Making the Most of Bio-Controls: Mode of Action and Compatibility -Biological Fungicides-

Greg Rogers
Field Development Manager
Certis USA

CERTIS USA
The Biopesticide Company

Biological Fungicides

* Bacillus Fungicides
* SAR/ISR Inducers

Bacillus Fungicides

* *B. subtilis*
  * *Serenade(s) - Strain QST 713 – Bayer*
* *B. subtilis var amyloliquefaciens*
  * *Taegro ECO – Strain FZB24 - Syngenta*
* *B. amyloliquefaciens*
  * *Double Nickel – Strain D747 - Certis*
  * *Serifel – Strain MBI 600 - BASF*
  * *Stargus – Strain F747 – Marrone Bio Innovations*

B.s and B.a Fungicides

* All are native soil-borne organisms
  * Happiest in the soil!
* B.s and B.a closely related species
* All products are different strains of bacillus
* Compatibility claims vary
  * Double Nickel
    * No Antibiotics
    * Coppers are ok - CAVEAT
    * No PAA/H_2O_2's

Double Nickel™ LC
BIOFUNGICIDE

Foliar or fruit application:

- Antimicrobial metabolites (lipopeptides) kill pathogenic fungi and bacteria by destroying their cell walls and cell membranes
- Lipopeptides produced during fermentation (“in the bag”)
- Additional lipopeptides produced as spores germinate upon application
- Epiphytic colonization (Competition)
- Systemic acquired resistance (SAR)

Soil application:

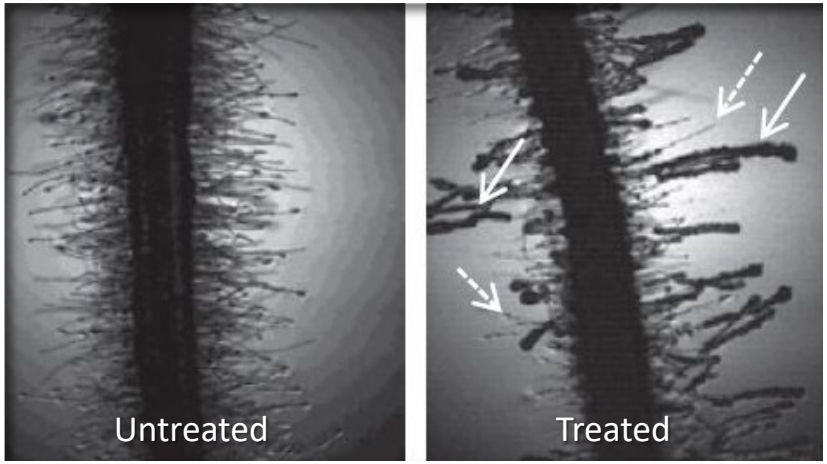
- Forms biofilm on root surfaces
- Barrier to infection by pathogens
- Lipopeptides may kill pathogens on application
- Induced systemic resistance (ISR) to pathogens
- Plant growth promotion (PGPR)

CERTIS

Double Nickel™ LC
BIOFUNGICIDE

Host colonization by Bacillus amyloliquefaciens

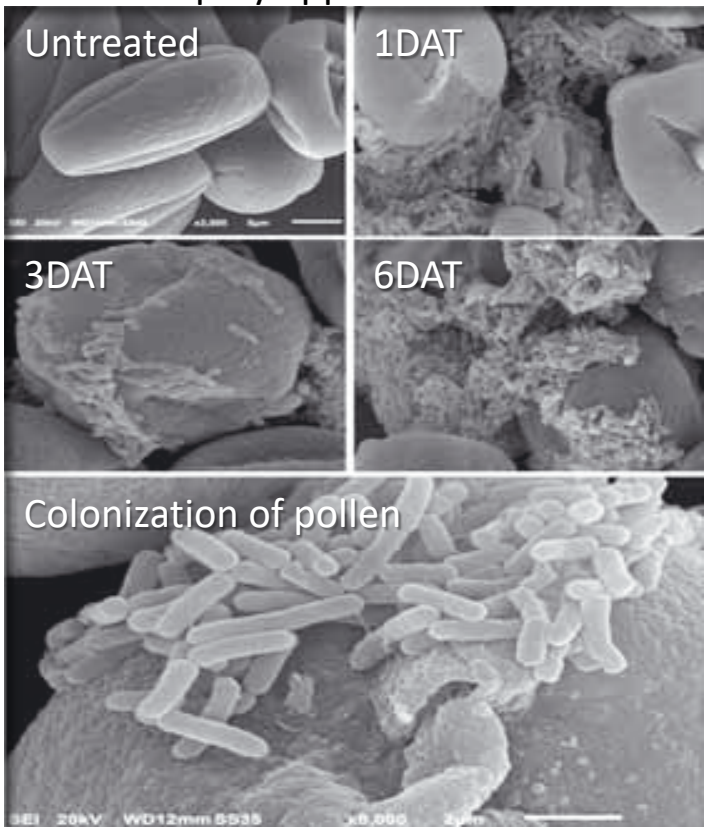
Colonization of tomato root hairs by *Bacillus amyloliquefaciens* (soil application).



Solid arrows indicate fully colonized root hairs.
Dashed arrows indicate non-colonized root hairs.

Source: Nihorimbere *et al.* FEMS Microbiol. Ecol. 79 (2012): 176-191.

Colonization of kiwifruit pollen by *Ba* D-747 after spray application.

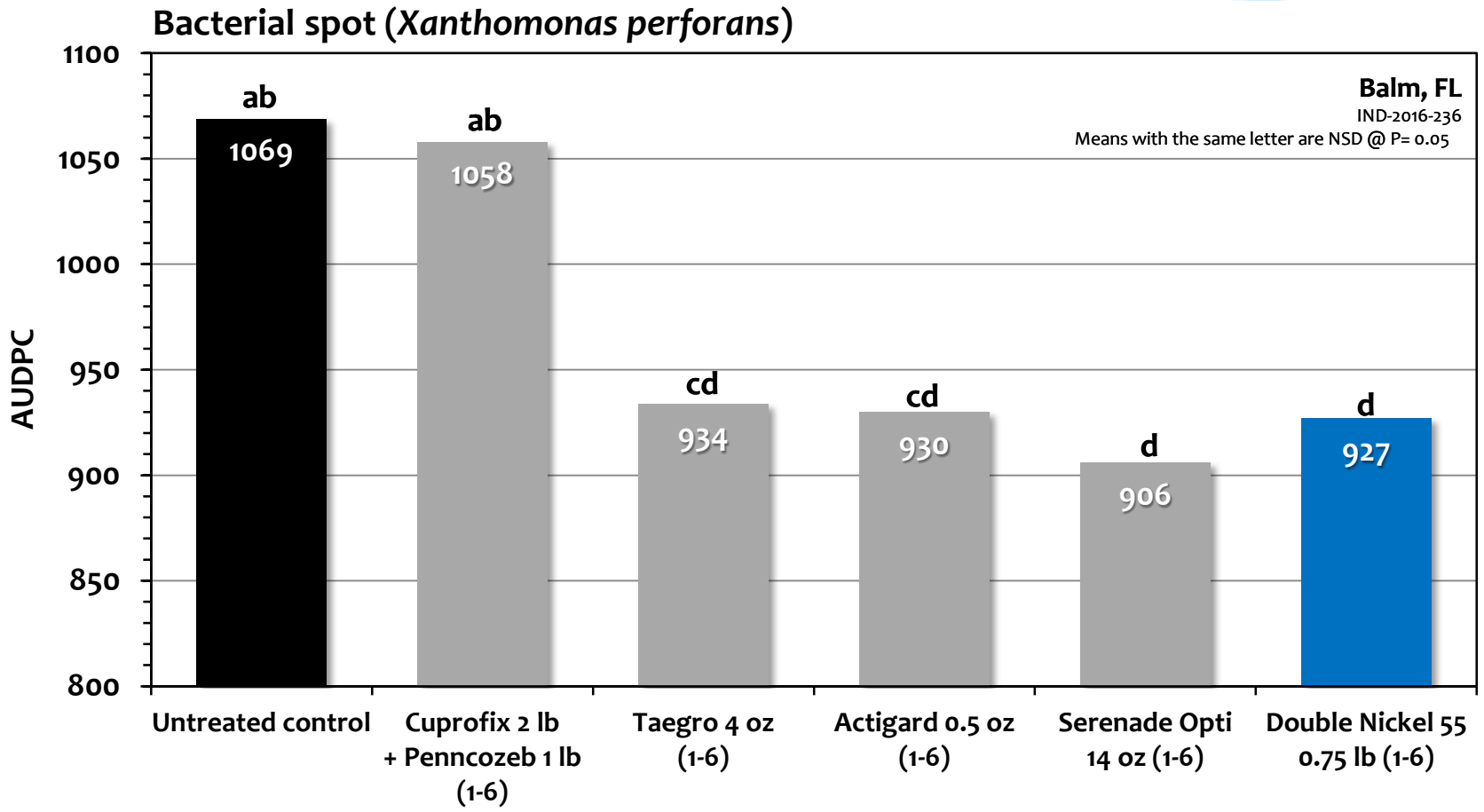


Source: G. Balestra *et al.* 2014. *L'Informatore Agrario* 22: 50-53.

