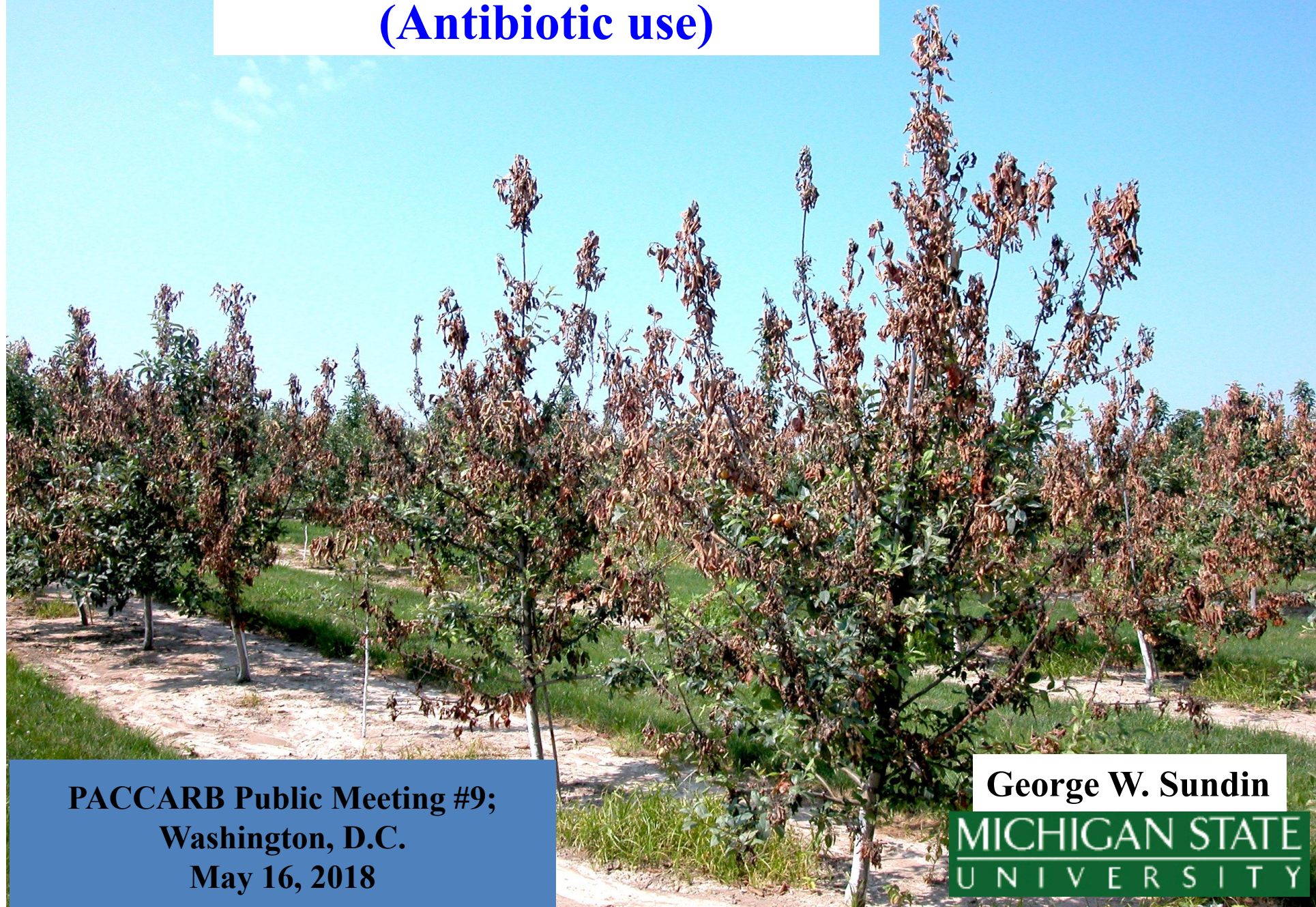


Plant Disease and Control (Antibiotic use)



