



## Key Disease Points of Fire Blight

- Varietal susceptibility
- Rootstock susceptibility
- Reduction of inoculum levels prior to and during bloom
  - cankers
- Killing pathogen inoculum on blossoms leading to a reduction in shoot blight

## Fire Blight; Looking Forward to 2008:

- Streptomycin
- Full registration for oxytetracycline (Mycoshield, generics such as FlameOut)
- Serenade MAX -- biological control option
- Section 18 for an alternate antibiotic
  - Kasugamycin (Kasumin)
  - Relevant to Southwest MI, Fruit Ridge

## Amplification of Fire Blight Bacteria in Orchards

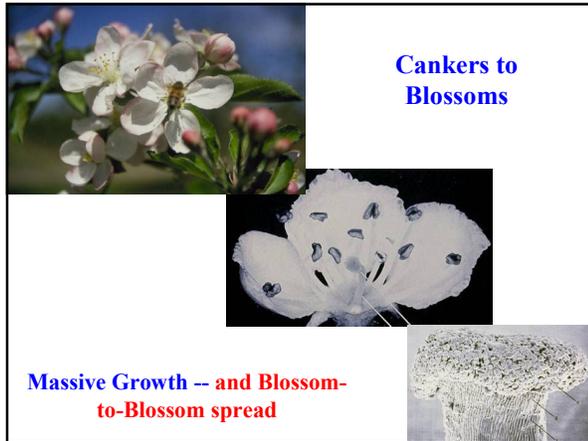
- Where do we see extensive growth -- And spread of the pathogen -- and infection?
- Blossoms
  - Rattail bloom
- Secondary spread from the initial shoot blight strikes
  - Minimum of 50 cells to cause a shoot blight strike
  - 1,000-10,000 X or more amplification of cells that come out as ooze

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  - 100-1,000 X or more cells come out as ooze

Targets for management: initial inoculum, blossoms, prevention of the first shoot blight strikes





**Bactericides / Biological Controls  
Evaluated in the Fire Blight Program**

- STANDARDS
- Streptomycin (Agrimycin) and a generic
- Oxytetracycline (Mycoshield)
- EXPERIMENTAL ANTIBIOTICS
- Gentamicin
- Kasugamycin (Kasumin)

**Materials Currently Available for  
Fire Blight Disease Management**

- Overwintering Inoculum
  - Copper
- Blossom Blight
  - Streptomycin (Agrimycin and generics)
  - Oxytetracycline (Mycoshield)
  - Serenade MAX
  - BlightBan A506
  - Bloomtime E325
- Shoot Blight
  - Prohexadione-Ca (Apogee)

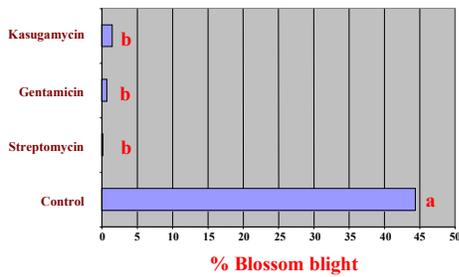


## Copper for Fire Blight Management

- Blanket trees with a spray at 1/2 inch green tip (2 lbs metallic Cu per acre)
- The fire blight pathogen *Erwinia amylovora* is highly susceptible to copper
- Spray will kill pathogen cells emerging as ooze from canker margins
- Reduction of inoculum is critical for blossom blight reduction