CERTIS

Double Nickel 55®
BIOFUNGICIDE

Tomato

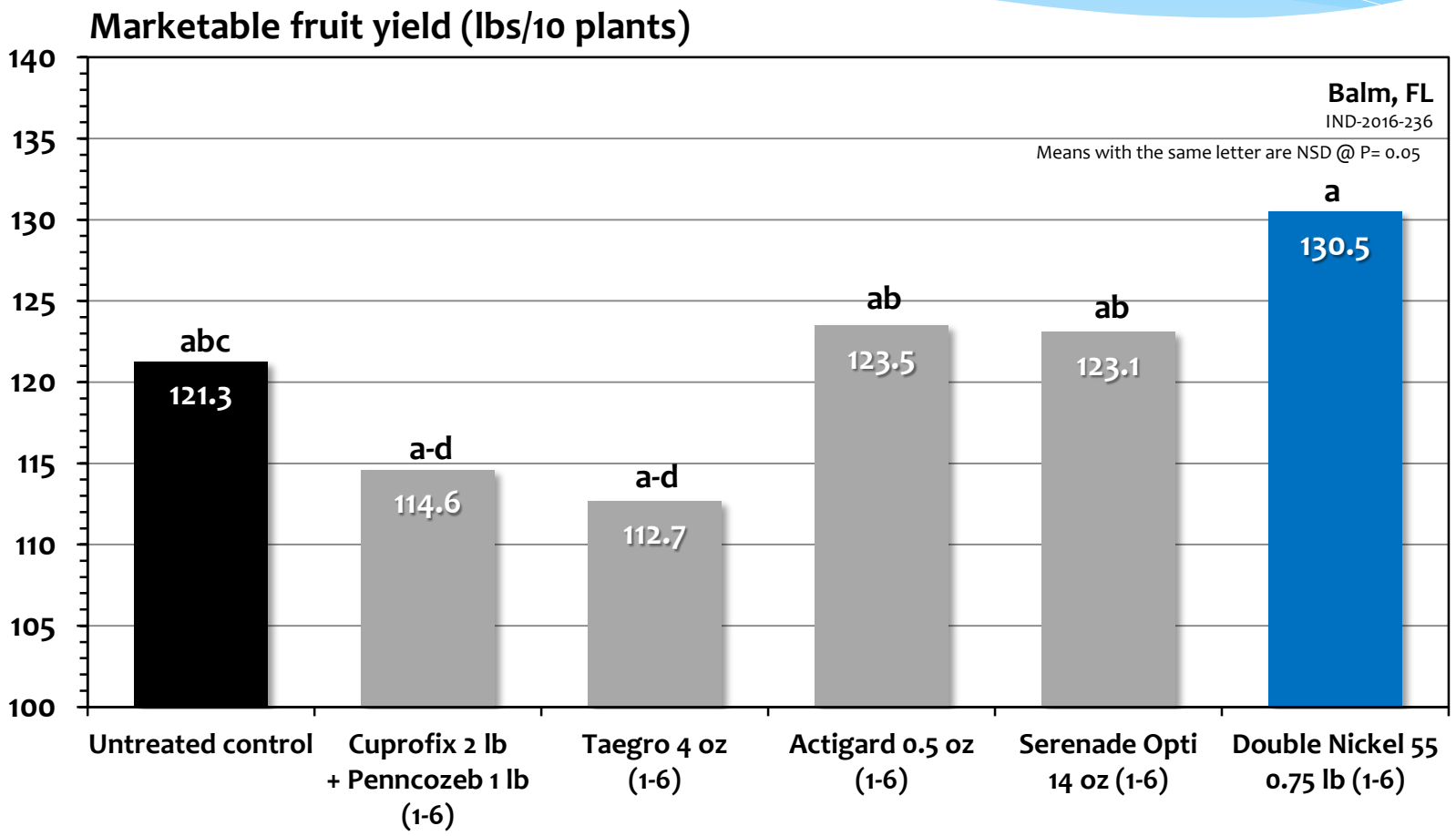


- Variety: Tycoon
- Treatments: 6 weekly applications from Sep 13 – Oct 18, 100 gal/ac
- AUDPC based on severity ratings on Oct 3, 28, and Nov 3, trial inoculated on Aug 31
- Cooperator: G. Vallad, Univ FL

CERTIS

Double Nickel 55®
BIOFUNGICIDE

Tomato



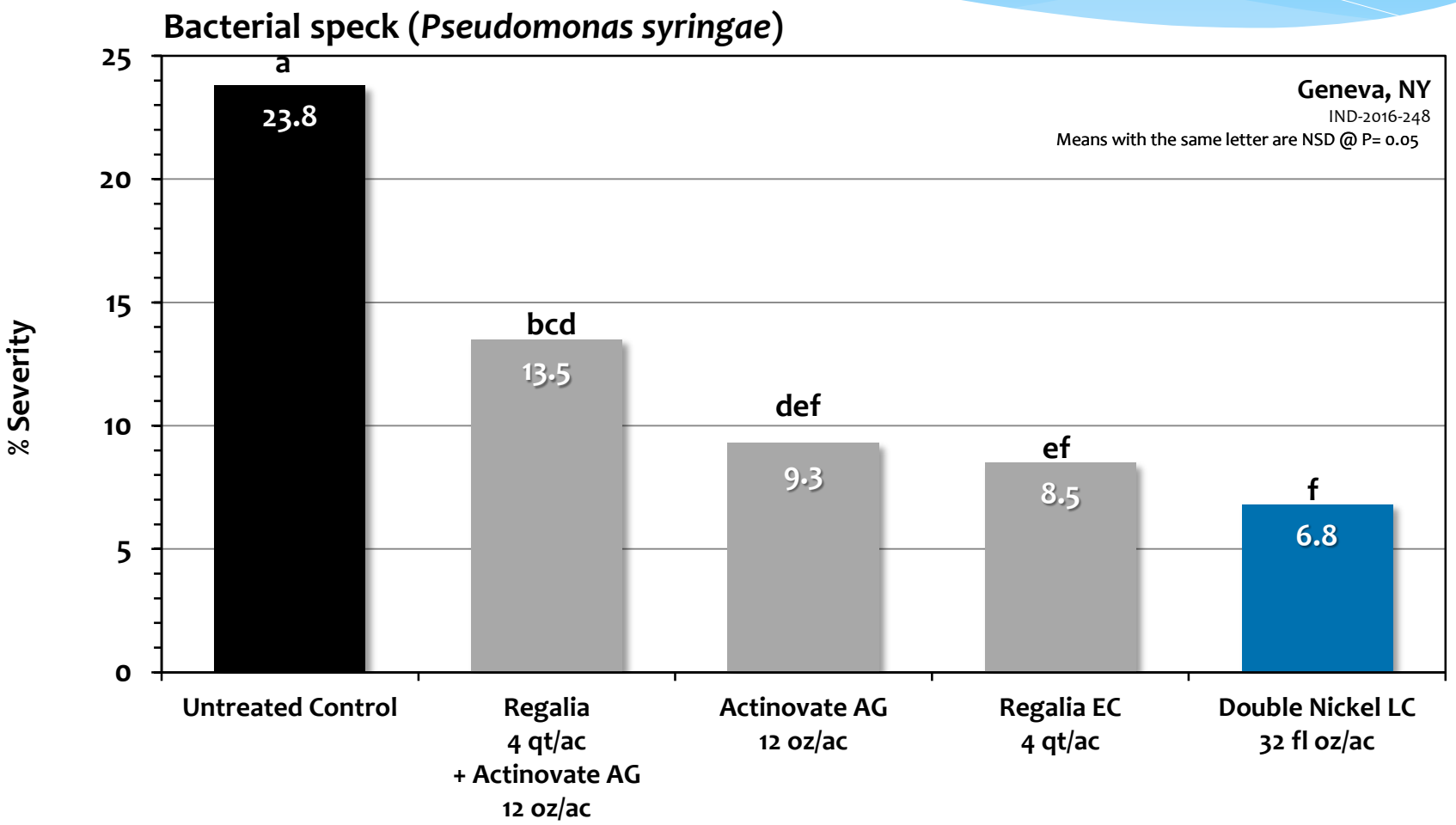
- Variety: Tycoon
- Treatments: 6 weekly applications from Sep 13 – Oct 18, 100 gal/ac
- AUDPC based on severity ratings on Oct 3, 28, and Nov 3, trial inoculated on Aug 31
- Cooperator: G. Vallad, Univ FL

CERTIS

Double Nickel LC®

BIOFUNGICIDE

Tomato



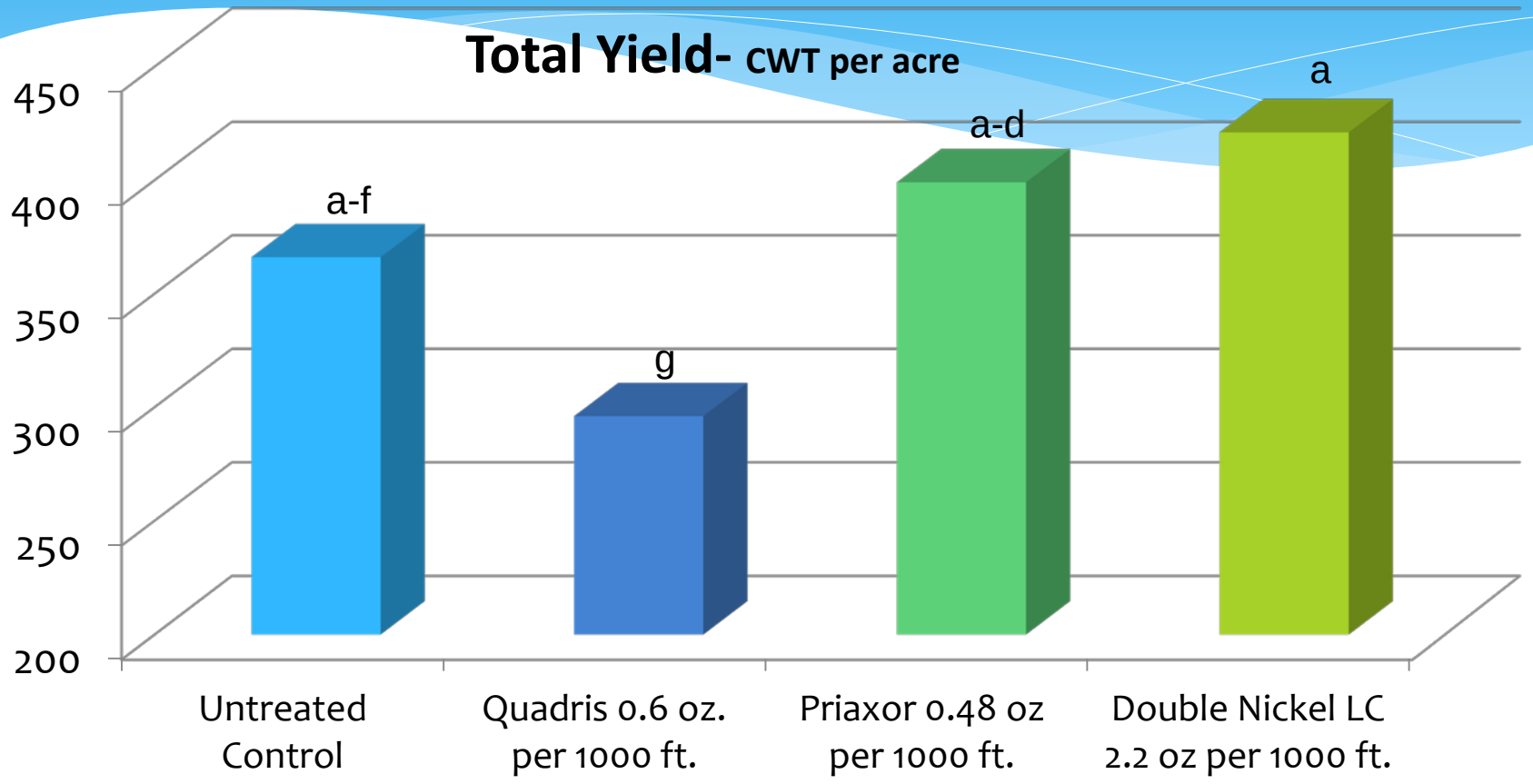
- Variety: BHN 589
- Treatments: 4 weekly applications from Jun 27 – Jul 19, 40 gal/ac @ 40 psi
- Disease was assessed on Jul 11, percent effected leaf area
- Cooperator: C. Smart/H. Lang, Cornell Univ