**PACCARB Public Meeting #9;
Washington, D.C.
May 16, 2018**

George W. Sundin

**MICHIGAN STATE
UNIVERSITY**

Bacterial Plant Diseases

- **Occur on most crop plants, fruits, vegetables etc.**
- **Major effects of diseases are spots and rots on fruit or lesions on leaves that lead to reductions in yield**
- **Wilting diseases can kill plants**



Fire blight of apple, MI 2016



Disease epidemics are devastating to growers [2000, Southwest Michigan]



- **Tree losses -- approximately 450,000 trees killed**
- **Acreage -- approximately 2,300 acres lost in five counties**
- **35% overall yield reduction statewide**
- **\$42 million direct economic loss**

Bacterial Diseases are Exceedingly Difficult to Control

- **Lack of host resistance is a critical issue**
- **The most popular varieties are typically the most disease susceptible**



'Gala'

'Golden Delicious'

Bacterial Diseases are Exceedingly Difficult to Control

- **Bacterial pathogens – large population sizes, disease spreads very quickly**
- **Copper bactericides**
 - **Not highly effective, issues with copper resistance**
 - **Can be phytotoxic to plant**
 - **Long-term copper buildup in soils**
- **Biological control**
 - **Not available in all systems**
 - **Limited effectiveness, especially in humid climates (East, Southeast, Midwestern U.S.)**

Antibiotics examined by researchers for plant disease control (1940s)

- **Penicillin**
- **Streptomycin**
- **Aureomycin**
- **Chloramphenicol**
- **Oxytetracycline**

Antibiotic use for plant disease control in the U.S.

- **Streptomycin** – use started in the 1950s
 - **Mostly for fire blight of apple and pear**
 - **Some usage on tomato, discontinued**
- **Oxytetracycline** – use started in the 1980s
 - **in response to streptomycin resistance in the fire blight pathogen**
- **Kasugamycin** – registered in 2015
 - **Fire blight**
 - **Also developed in response to streptomycin resistance**
 - **No uses outside of plant agriculture**

Antibiotic use for plant disease control in the U.S.

- **Antibiotic use on plants is typically estimated to comprise < 0.5% of total antibiotic use in the U.S.**

Fire blight: match between a plant disease system and an antibiotic for control

- **High economic value crop**
- **Focused time frame of use**
 - **Need is during bloom (~ 2-3 weeks)**
 - **Significant population reduction necessary for disease control on flowers**
- **System amenable to use of streptomycin**
- **Development of disease forecasting / warning systems to properly time spray applications**



ca. 10^6 to 10^7 cells / stigma

Streptomycin Usage on Apple

- Growers use fire blight disease prediction models to identify when sprays are needed
- Extension personnel educate growers on model use

Bainbridge, MI May 2012 – Berrien county

Day	Date	Min Temp (° F)	Max Temp (° F)	Avg Temp (° F)	Rain (In./chance)	Dew/fog/spray (User entered)	Hours of leaf wetness recorded at station	Hours of leaf wetness (Recorded at Eunomys alatus)	DD40	DD55	DH65	EIP	Bactericide applied today?	Trauma	B	H	W	T	Progress toward infection	Risk
Tue	5/1	46.7	65.2	56.1	0.08	None	15	15	16	4	0	0	-	-	+	-	+	-	0%	Medium
Wed	5/2	57.8	81.6	68.1	0	None	9	10	28	13	125	64	-	-	+	-	(-)	+	0%	Medium
Thu	5/3	62.5	85.2	74	1.22	None	6	4	34	19	218	176	-	-	+	+	+	+	18.4%a	Infection
Fri	5/4	47.9	76	63.8	0	None	12	9	24	10	45	199	-	-	+	+	+	+	27.7%a	Infection
Sat	5/5	55.6	72.3	63.2	0	None	7	5	23	8	31	150	-	-	+	+	(-)	+	35.6%a	High

Michigan State University Enviroweather website



Streptomycin Usage on Apple

- **Target is fire blight disease**
 - **Spray timings during bloom**
- **100 ppm spray is used**
- **~ 33,600 lbs of streptomycin applied (2015 data*)**
 - **17% solution (5,712 lbs a.i.)**
- **26% apple acreage treated in 2015**

