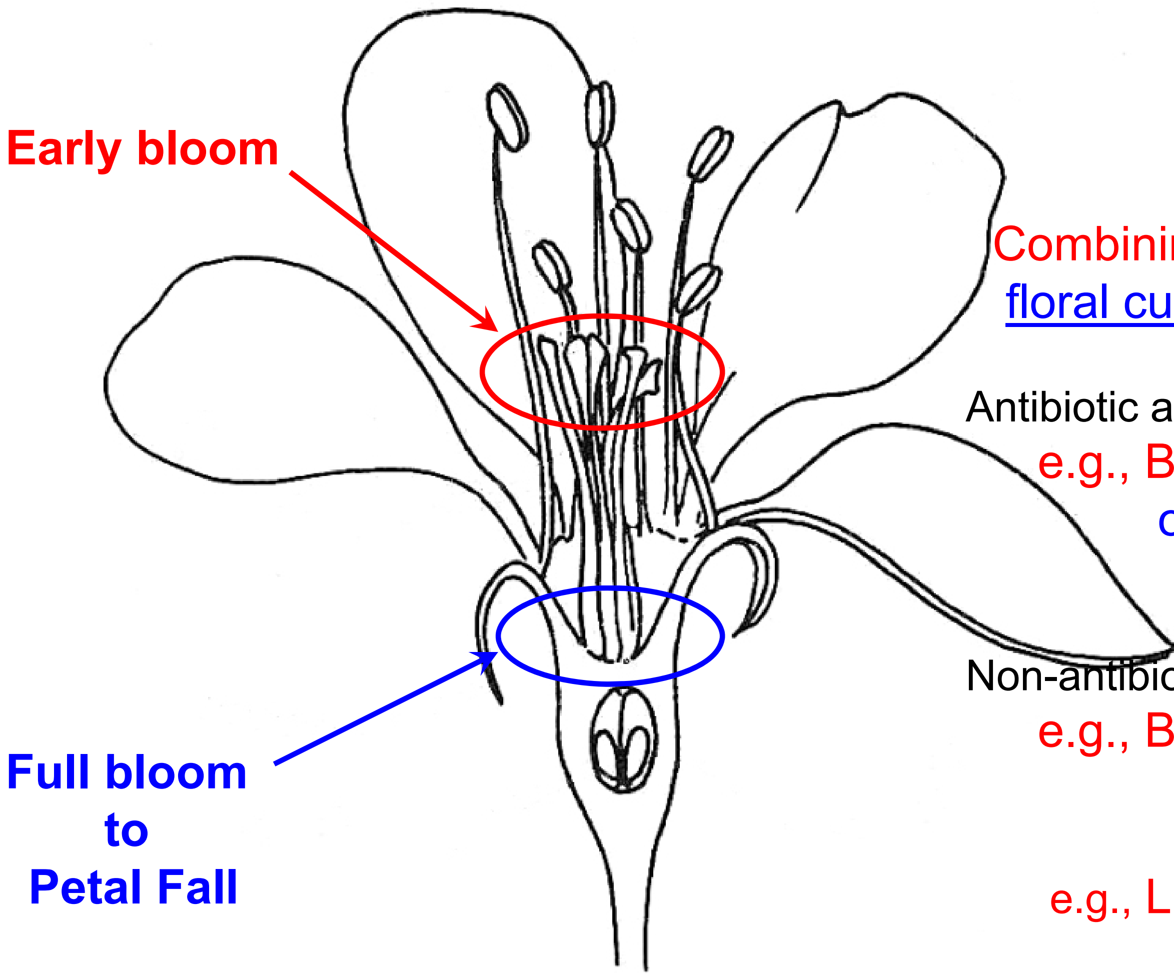
Biofilm of Blossom Protect yeast cells on nectary of pear flower sampled near petal fall

Photo by T. Sawyer

The following slide shows a pome fruit flower and the two areas of the flower targeted in fire blight control. ‘Integrated control’ sequences materials that inhibit pathogen growth on the stigma with those that suppress its activity on the nectary. For example, previous research demonstrated that the biological material, Bloomtime, which is effective on the stigma but not the nectary, slowed pathogen buildup to reduce infection risk. Then, later in bloom, an antibiotic, which is better suited to suppression of infection in the nectary, was shown to be more effective when it followed the Bloomtime treatment.