CERTIS

Double Nickel LC®

BIOFUNGICIDE

Rhizoctonia in Potatoes



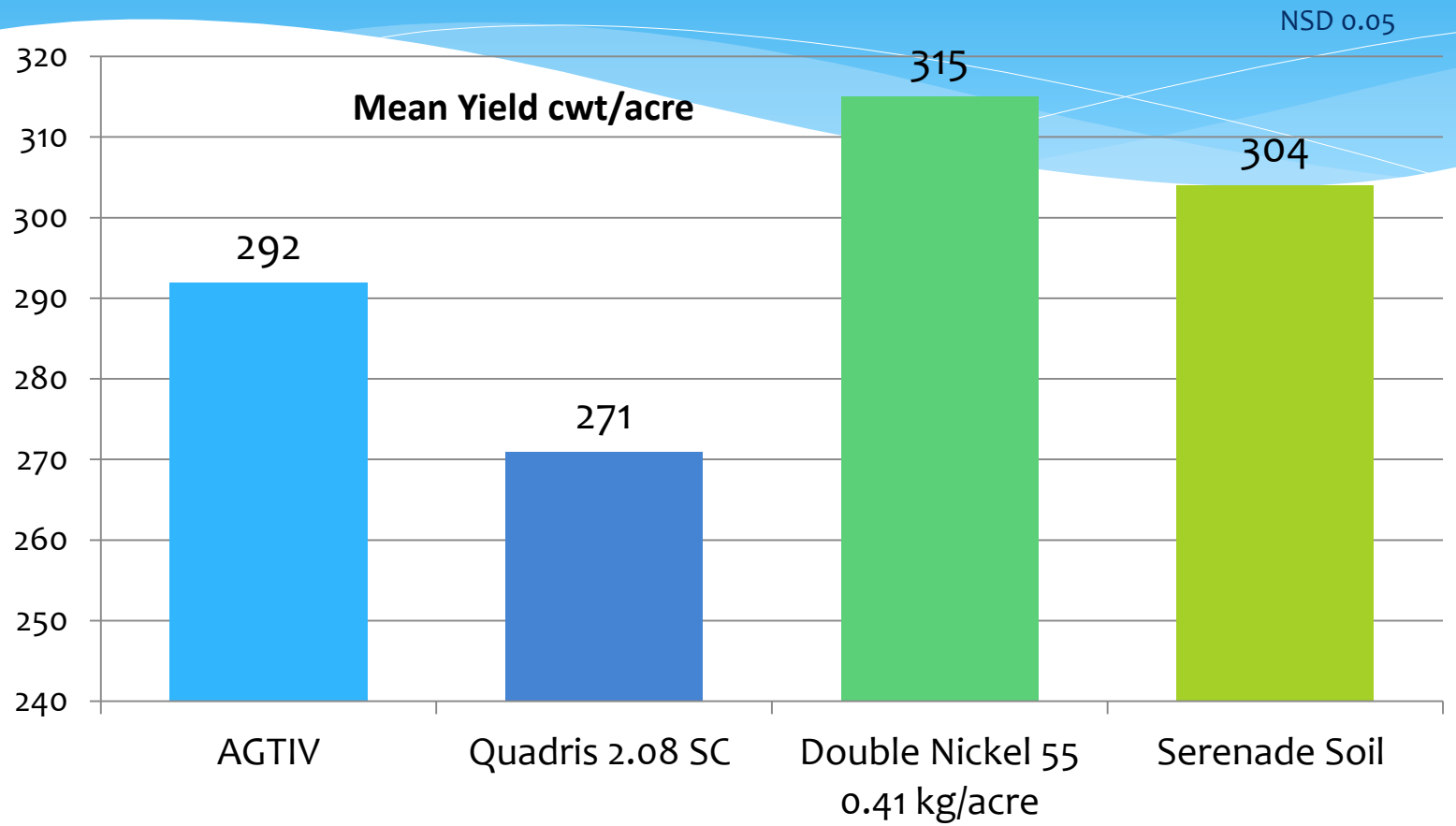
Kirk, Schafer, Rosenzweig & Steere: Michigan State University, East Lansing, MI.
Trial: MSU: Horticultural Experimental Station, Clarksville, 2014. RCB design, 4 reps, one application spray in furrow at planting, very high infection rate of Rhizoctonia. Means with same letters NSD at 0.05. CER-2014-068

CERTIS

Double Nickel 55™

BIOFUNGICIDE

Rhizoctonia Control in Potatoes



Bruxelles, Manitoba. At plant over seed furrow application. NSD at 0.05 level. IND-2016-185

CERTIS

SAR/ISR Inducers

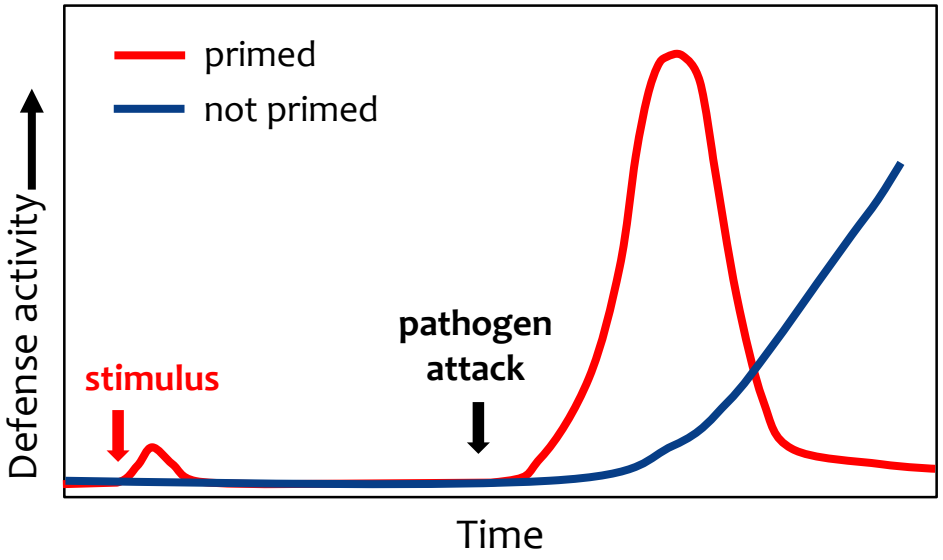
* LifeGard – Certis USA
  * *Bacillus Mycoides* isolate J
* Regalia – Marrone Bio Innovations
  * Extract of *Reynoutria sachalinensis*, (Giant Knotweed)
* ActiGard (Not NOP or OMRI) - Syngenta
* Vacciplant – Helena
  * Laminarin an oligosaccharin

Priming of Plant Defenses

LifeGard WG
BIOLOGICAL PLANT ACTIVATOR

- **Defense priming:** An induced state in which plants respond to very low levels of a stimulus in a more rapid and robust manner than unprimed plants.
- Priming for enhanced defense is a component of SAR.
- Defense priming is associated with elevated levels of PR-proteins.

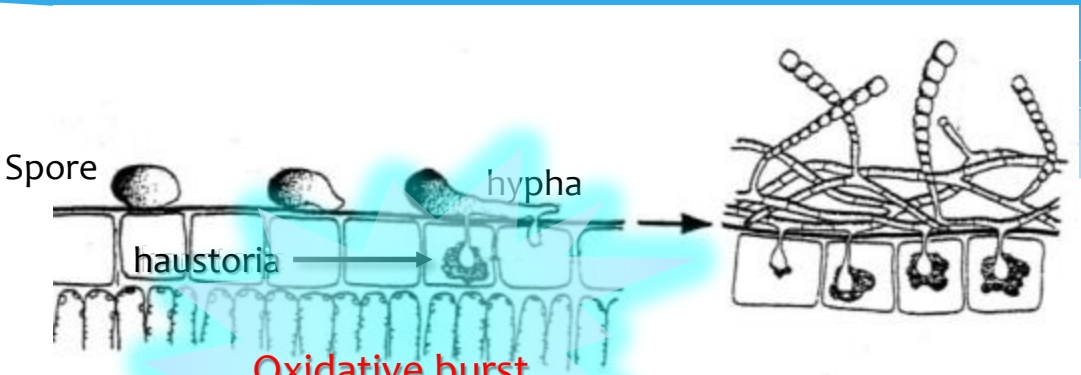
Adapted from Conrath *et al.* 2015. Ann. Rev. Phytopathol. 53: 97–119.



