Lessons Learned on the Use of Antibiotics in Fruit Tree Disease Control

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FIRE BLIGHT OF APPLE

https://fruitgardener.wordpress.com

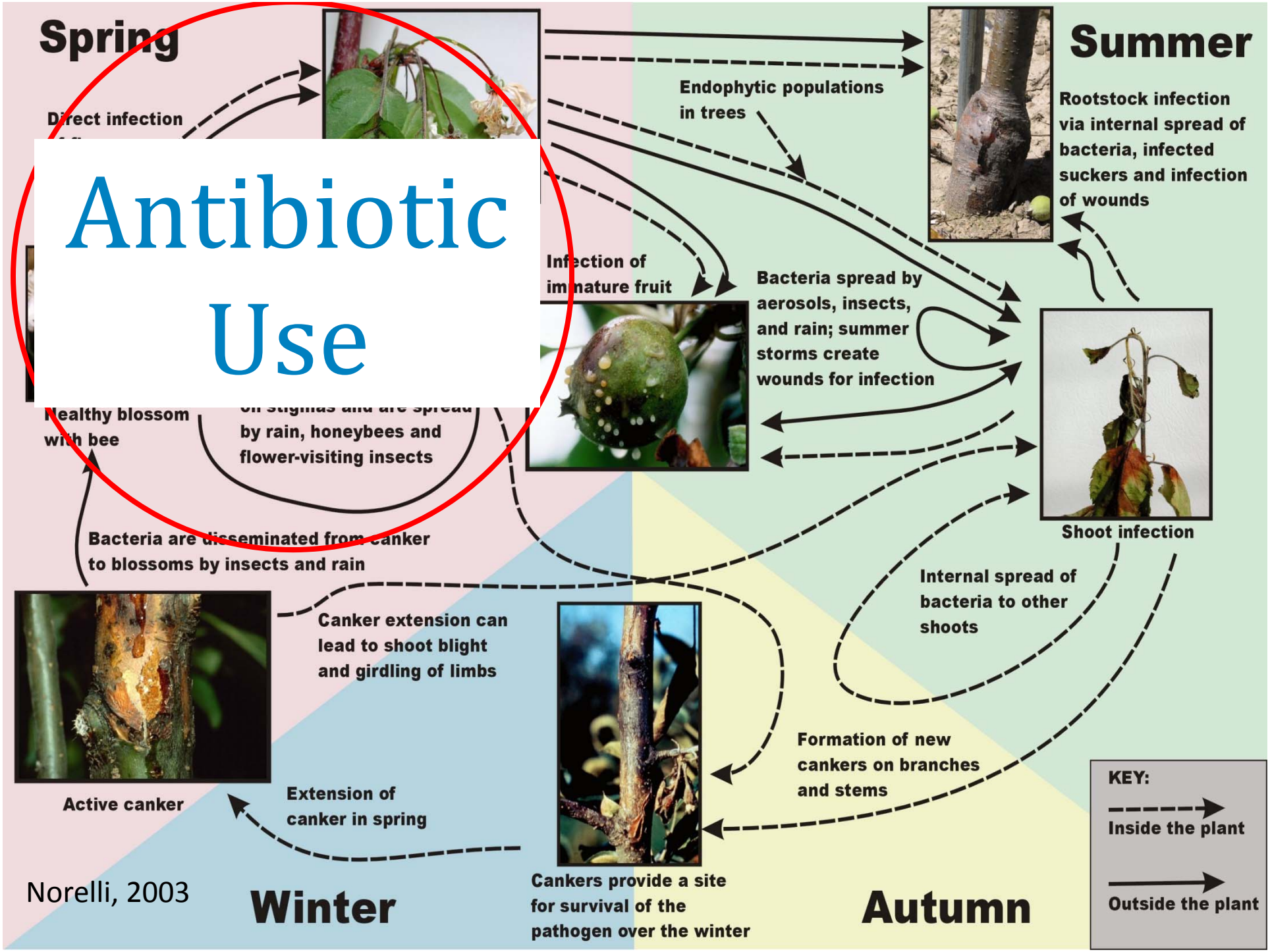
The Pathogen

- *Erwinia amylovora*
  - Gram negative bacterium
- Pathogen of Rosaceous plants
  - Especially apples and pears
- Can become systemic with in trees
  - Can severely damage or kill trees
- Generally requires warmth (15°C; 59°F) and wetting events to infect
- Moves via wind, rain, and insect movement