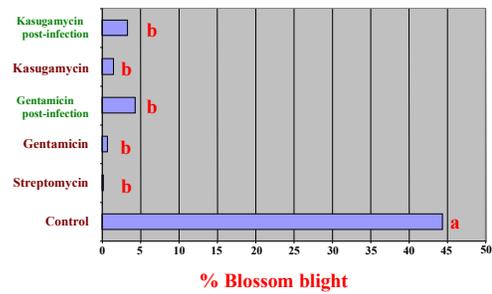


## Antibiotics Trial, 2007

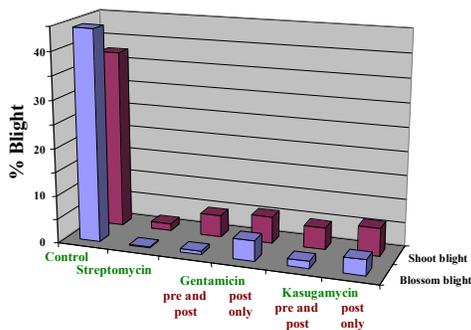


Spray Day 1; Inoculate Day 2; Spray Day 3

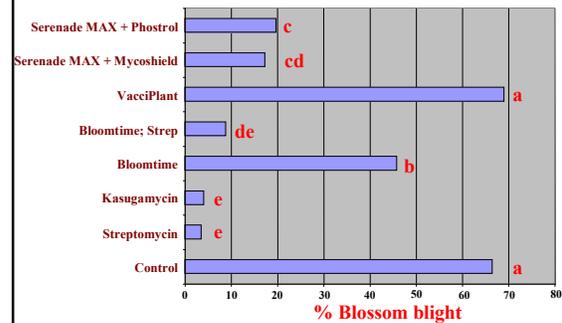
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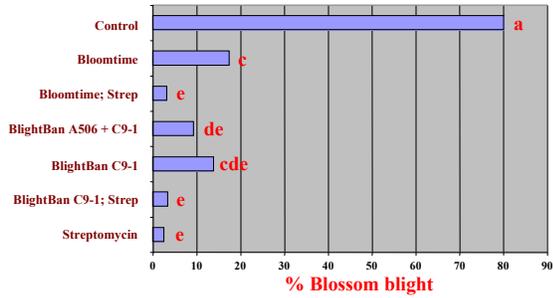


## Biological Control Trial, 2007



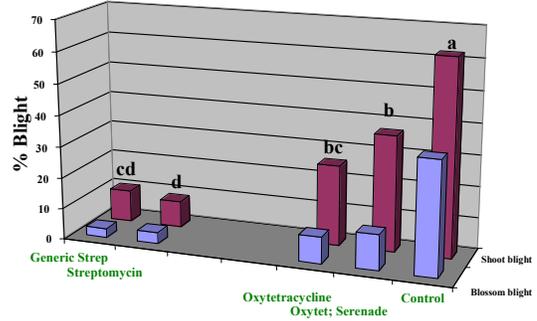
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## Bacterial Antagonists Trial, 2006



Spray Day 1; Inoculate Day 2; Spray Day 3

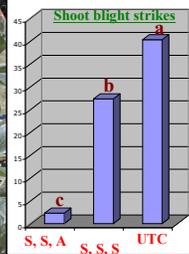
## Antibiotics Trial, 2006



Spray Day 1; Inoculate Day 2; Spray Day 3

### Apogee:

- Reduces active shoot growth
- Limits shoot blight strikes
- Reduces # cankers
- Can cause fruit cracking on Empire and Winesap



No Apogee  
10<sup>8</sup> cfu/ml  
Leaf inoculation



Apogee  
10<sup>8</sup> cfu/ml  
Leaf inoculation



## Apogee (mechanism of action)

- How does this material work?



- Same cell numbers in Apogee-treated (no disease) and non-treated (diseased) 'Jonathan' shoots

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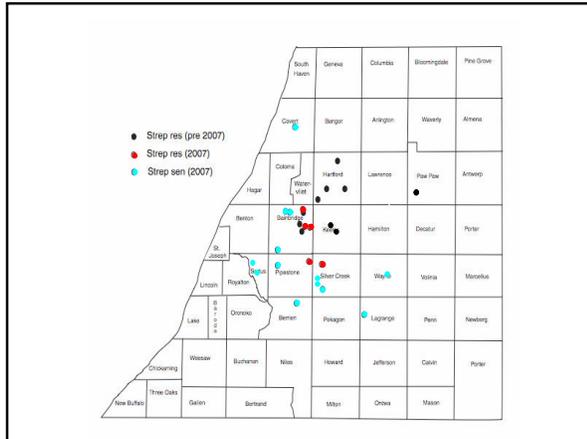
- How does this material work?
- Another growth inhibitor (Paclobutrazol) shows similar effects on apple shoot growth inhibition and disease reduction
- Antimicrobial compounds produced by apple?
- What about cellular effects?
  - Cell wall thickening in xylem

## Streptomycin Resistance

- Western U.S. -- Chromosomal-based resistance; 1970's
- Michigan -- new gene-based kind of resistance in most isolates
  - Only ~ 3% of Michigan isolates have the chromosomal resistance
- What is the status of resistance in 2007?