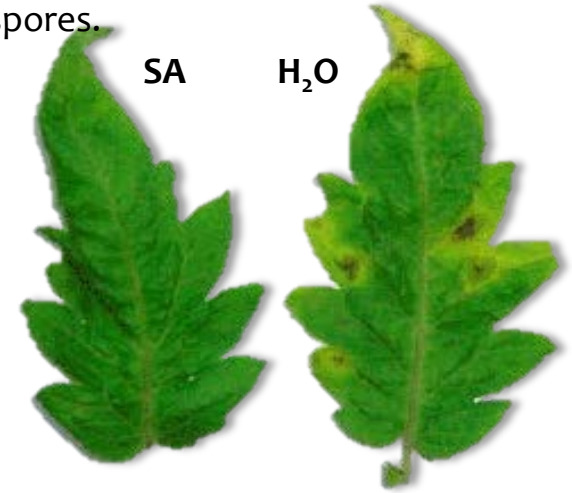
Source: www.slideshare.net/DhanyaAgri/primeome-a-molecular-approach-towards-defense-priming

CERTIS USA
The Biopesticide Company

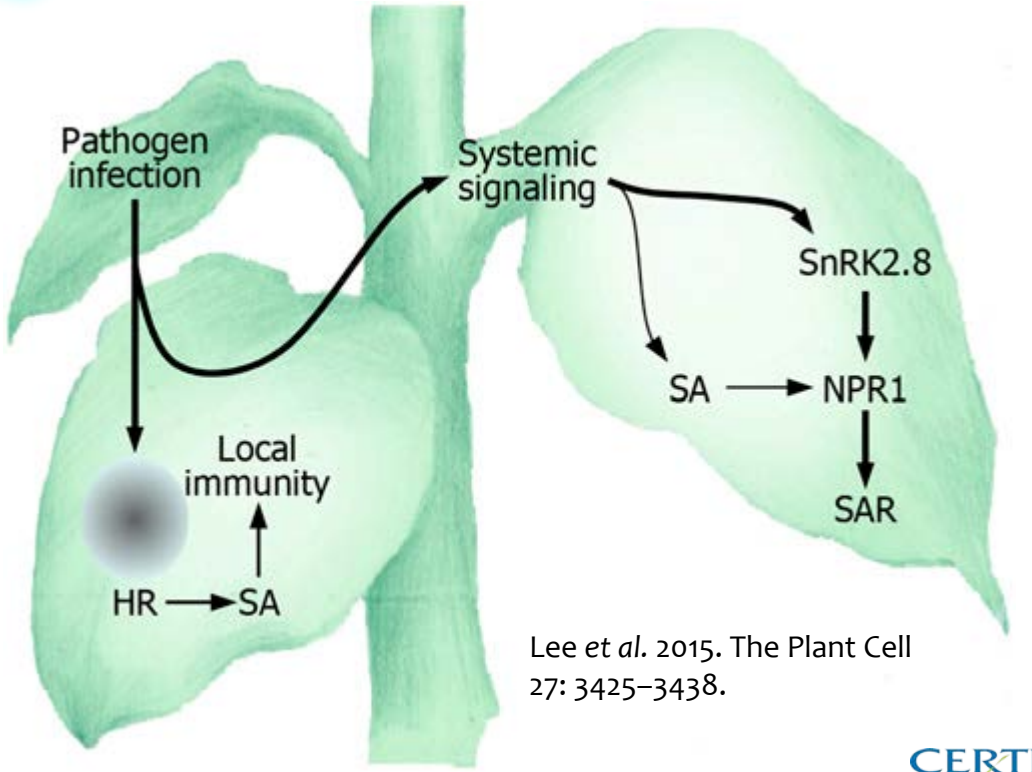
Plant Defense against Pathogens



Protection of tomato leaves against *Alternaria alternata* by foliar spray of salicylic acid (SA) four days after inoculation with *Alternaria* spores.



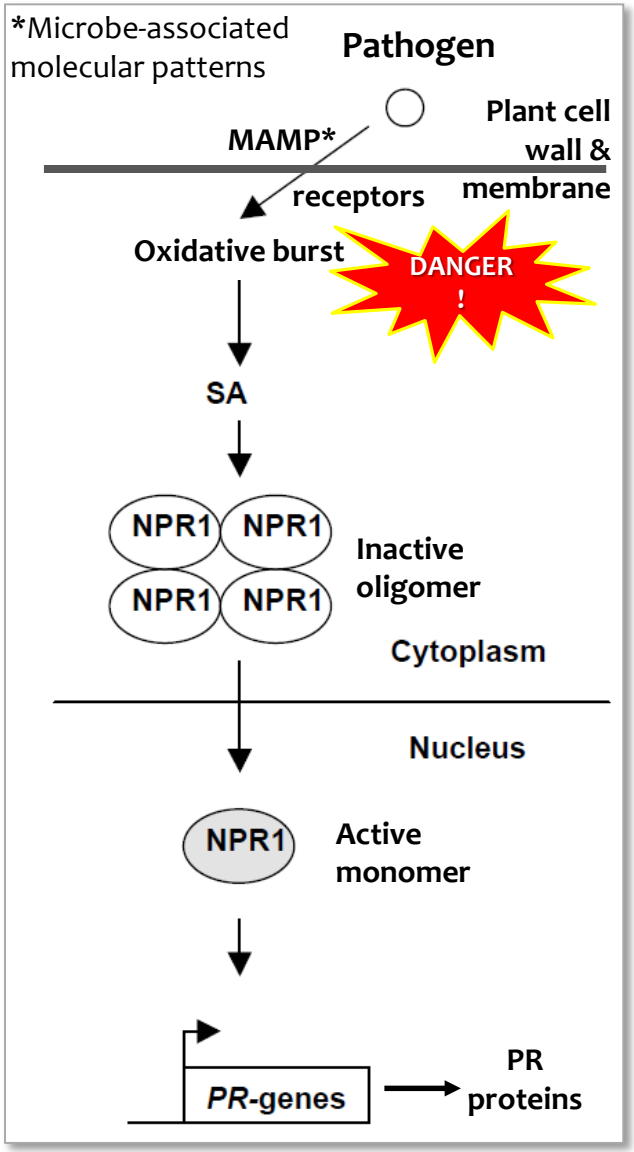
M. Esmailzedah *et al.* 2008. *J. Biol. Sci.* 8(6): 1039 – 1044.



Lee *et al.* 2015. The Plant Cell 27: 3425–3438.

CERTIS

Induced Defense against Pathogens



NPR1 = "Non-expresser of Pathogenesis-Related proteins"

Pathogenesis-related (PR) proteins:

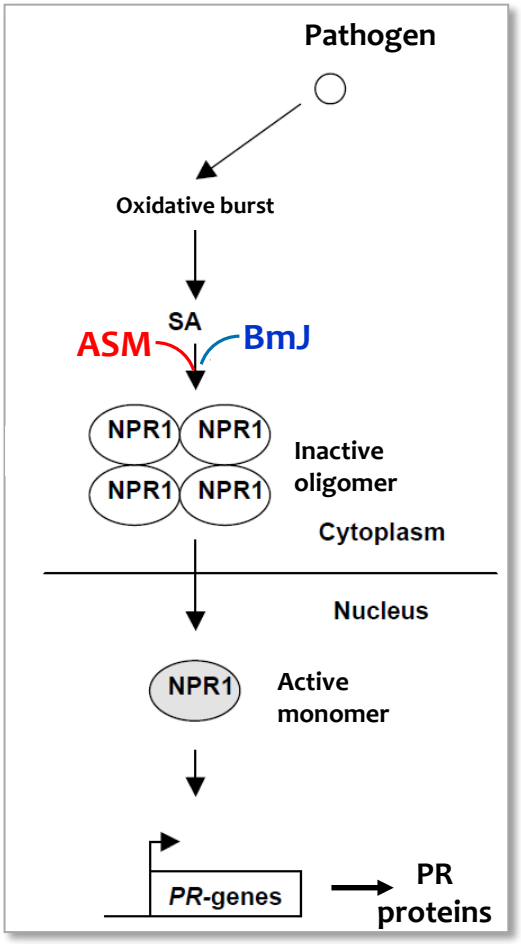
- Coded by host plant genes expressed only in pathological or related situations.
- Some are antimicrobial, others function to signal infection to nearby cells.

Family	Type member	Properties
1	PR-1	anti-oomycete
2	β-1,3-glucanase	endogluconase
3	Chitinase	endochitinase
4	Chitinase	endochitinase
5	Thaumatin-like	fungal membrane disruption
6	Proteinase-inhibitor	inhibits pathogen proteinases
7	Endoproteinase	inhibits pathogen proteinases
8	Chitinase	endochitinase
9	Peroxidase	liginification
10	Ribonuclease-like	digests RNA
11	Chitinase	endochitinase
12	Defensin	plasma membrane disruption
13	Thionin	plasma membrane disruption
14	Lipid Transfer Protein	plasma membrane disruption

CERTIS

BmJ Mode of Action

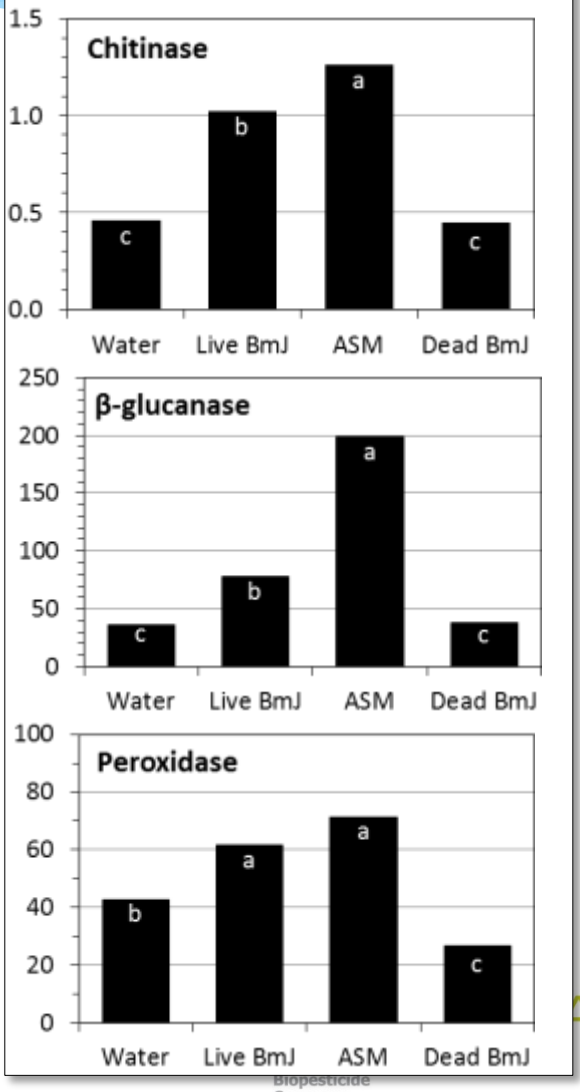
LifeGard™ WG
BIOLOGICAL PLANT ACTIVATOR



- No direct antagonistic effects on plant pathogens.
- LifeGard spores triggers the SAR process by directly activating NPR1 protein in 3 hours
- Mode of Action similar to acibenzolar-S-methyl (ASM): Actigard, Blockade, Bion (Syngenta) - BUT –
- No phytotoxity observed in 20 years of trials.
- LifeGard response persists 18 – 21 days (vs. ~14 days for ASM).