Fire Blight

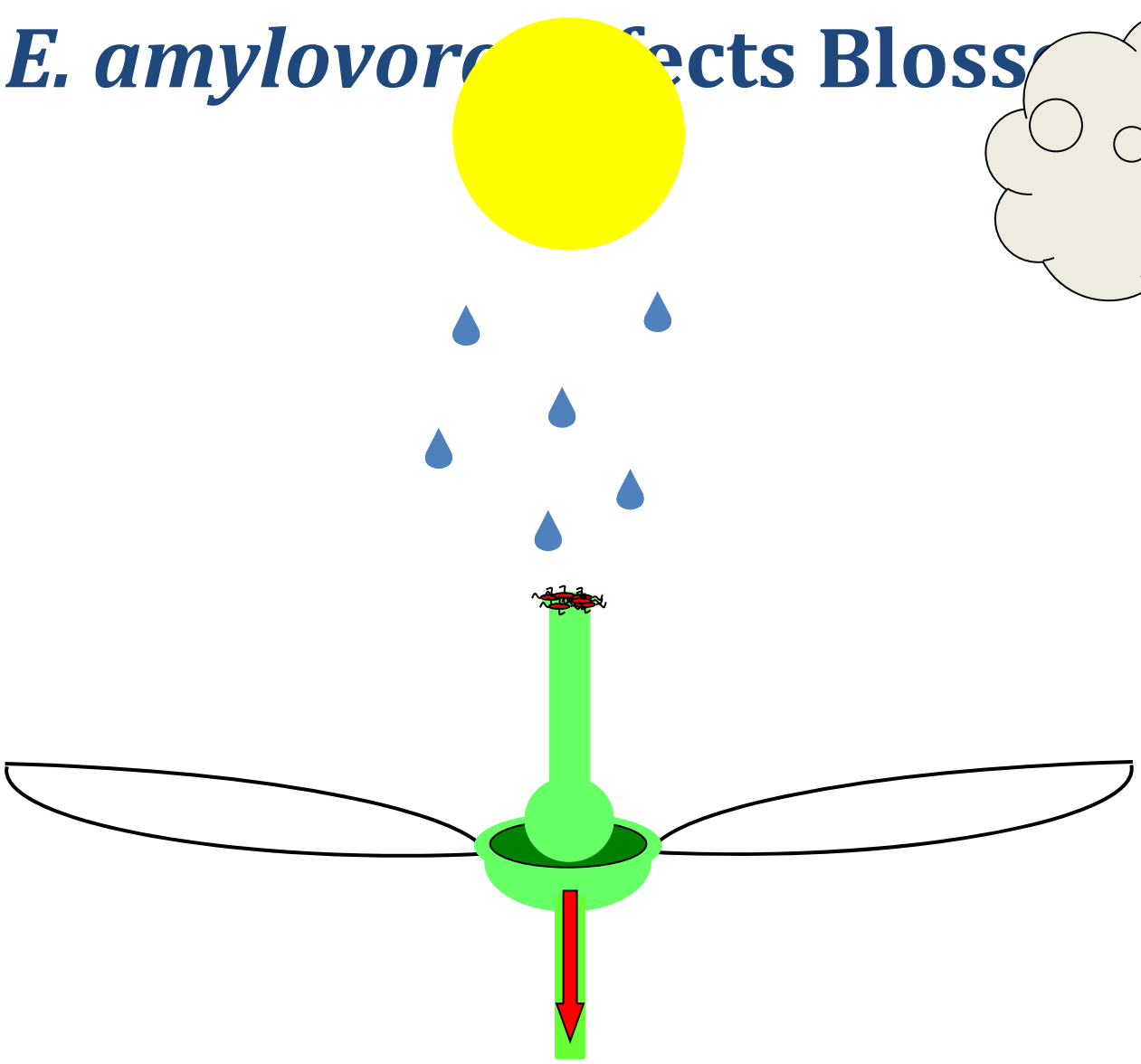
- Sporadic disease of devastating consequences
  - Does not occur every year
- Multiple phases of disease that often occur seemingly separately
  - Blossom blight, shoot blight, rootstock blight, canker blight
- Forms cankers on twigs and stems
- Kills flowers, fruitlets, and shoots
- Kills sensitive rootstocks