With non-antibiotic control, biological and chemical materials are sequenced similarly to achieve a high level of fire blight control. Generally, biologicals and lime sulfur suppress pathogen growth on stigmas. Chemical materials (soluble coppers and Serenade Optimum), and also the yeast in Blossom Protect, suppress infection in the nectary. The sequences of materials shown in the next slide differ somewhat for apple and pear due to the use of lime sulfur for thinning on apples but not on pears.

Q4: Can effective non-antibiotic control be achieved?



Combining a stigma product with a floral cup product improves control

Antibiotic approach:
e.g., Bloomtime Biological then
oxytetracycline

Non-antibiotic approach:
e.g., Blossom protect then
Serenade Optimum **PEARS**

e.g., Lime sulfur & fish oil then
Blossom protect then
soluble copper or
Serenade Optimum **APPLES**

‘Integrated control’

very good to excellent control

Fixed copper products are often used during the dormant or the delayed dormant (green tip) periods to kill bacteria oozing from active fire blight cankers. These materials are generally phytotoxic when used later. The new soluble coppers contain a much lower level of metallic copper and can be used during and after bloom. Thus, they may play a role in controlling both blossom blight and shoot blight. They do carry some risk of russetting, and more testing in diverse environments is needed to understand this. Blossom Protect followed by a soluble copper (Previsto) (blue bar) performed as well or better than the antibiotic standard (green bar). (Data shown in 2nd slide ahead.)

Soluble Coppers

-- Intended as bloom and petal fall treatments --

- Previsto (pending registration)
  - Copper ammonium complex in alginate carrier that reduces phytoxicity (alkaline pH) – 3.2% metallic copper
  - Extensive fruit finish testing (Smith, Hubbard, Sugar)
  - “Expected ~2015. Components of the formulation have been accepted as organic”

Lower risk of russetting but not zero

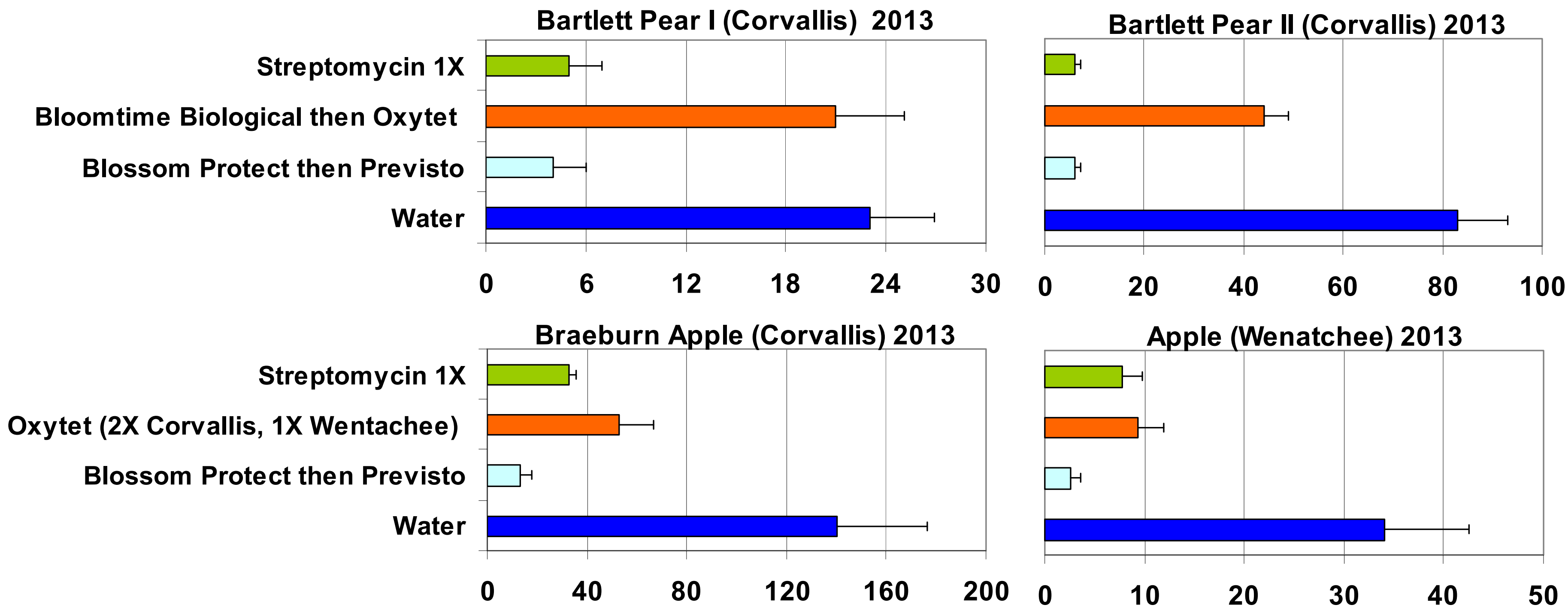
- Cueva (copper soap)
  - EPA registered, NOP approved, neutral pH
  - 1.8% metallic copper