MAKES THE PLANT RESISTANT !

Systemic sugar beet apoplastic PR protein activity 6 days after treatment.



References:
Bargabus et al. 2002. *Physiol. Mol. Plant Pathol.* 61: 289-298
Bargabus-Larson & Jacobsen. 2007. *J. Sugar Beet Res.* 44: 17-33.

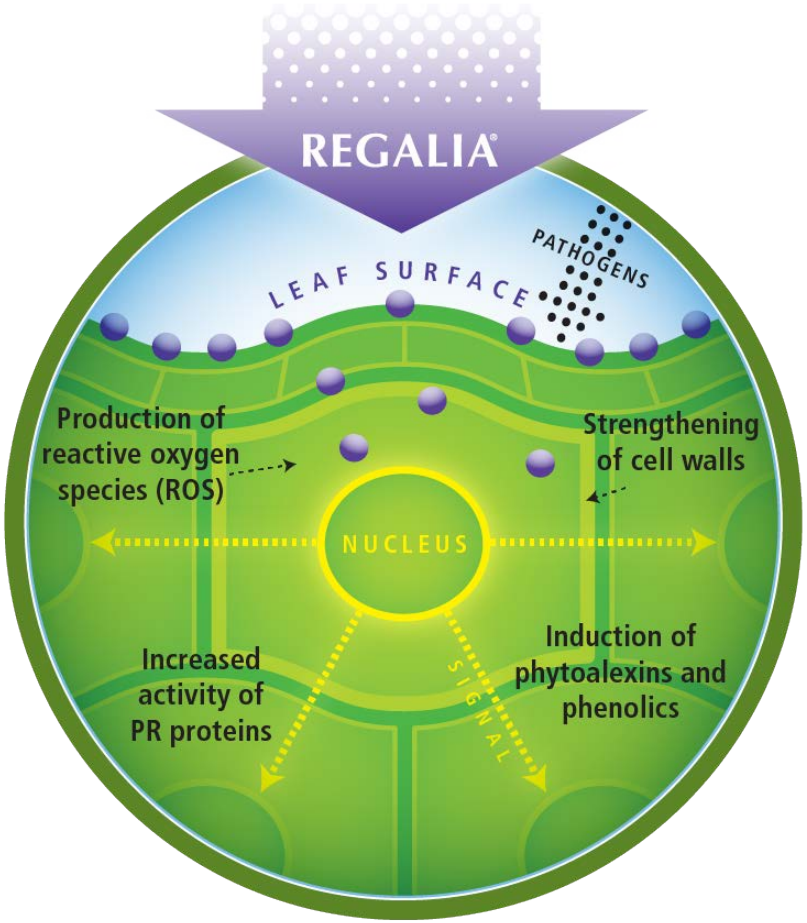
Biopesticide Company

Regalia® Mode of Action

Activates Plants' Natural Defenses

Induced Systemic Resistance (ISR)

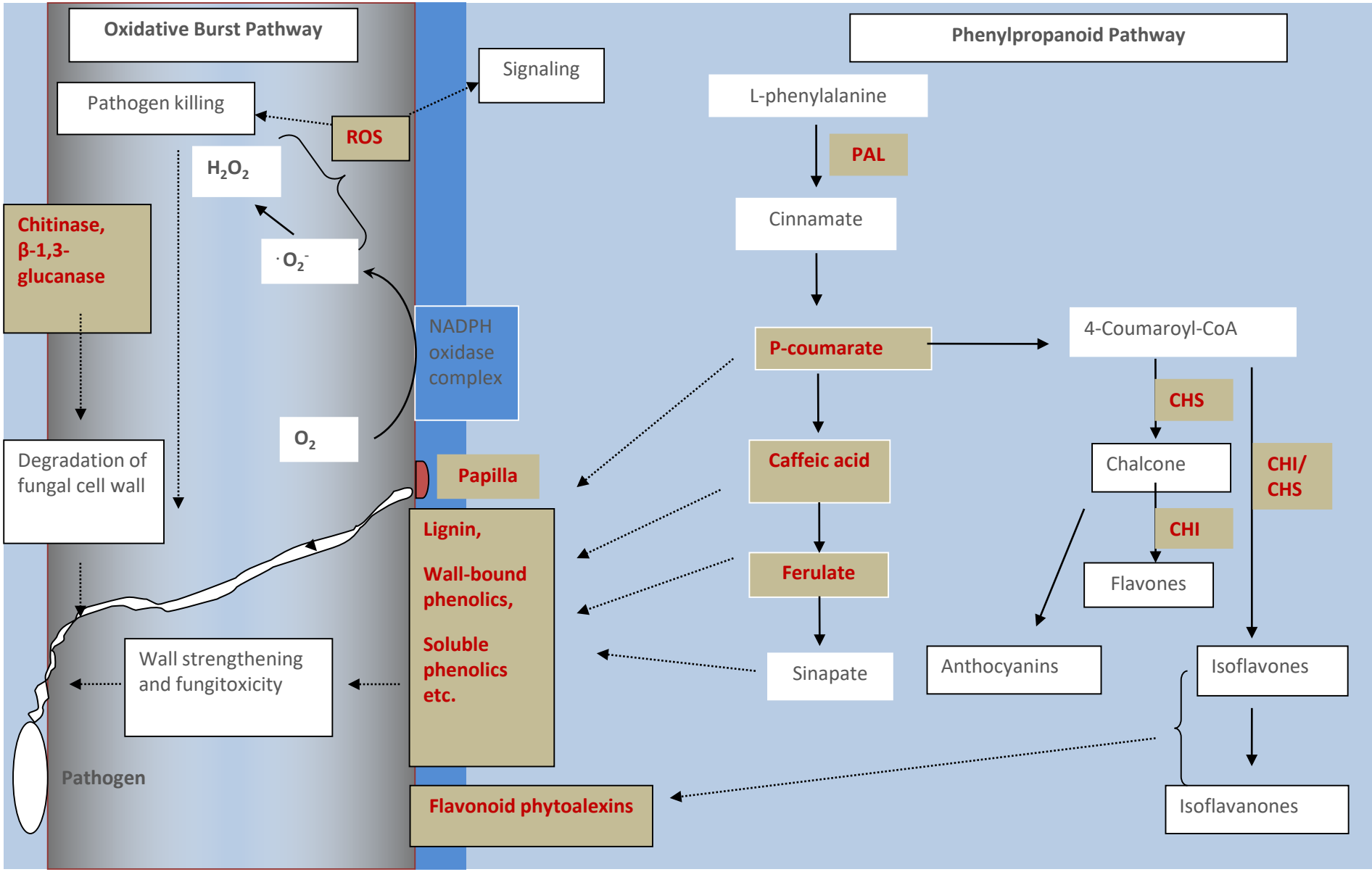
GROUP P5 FUNGICIDE



- **Inhibits Pathogen Growth**
- **Strengthens Cell Walls**
- **Promotes Plant Growth**
  - *Independent of disease control, increases leaf chlorophyll content*

Marrone Bio Innovations

Regalia® Mode of Action Summary



How to use ISR/SAR Compounds

* APPLY EARLY!!
* 1) Stand Alone (Rarely!)
* 2) In a program – replacing other products (Most Common)
* 3) In addition to a program (Special Cases)