Antibiotic Use



Norelli, 2003

How *E. amylovora* ffects Bloss



Control

- Integrated approach best
- Scion and root stock selection
  - Avoid highly susceptible scion on highly susceptible rootstock
  - Many desirable dwarfing rootstocks highly susceptible
- Prune out strikes or cankers and minimize vigorous growth
- Biocontrol agents
  - Usually integrated with antibiotics
- Antibiotic applications
  - Streptomycin, oxytetracycline, and kasugamycin in the US
  - Copper in early season before phytotoxic

Antibiotic Use Patterns

- Only used for blossom blight or after severe storm with hail
  - Protecting stigma surface or wounds
- Historically used on calendar basis
  - Frequent applications used regardless of risk
- Now predictions of blossom blight used to time applications
  - Not every year is good for fire blight
    - *MARYBLYT* and *Cougarblight*
  - Usually not more than 2 or 3 applications in season

Amounts Used in 2009

Oxytetracycline

www.nass.usda.gov

Crop	Acres planted	Percent treated	Ave. # sprays	Total active ingredient/year (lbs)
Apple	306,401	12	1.2	6,799
Peach	114,800	9	2.2	3,100
Pear	59,567	41	3.3	8,600

Streptomycin

Crop	Acres planted	Percent treated	Ave. # sprays	Total active ingredient /year (lbs)
Apple	306,401	16	1.9	13,600
Peach	114,800	--	--	--
Pear	59,567	30	2.7	4,200

Differences in Mode of Action

- Streptomycin is bactericidal
  - Means it kills the bacteria if concentration sufficent
  - Blocks the ability to produce proteins by binding to ribosome permanently
- Oxytetracycline is bacteriostatic
  - Only temporarily stops multiplication
  - Reversibly binds to ribosome where it stops production of proteins
- Kasugamycin is bactericidal
  - Similar mode of action to streptomycin

Resistance Problems?

- Strep resistance first developed in Western States
  - California (1971), Washington, Oregon (1972)
  - Ubiquitous in Washington by late 1980s
- Missouri (1983)
- Michigan (1991)
  - Has become widespread
- New York (2002; 2014)
  - First instance possibly an introduction; rapidly eradicated
  - Relatively restricted area

Resistance Problems?

- Many major apple producing countries with fire blight have reported Streptomycin resistance
  - Canada, New Zealand, Israel, Egypt, Mexico
- No reports Oxytetracyline resistance in the field to date
- Kasugamycin is very new and little data is available

How Does Streptomycin Resistance Work?

- Two forms in *Erwinia amylovora*
  - Chromosomal point mutation prevents binding to ribosomal protein

  - Acquired resistance involve the bacteria receiving a small mobile piece of DNA (plasmid) containing 2 genes that inactivate streptomycin
  - Both stable

Stockwell and Duffy, 2012

Possible Mechanisms of Oxytetracyline Resistance

- Three major strategies observed in non-plant pathogenic bacteria
  - Pumps to remove antibiotic from cell
  - Alter shape of ribosome (similar to chromosomal resistance to streptomycin)
  - Produce enzymes that can deactivate oxytetracycline (similar to plasmid-borne resistance to streptomycin)
- Stability of these traits is unknown in plant pathogenic bacteria

Stockwell and Duffy, 2012

Possibility of Resistance for Kasugamycin?

- In laboratory studies, no resistant isolates developed at high concentrations of kasugamycin
- Low doses did allow for development of resistant isolates (concentration effect)
  - Mutations in a gene involved in ribosome function
- Isolates tended to have reduced fitness compared to untreated isolates
  - May not be able to out compete wild-type bacteria
  - With selection pressure they may be able to maintain the population

McGhee and Sundin, 2011

Persistence of Products

- In protected environments, streptomycin and oxytetracycline found to no longer prevent fire blight after 5 days
  - Would be shorter with full environmental exposure
- Would require retreatment for disease control
- This is without any form of adjuvant
  - More on this in next section
- Work not yet done with Kasugamycin