Integrated control ✓

Blossom Protect ✓

Followed by new Previsto copper ✓

Replicated, inoculated orchard trials:



Lower right: Data of Tim Smith

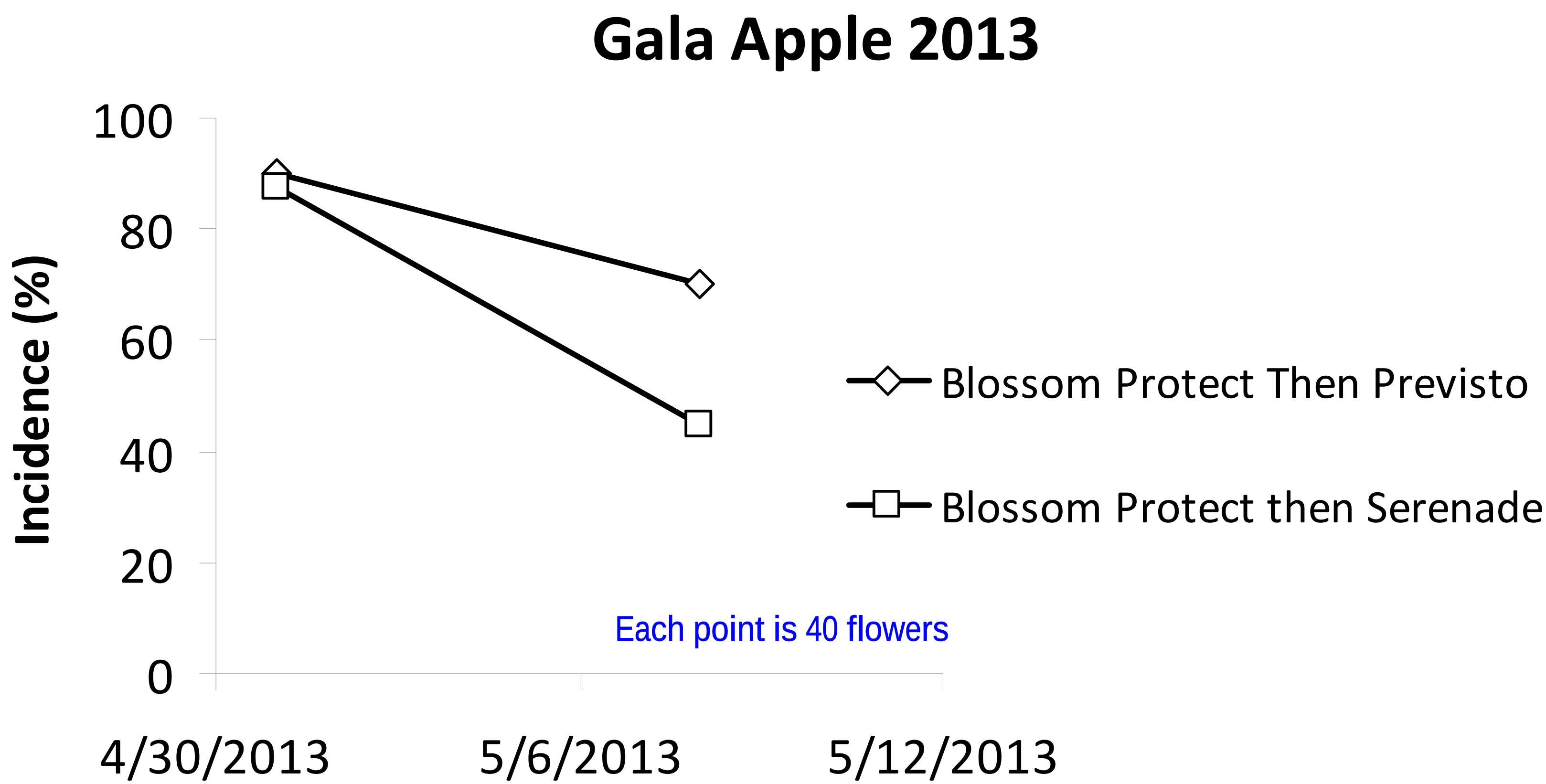
As mentioned earlier, some of the new materials carry a risk of russetting (fruit marking), which may lower the market grade of the fruit and cause a loss of crop value.