LifeGard™ WG

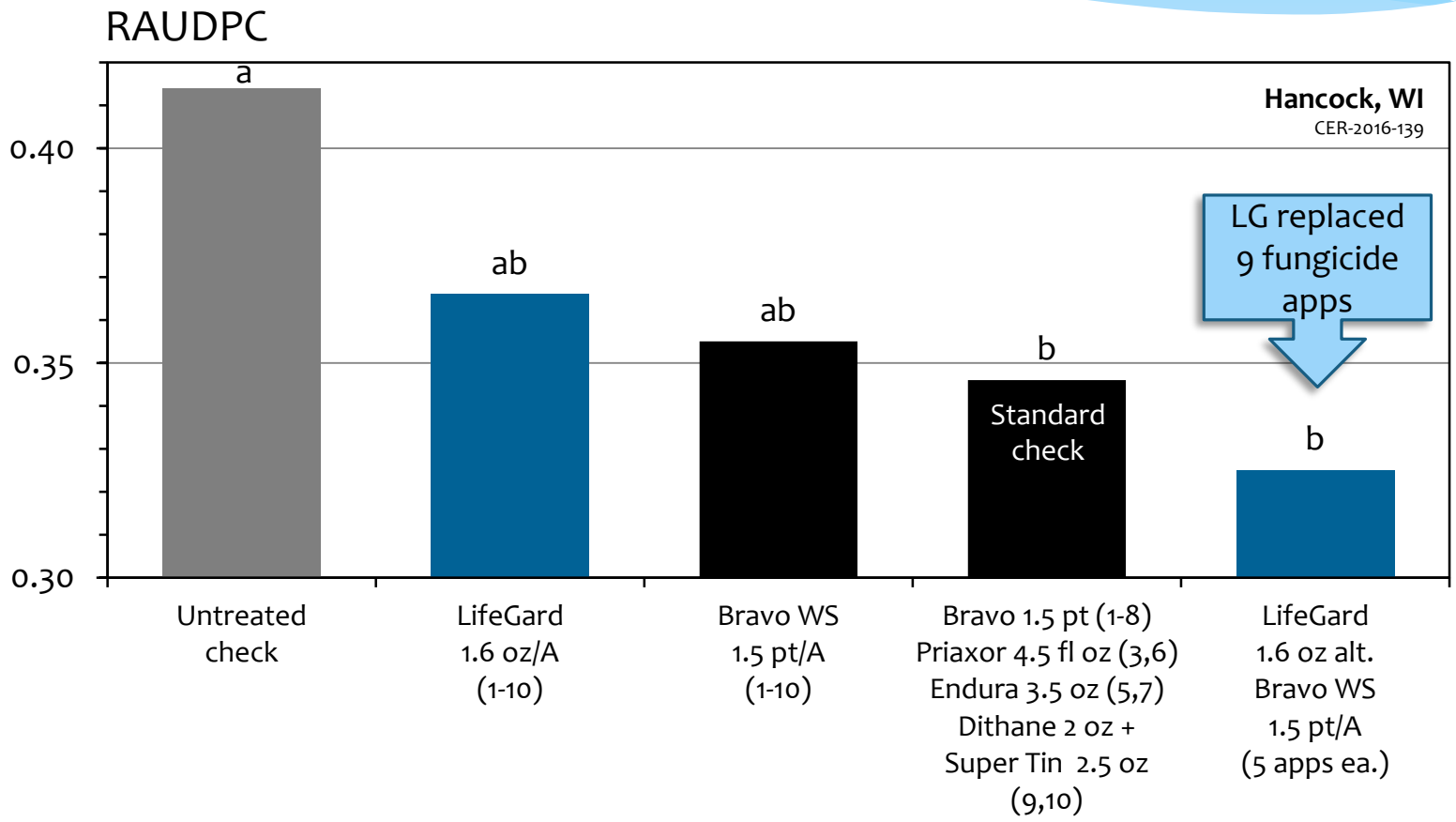
BIOLOGICAL PLANT ACTIVATOR

Potatoes

CERTIS USA

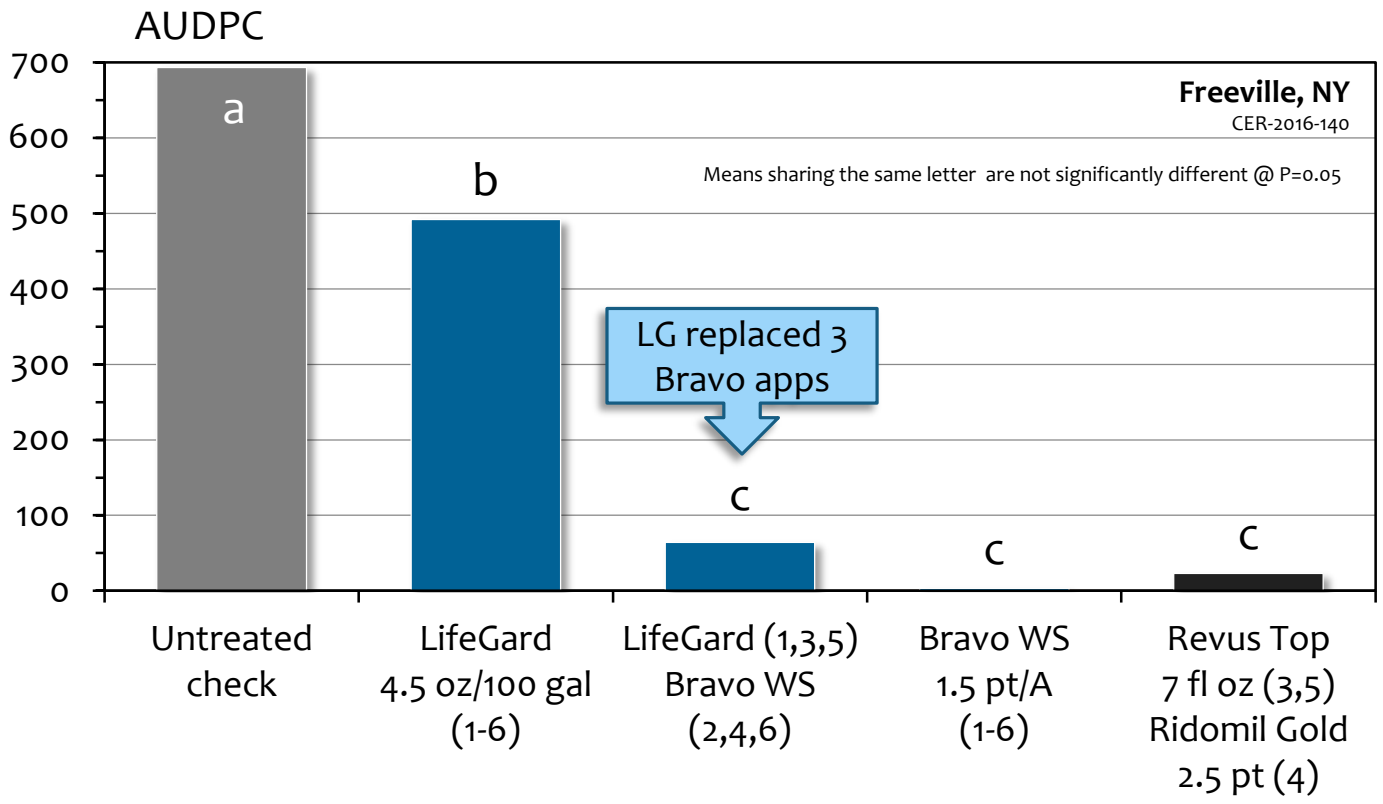
The Biopesticide Company

Potato Early Blight



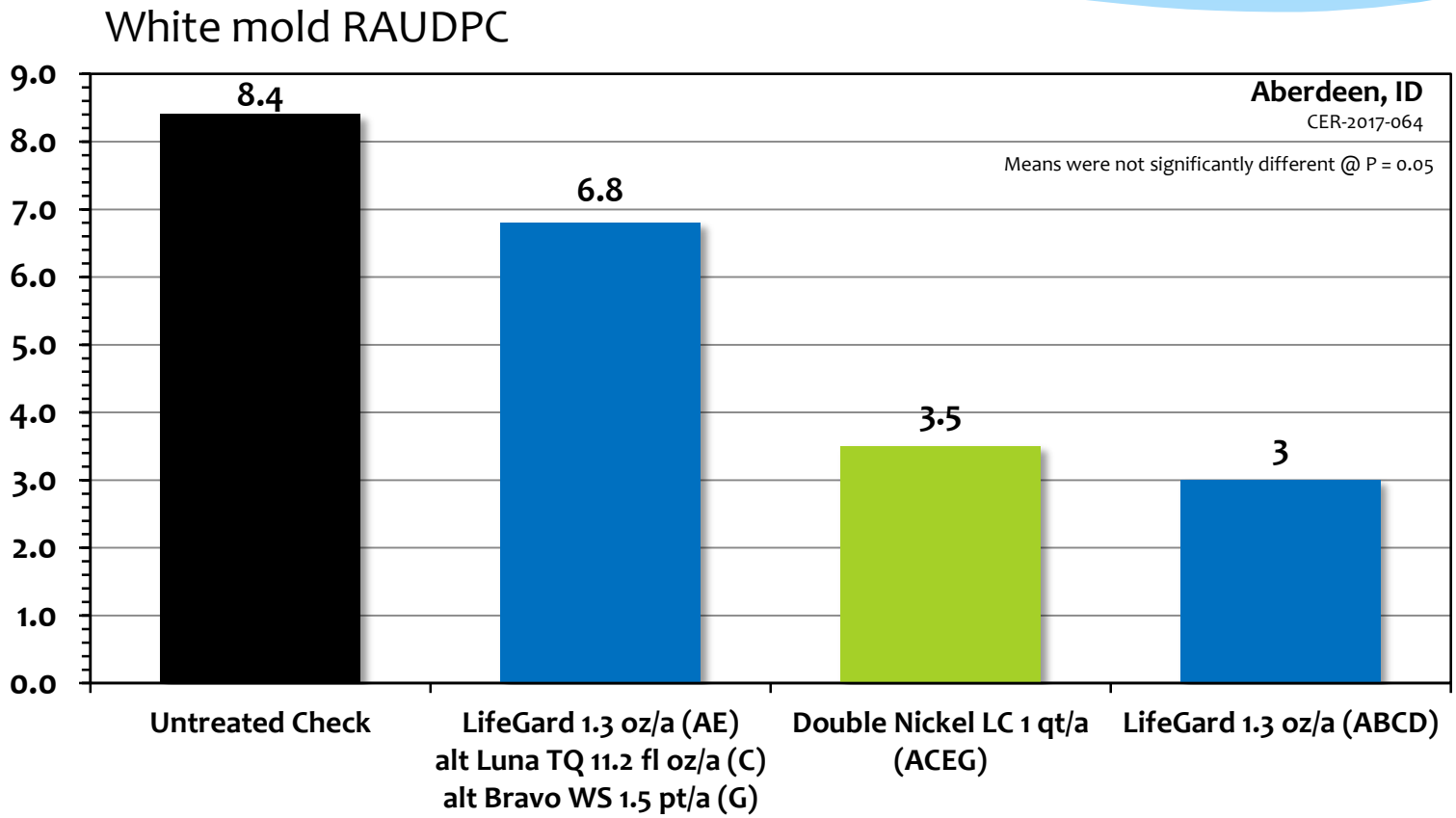
- 10 weekly applications 13 Jul - 7 Sep.
- Tractor-mounted spray boom delivering 35 GPA at 40 psi through 4 nozzles/row.
- LifeGard applied at concentration of 10^7 cfu/ml (4.5 oz/100 gal).
- Cooperator: A. Gevens & S. Jordan, Univ. Wisconsin