McManus, 2014; Stockwell and Duffy, 2012

https://growingproduce.com

BACTERIAL SPOT OF PEACH

https://extension.umass.edu

https://davesgarden.com

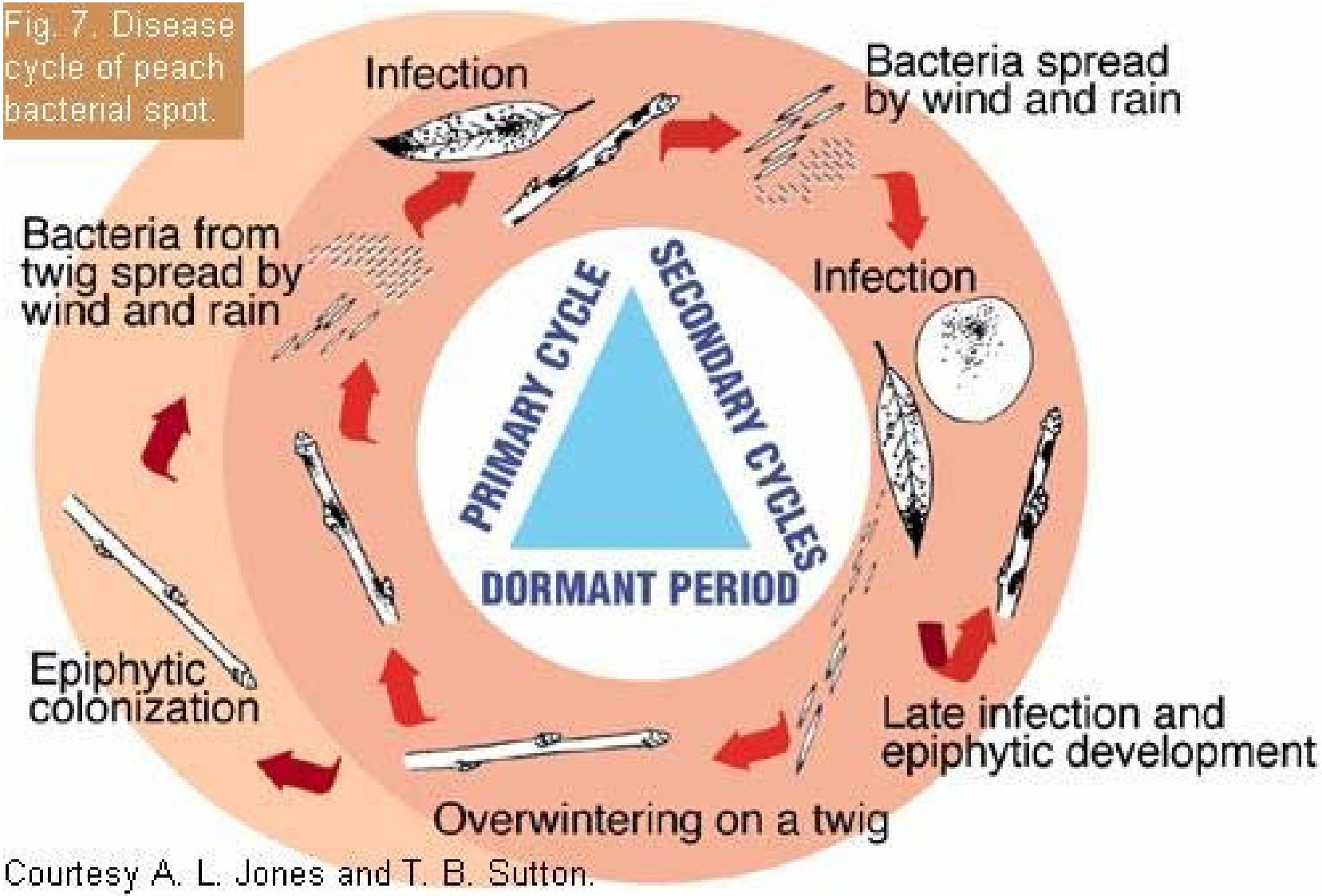
The Pathogen

- *Xanthomonas arboricola* pv. *pruni*
  - Gram negative bacterium
  - Same genus as the pathogen that causes citrus canker
- Does not become systemic within the plant
- Affect nearly all types of stone fruit
  - First detected on plum in Michigan in 1902-1903
- Likes warm and wet conditions

Bacterial spot

- Angular lesions on leaves
  - Newly emerged leaves can be infected; act as inoculum source
  - Leaves most susceptible until fully expanded
- Cankers form in previous year's twigs
  - Buds are usually killed
  - Can extend from apical bud killing twig beneath
- Fruit lesions worst on young fruit
  - Prior to shuck split, fruit develop pits
  - Later infections can still crack fruit and allow other pathogens to enter

Fig. 7. Disease cycle of peach bacterial spot.