Serenade Optimum is an apparently ‘fruit safe’ material, which is made by fermenting a strain of *Bacillus subtilis*. The antimicrobial activity of Serenade comes mostly from biochemical compounds produced by the bacterium during fermentation, and not because of the bacterium’s colonization of flowers in the orchard (which is in contrast to Bloomtime or Blossom Protect). Serenade has both antibacterial and antifungal activity. Therefore, it can be used to suppress the fire blight pathogen (two slides ahead) as well as the Blossom Protect yeast (next slide), which has a potential to cause fruit russet.

3rd slide ahead shows the incidence of fruit russet on the ‘especially easy-to-russet’ pear cultivar ‘Comice’ after treatment with various fire blight control products. The five taller bars on the left are copper materials, Ser= Serenade, Strep = streptomycin, Oxytet = oxytetracycline, and Ck = water control. Like antibiotics, flowers and fruit sprayed with Serenade Optimum show a very low level of russetting.

Managing yeast-induced russet:

Yeast populations in flowers are suppressed by Previsto & Serenade Optimum



2013 trials with Serenade Optimum:

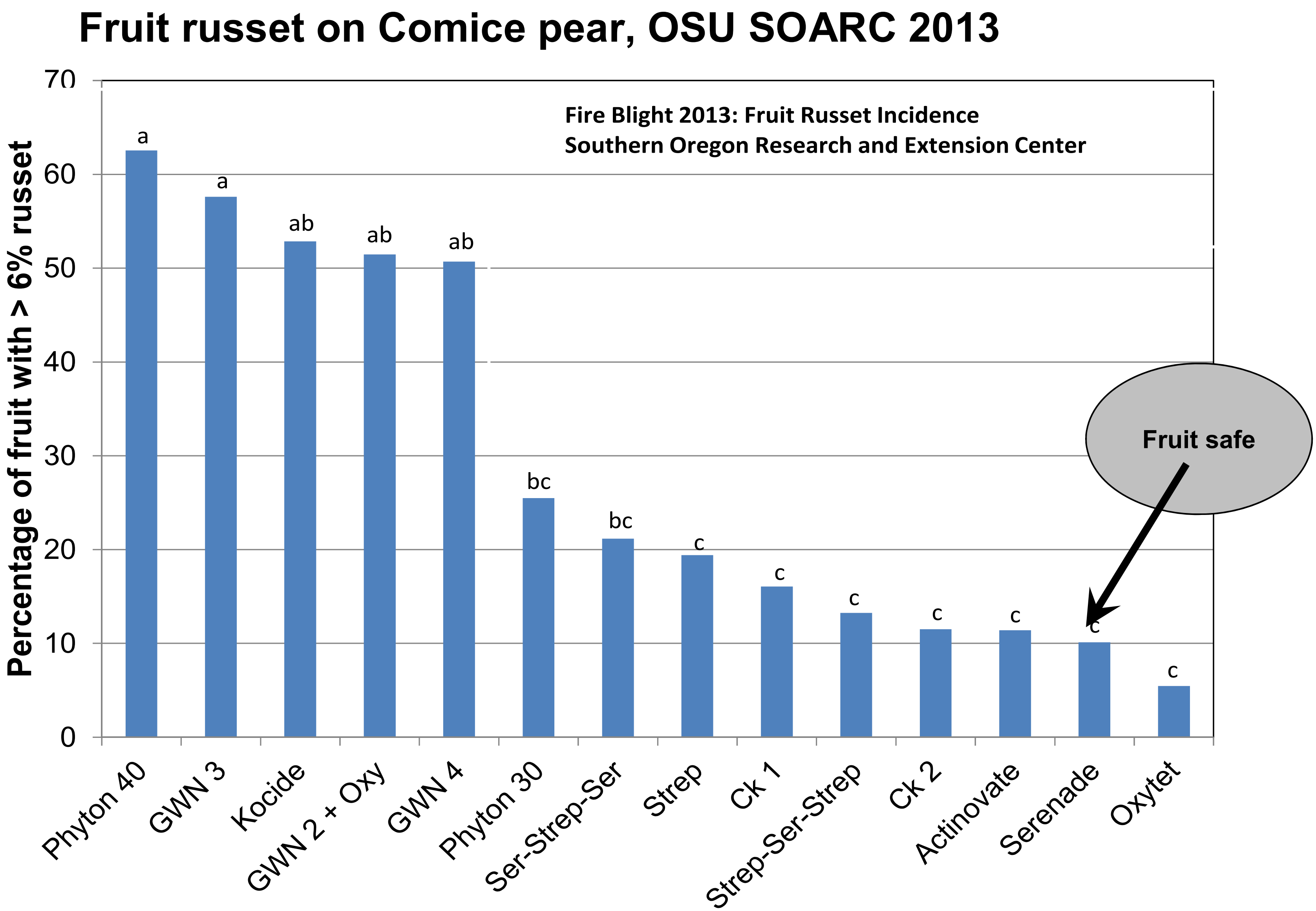
Inoculated trials	**Fire Blight Strikes per tree**		
2013 treatments	Corvallis	Medford	Hood River
Untreated control	91	22	27
Serenade Optimum	49 *	2 #	3 #
Streptomycin	55 $^{\beta}$	1 #	1 $^{\alpha}$