Potato Late Blight



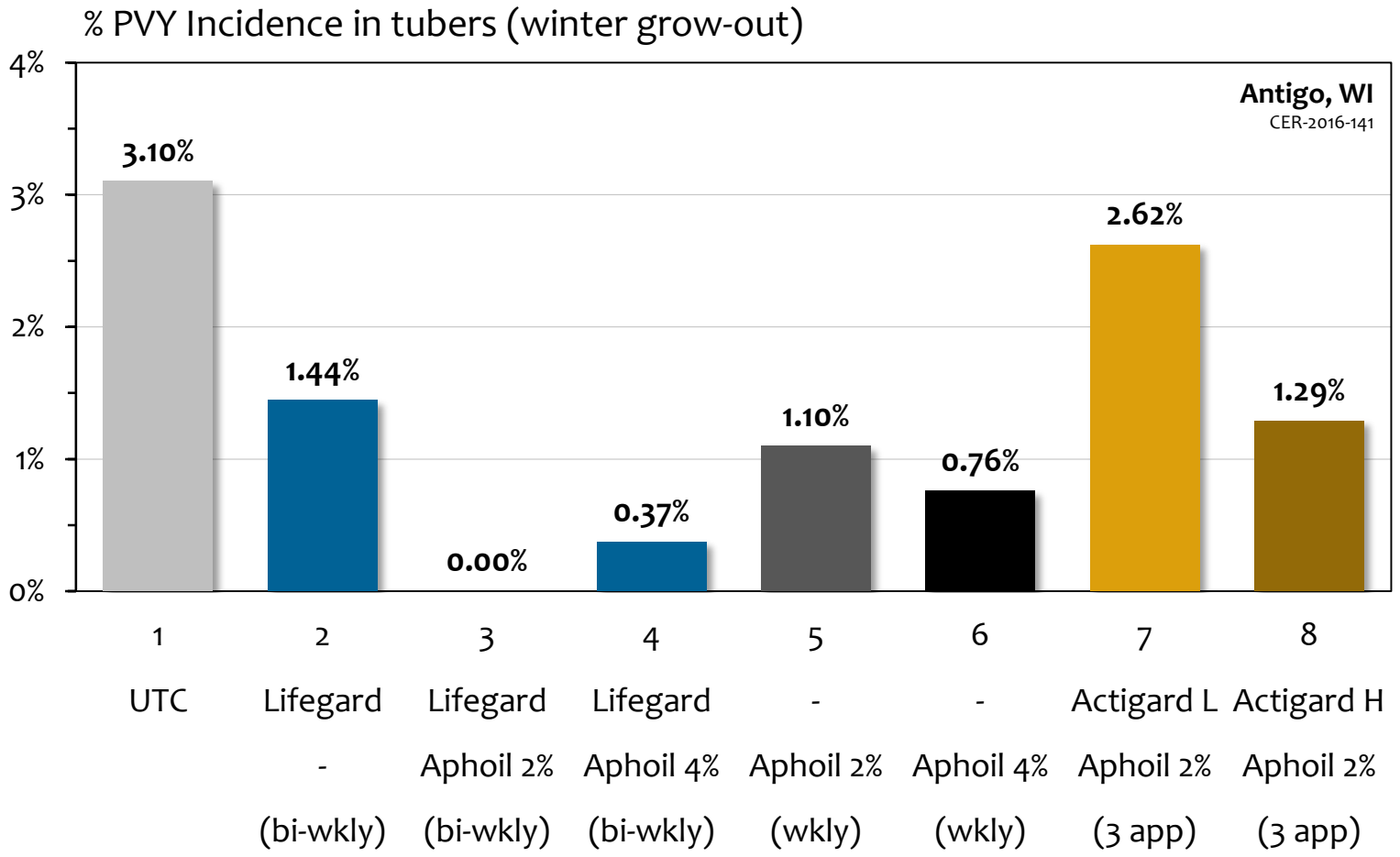
- Variety: Katahdin
- Artificially inoculated with *P. infestans* (US-24) at 1 day after 2nd application.
- Cooperator: H. Mayton & W.E. Fry, Cornell Univ.

Potato – White mold



- Variety: Russet Burbank
- Treatments applied at 7d intervals starting July 18 through Aug 29.
- Tank mix size of 2 liters, applied at 25 gal/ac @ 30 psi
- Cooperator: P. Wharton, Univ. Idaho

Potato



- LifeGard applied at 1.78 oz./acre in 28 GPA.
- No statistically significant differences between treatments ($P > 0.05$).
- Cooperator: R. Groves, Univ. Wisconsin

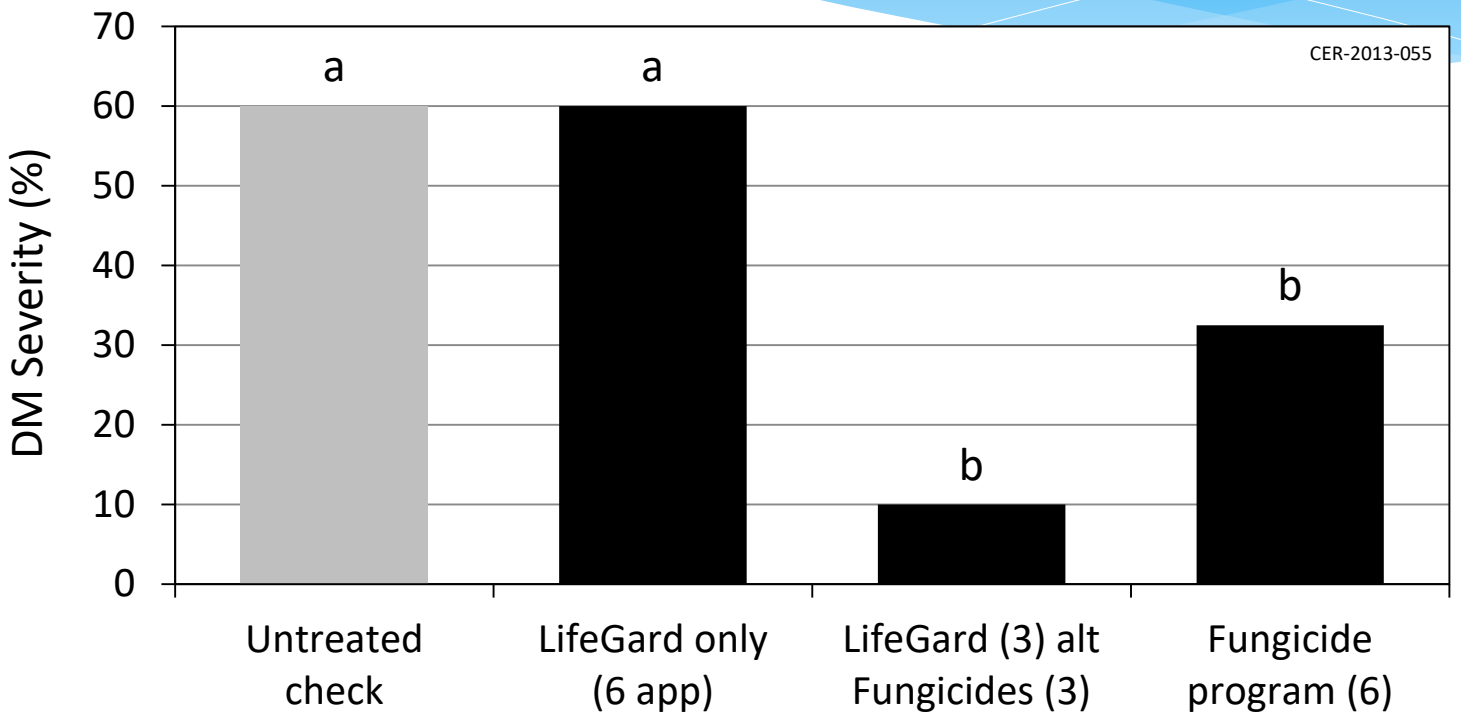
LIFEGARD™ WG

BIOLOGICAL PLANT ACTIVATOR

Cucurbits

Downy mildew in cucumbers

David Langston, University of Georgia, Tifton, Georgia

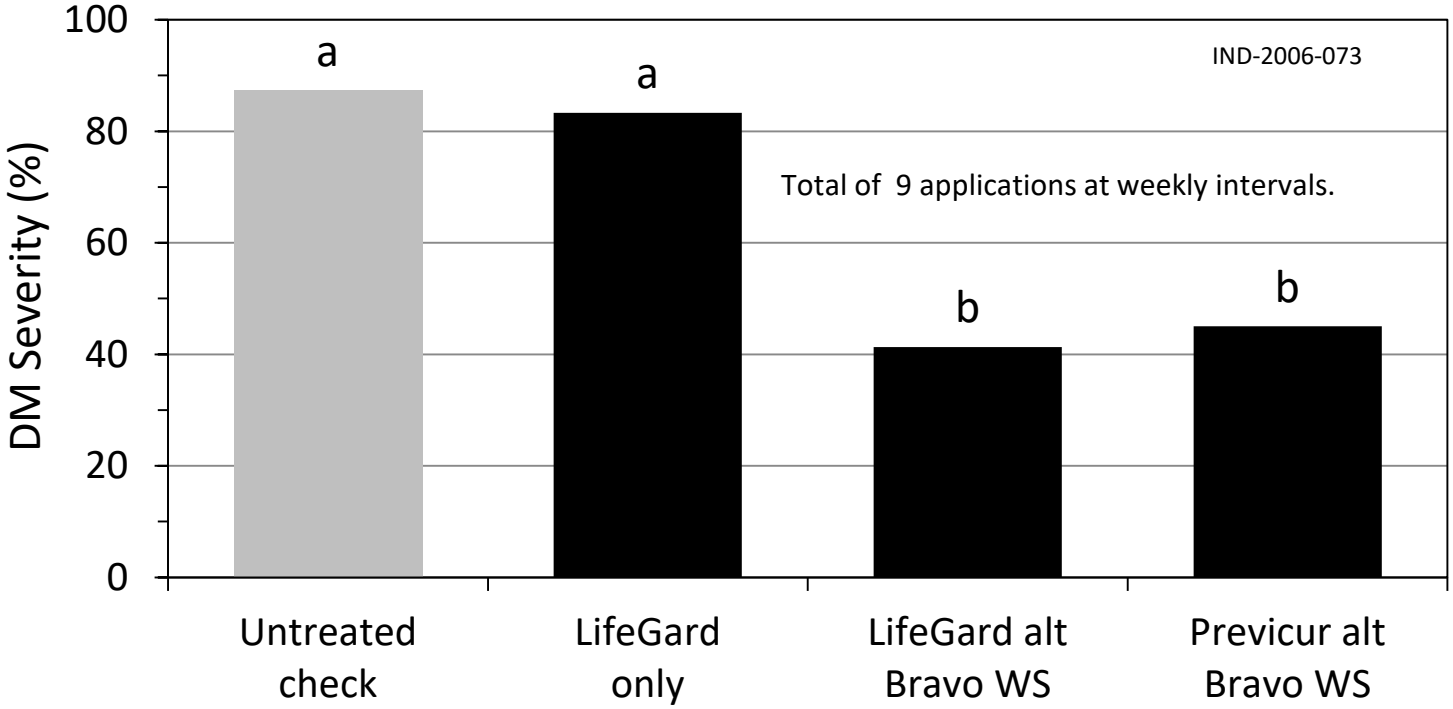


Treatment	Spray sequence (weekly intervals)					
	A	B	C	D	E	F
LifeGard only	LifeGard	LifeGard	LifeGard	LifeGard	LifeGard	LifeGard
LifeGard alt Fungicides	LifeGard	Zampro + Manzate	LifeGard	Ranman + Manzate	LifeGard	Zampro + Manzate
Fungicide program	Zampro + Manzate	Ranman + Manzate	Zampro + Manzate	Ranman + Manzate	Zampro + Manzate	Ranman + Manzate

LifeGard applied at 4.5 oz. per 100 gal. , 40 GPA.