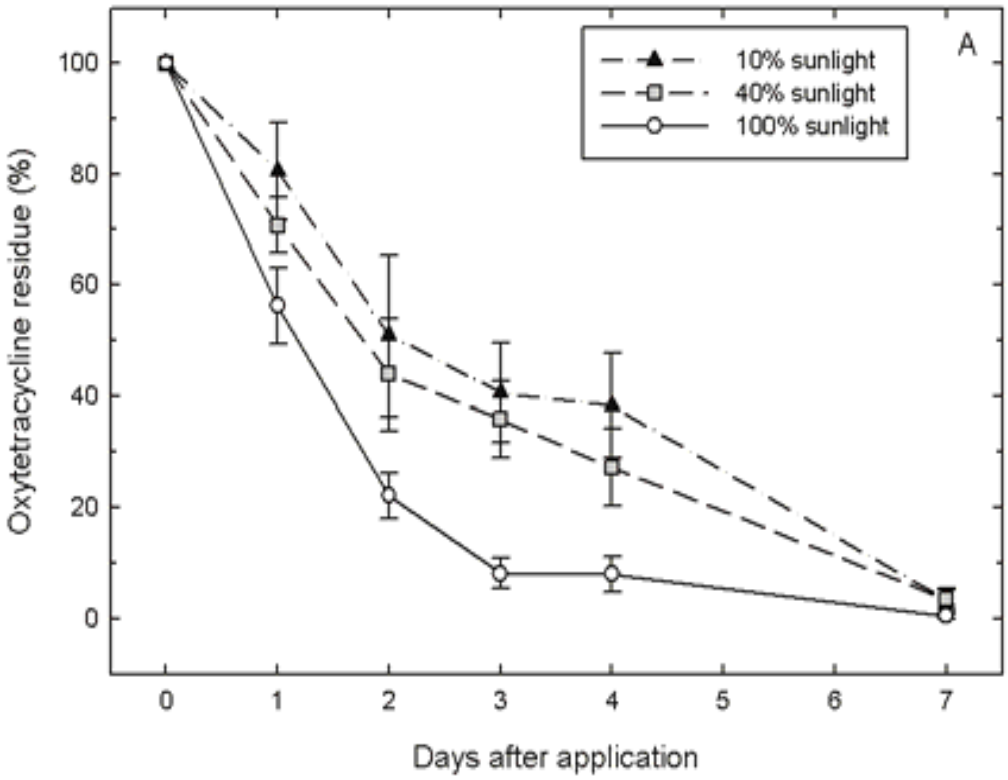
Courtesy A. L. Jones and T. B. Sutton.

Control Strategies

- First line of defense – RESISTANCE
  - Most low chill cultivars from UF program have resistance
  - Nearly impossible to control on susceptible cultivars even with chemical control
- Good fertilization can reduce susceptibility
- Minimize blowing sand
- Copper in early season – highly phytotoxic
- Oxytetracycline used after shuck split
  - Applications based on precipitation patterns

Effect of Sunlight Exposure on Residue

- 3 levels of sunlight
  - 10, 40, 100%
- Sig. lower (P > 0.05) residue with 100%
- At no level of sunlight, did residue last longer than 7 days
- Similar to results on tomato