## Streptomycin Resistance Monitoring in Southwest Michigan

- 1991 -- 1993
  - 9 / 31 orchards sampled
- (2003-2007) -- Enlarge sampling effort outside of resistance “pocket”
- 2003 -- 6 / 22 orchards
- 2004 -- 1 / 5 orchards
- 2007 -- 11 / 35 orchards

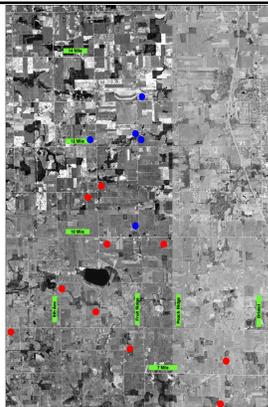


## Streptomycin Resistance in Michigan

- Early-mid 1990's -- Southwest Michigan
- 2004 -- Fruit Ridge area (7 of 8 orchards sampled)
- 2005 -- Fruit Ridge area (10 of 15 orchards sampled)
  - Orchards without resistance are located in the northern area of the Ridge
- 2006 -- Confirmed resistance in one orchard in the northern area of the Ridge
- 2006 -- Oceana county -- 7 of 8 orchards
- 2007 -- Oceana county -- all strep sensitive

- 2003 -- 1 / 6 orchards  $Sm^R$
- 2004 -- 7 / 7 orchards
- 2005 -- 10 / 15 orchards
- 2006 -- 2 / 2 orchards
- 2007 -- 3 / 3 orchards

$Sm^R$  ●  
 $Sm^S$  ●



## Genetic Tracking of Streptomycin-resistant Isolates

- We have identified the streptomycin-resistance genes in *Erwinia amylovora* isolates in Michigan
- Because of where the genes are located, we can track movement of individuals
- Almost all streptomycin resistance in Michigan is due to two strain-types

### Strep-resistance Distribution

Region	No. of Sm <sup>R</sup> Isolates	bp 1,515 insertion	bp 17,527 insertion
Southwest	66	23	43
Kent County			
Oceana County			

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Region	No. of Sm <sup>R</sup> Isolates	bp 1,515 insertion	bp 17,527 insertion
Southwest	66	23	43
Kent County	93	91	2
Oceana County	19	0	19

### Streptomycin Resistance in *Erwinia amylovora* in Michigan



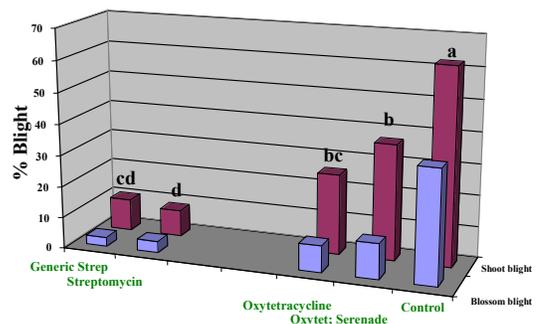
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- Rotation of modes of action
- **PROBLEM:** alternatives are not as effective as streptomycin
- Resistance management for pathogens: **objective is to kill as much of the pathogen as possible**

### Shoot Blight Consequences of not Killing Pathogen on Blossoms



### What About Resistance Management Practices in Cases Where We Don't Have Streptomycin Resistance?

- Streptomycin is best material -- use it
- Do not overuse streptomycin
  - 2-3 applications during bloom
  - Alternate or more preferably tank-mix under conditions of high disease pressure where more than 3 applications needed during bloom
  - Do not use after bloom as a routine bactericide
  - Hail application is a special case -- **should be put on within 12 hrs**

### Conclusions -- Northwest Michigan

- Variety choices, rootstock choices
- Antibiotics -- streptomycin, oxytetracycline
- Biologicals -- Serenade MAX
  - *Pantoea agglomerans* C9-1 and E325 -- **not giving up on these yet**
- Apogee
- Streptomycin resistance continues to spread in Michigan



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