Three antibiotics are registered on apple for fire blight management

- **Streptomycin – 33,600 lbs**
 - 5,712 lbs a.i. (17% product)
 - 26% apple acreage
- **Oxytetracycline – 8,100 lbs**
 - 1,377 lbs a.i. (17% product)
 - 11% apple acreage
- **Kasugamycin – 1,300 lbs**
 - 26 lbs a.i. (2% product)
 - 4% apple acreage

Huanglongbing (HLB)
disease of citrus



Huanglongbing (HLB) disease of citrus



psyllid vector






HLB issues for the Florida citrus industry

- **Management is extremely challenging**
 - **No known host resistance**
 - **Psyllid vector is tough to manage with insecticides**
- **HLB disease results in tree death**
- **Since 2007, Florida has lost to HLB*:**
 - **162,200 citrus acres, \$7.8 billion revenue**
 - **7,513 jobs**

HLB issues for the Florida citrus industry

- **Management is extremely challenging**
 - **No known host resistance**
 - **Psyllid vector is tough to manage with insecticides**
 - **HLB disease results in tree death**
 - **Since 2007, Florida has lost to HLB*:**
 - **162,200 citrus acres, \$7.8 billion revenue**
 - **7,513 jobs**
 - **Florida citrus production:**
 - **avg. 284 million boxes (1996-2000)**
 - **avg. 235 million boxes (2001-2005)**
 - **avg. 176 million boxes (2006-2010)**
 - **avg. 132 million boxes (2011-2016)**
- HLB discovered in FL in 2005
- 



Huanglongbing: potential for antibiotic management

- **Growth flush**
- **HLB pathogen is active in phloem of leaves at flush**
- **Psyllid also actively feeds on these leaves**
- **For management: flush leaves have thinner cuticles, amenable to penetration with oxytetracycline or streptomycin**

Use information for antibiotics for HLB management in FL

Product Details	Firewall SO WP™ (streptomycin)	Fireline 17 WP™* (oxytetracycline)	Mycoshield® * (oxytetracycline)
Preharvest Interval(days)	40	40	21
Maximum Number of Applications per Calendar Year	3	3	8
Minimum Retreatment Interval (days)	21	21	21

New usage in Florida likely will significantly increase the amount of antibiotics used in plant agriculture in the U.S.

367,500 acres of oranges in Florida (NASS, 2015)

Antibiotics are applied with penetrating surfactants in an attempt to increase uptake by flush leaves

**90% of oxytetracycline applied to plants is degraded by sunlight within 3 days
(Christiano et al. 2010; Plant Dis. 94:1213-1218)**

Published data on antibiotic resistance in plant agricultural habitats

- **Streptomycin application in apple orchards had no effect on the nontarget soil bacterial community under trees**
 - **Shade et al. (2013) Appl. Environ. Microbiol. 79:6617-6625**
 - Study conducted in Wisconsin
 - **Walsh et al. (2014) Frontiers Microbiol. 4:383**
 - Study conducted in Switzerland
- **Application of streptomycin for 10 years in apple orchards did not increase the abundance of Sm^R culturable leaf bacteria**
 - **Yashiro and McManus (2012) PLoS ONE 7:e37131**
 - Study conducted in Wisconsin

Published data on antibiotic resistome in plant agricultural habitats

- **Application of streptomycin in apple orchards did not increase the abundance of mobile genetic elements in flower, leaf, or soil bacterial populations**
 - **Duffy et al. (2013) FEMS Microbiol. Lett. 350:180-189**
 - Study conducted in Switzerland
- **New antibiotic resistome studies are underway in:**
 - **Michigan apple orchards**
 - **Florida citrus groves**

Summary – Antibiotic use in plant agriculture

- **Streptomycin, oxytetracycline, kasugamycin**
- **Targets are diseases on high-value tree crops**
- **The nature of bacterial plant diseases and the economic necessity of growing highly disease-susceptible cultivars contributes to antibiotic use**

- **Current data does not implicate antibiotic use in causing an increase in antibiotic resistance in nontarget bacteria**
 - **flower, leaf, soil habitats**

Funding sources:

USDA – NIFA

MSU Project GREEN

MI Apple Committee