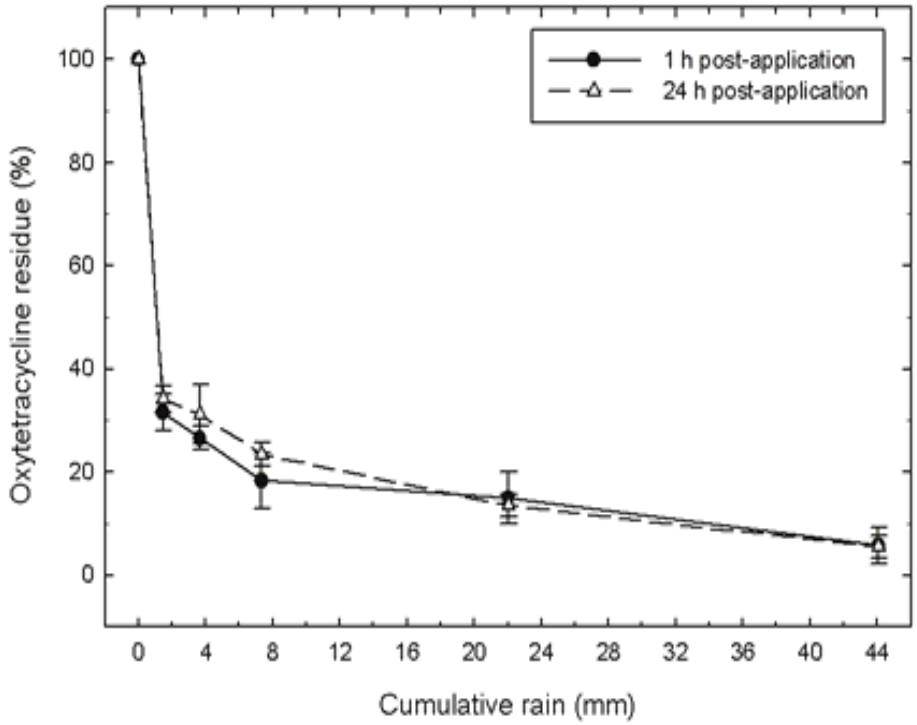


Christiano et al., 2010

Rainfastness of Oxytetracycline

- No difference in rain-fastness between 1 and 24 hrs post-app.
  - Drying time did not change result
- 2/3 of OTC removed by 1.5 mm (0.05 in) rain

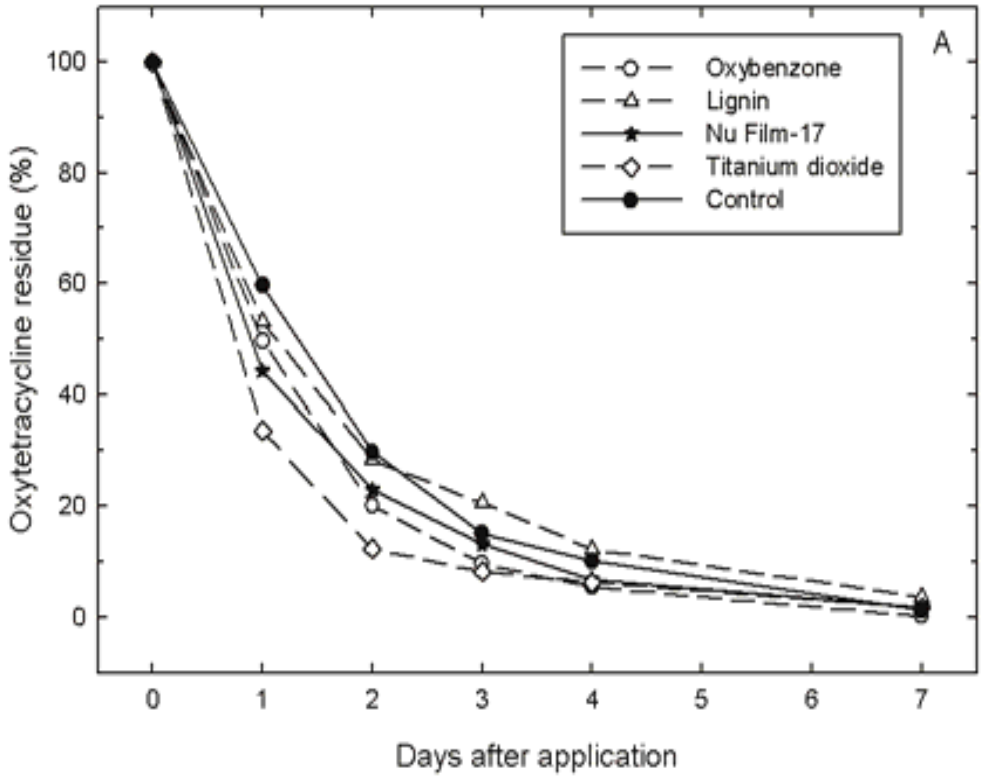
OTC = oxytetracycline



Christiano et al., 2010

Effect of UV Protectants on Residue

- Tested 4 compounds
  - Oxybenzone
  - Lignin
  - Nu Film-17
  - Titanium dioxide
- None improved residue levels
  - All levels fell exponentially in first 2 days



Christiano et al., 2010

Other Observations

- Found that ‘virtually’ all OTC residue remained on leaf surface
  - Only found in vascular system by trunk injections in literature
- OTC is temperature stable in dark
  - Between 25-40°C (77-104°F)
- 50 ppm of OTC was sufficient for control of bacterial spot on leaves

Conclusions

- Antibiotics important tools to manage bacterial tree fruit diseases
  - Only found to be effective against non-systemic phases of disease
- Generally low persistence
  - Quickly degraded by environmental factors
- With enough selection pressure, resistance can occur
  - Multiple mechanisms possible
- Must be good stewards to keep valuable tools

Any Questions?

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