* FB with Blossom Protect @ 80%, $^{\beta}$ FB

30%, 80% & FB, $^{\alpha}$ 80% & FB

Data of David Sugar, Medford, & Vern Fischer, Hood River

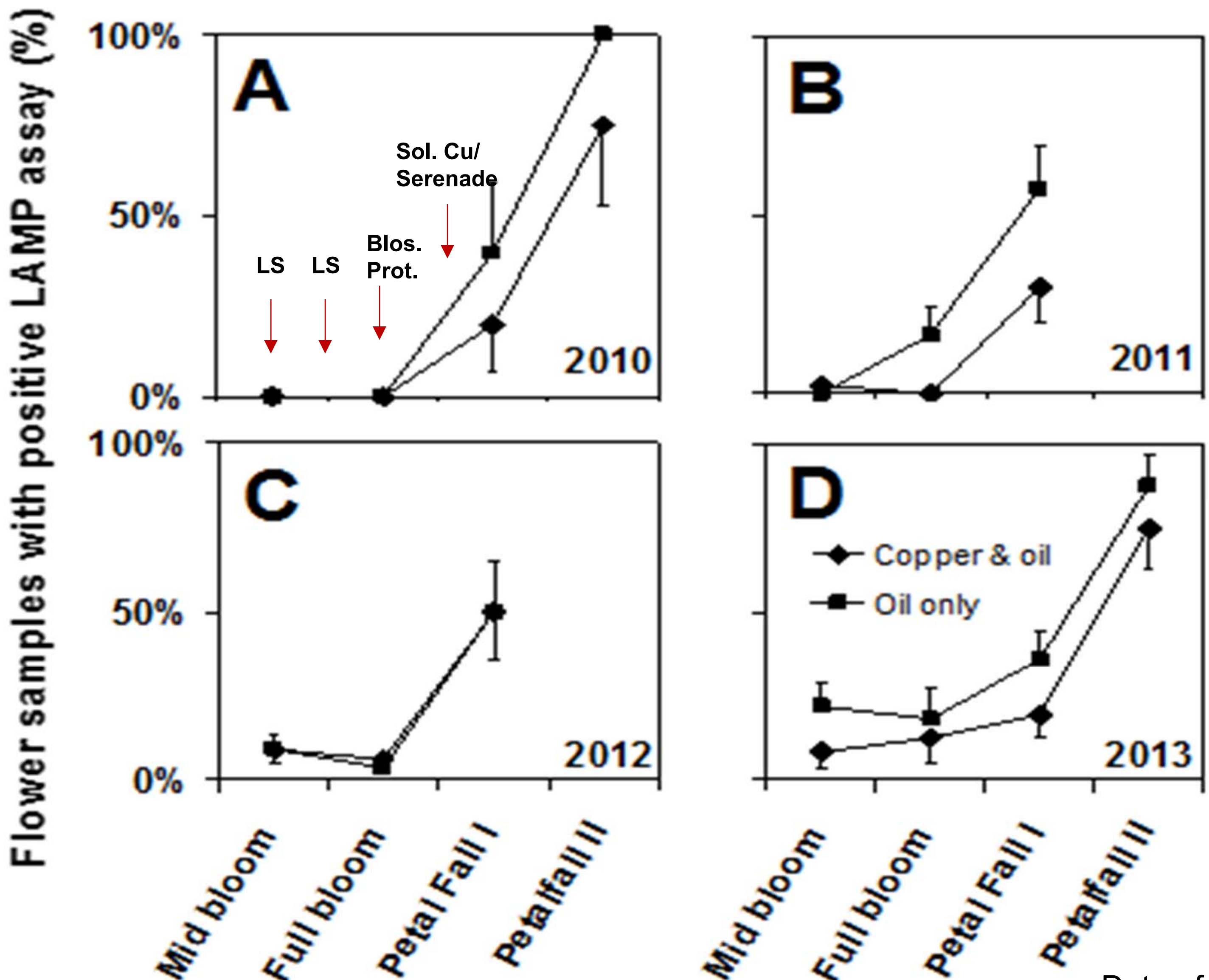
2013 trials with Serenade Optimum:



Data of David Sugar

In the next slide, the build-up of fire blight bacteria in flowers is shown for a series of four bloom periods in California orchards. The red arrows indicate a potential non-antibiotic control program for fire blight in organic apple – lime sulfur (king bloom open), lime sulfur (70% bloom), Blossom Protect (80-90% bloom), and a soluble copper or Serenade (full bloom to petal fall). In the study, two additional treatments were applied 3 to 4 weeks before bloom – oil only or oil plus a fixed copper. The purpose of the fixed copper was to suppress fire blight bacteria emerging from old (holdover) cankers. In 3 of 4 years, the oil plus copper applied pre-bloom slowed the build-up of the fire blight pathogen in the flowers, and thus is another control measure that should be considered as part of non-antibiotic control.

Sequenced program of materials relative to bloom stages and pathogen population build-up in the flowers:



Data of Rachel Elkins

Summary

Good progress has been made in developing non-antibiotic fire blight control for organic apples and pears. For more background, watch the eOrganic webinars http://www.youtube.com/watch?v=59_-51AT2Fk (2012) and http://www.youtube.com/watch?v=NuKxKCWKl28 (2013). Additional information on fire blight control in organic tree fruit can be found at http://www.tfrec.wsu.edu/pages/organic/fireblight .

More results will be forthcoming.