Downy mildew in summer squash

Ken Pernezny, UFL, Fort Pierce, Florida



LifeGard applied at 4.5 oz. per 100 gal. , 32-64 GPA, dependent on plant size.

LIFEGARD™ WG

BIOLOGICAL PLANT ACTIVATOR

Fruiting Vegetables

Bacterial leaf spot in tomato

Mills River, NC

CER-2012-034

LifeGard™ WG
BIOLOGICAL PLANT ACTIVATOR

Appl	Standard program	LifeGard program	Actigard program
1	Endura, Kocide, Actigard	BmJ	Actigard
2	Kocide	BmJ	Actigard
3	Endura, Kocide, Actigard	BmJ	Actigard
4	Kocide	BmJ, Manzate, Kocide	Actigard, Manzate, Kocide
5	Endura, Kocide, Actigard, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
6	Kocide, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
7	Endura, Kocide, Actigard, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
8	Kocide, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
9	Endura, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
10	Ranman	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo
11	Endura, Bravo	BmJ, Manzate, Kocide, Bravo	Actigard, Manzate, Kocide, Bravo

Untreated check

Grower standard

LifeGard program

Actigard program

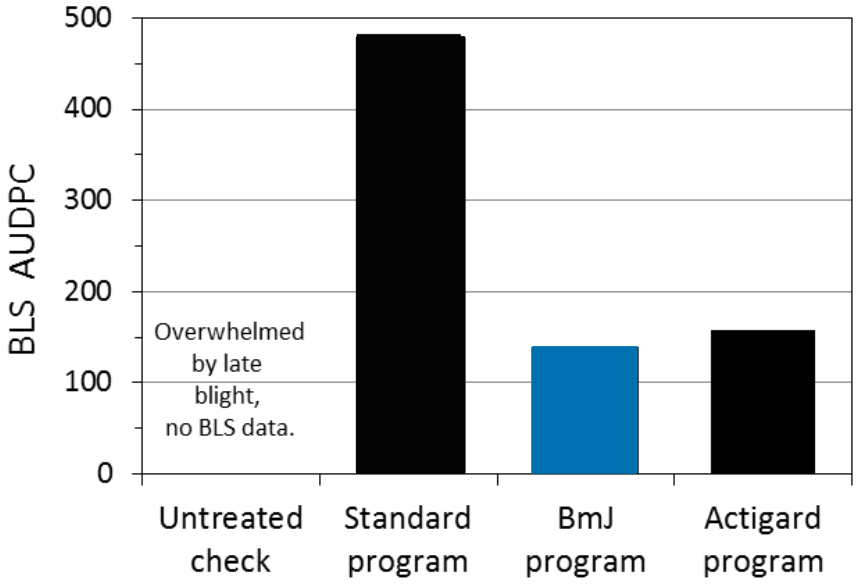
CERTIS USA
The Biopesticide Company

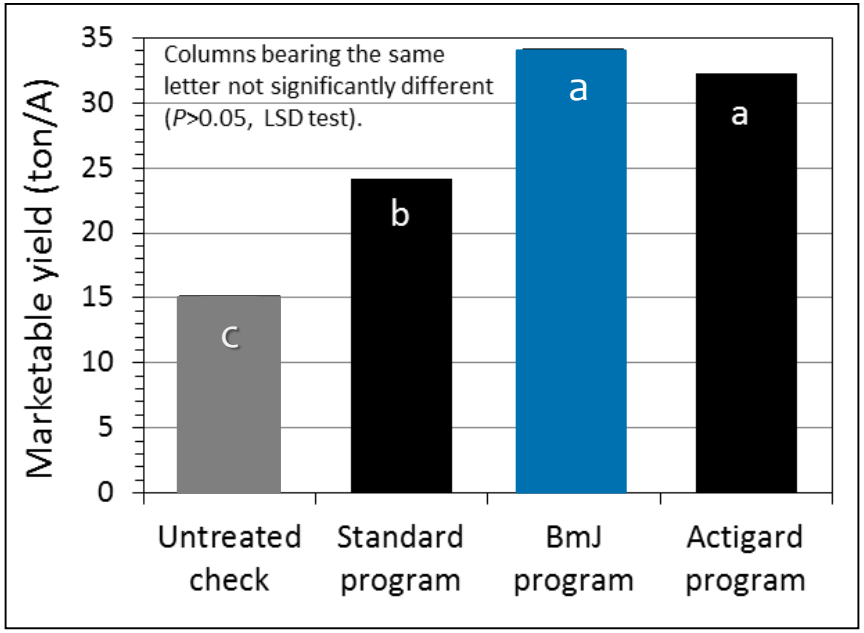
Bacterial leaf spot in tomato

Mills River, NC

CER-2012-034

LifeGard WG
BIOLOGICAL PLANT ACTIVATOR



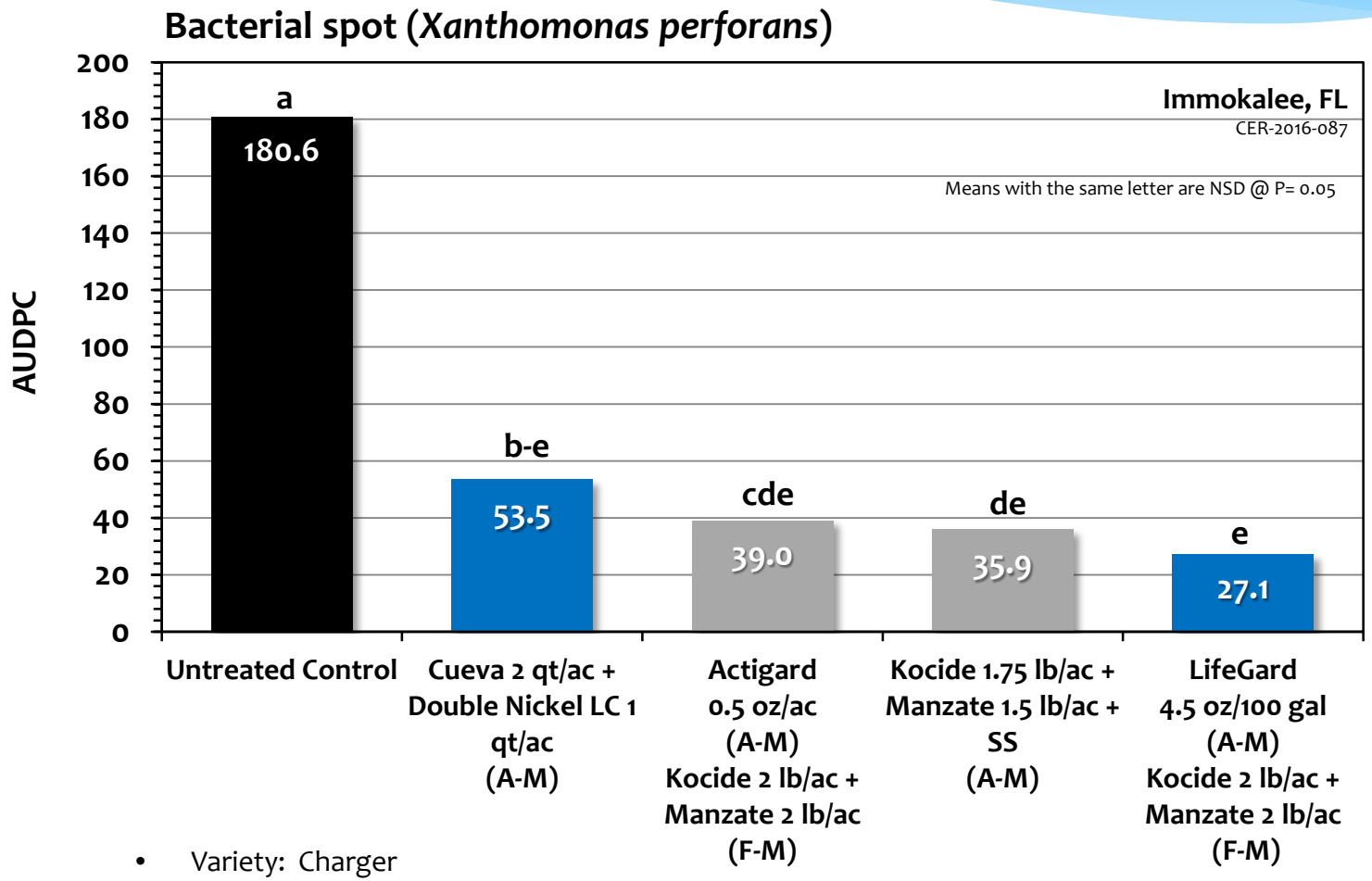


Application rates:

LifeGard WG: 3.5 oz/100 gal (8×10^6 cfu/ml)
Kocide® 3000 ($Cu(OH)_2$, Kocide L.L.C.): 1.75 lb/Ac
Manzate® DF (Zn/Mn/EBDC, UPI): 1.5 lb/Ac
Bravo Weather Stik® (chlorothalonil, Syngenta): 1.5 pt/Ac
Endura® (boscxalid, BASF): 3.5 oz/Ac
Ranman® (cyazofamid, FMC Corp.): 2.75 oz/Ac
Actigard® (ASM, Syngenta): 0.5 oz/Ac

CERTIS USA
The Biopesticide Company

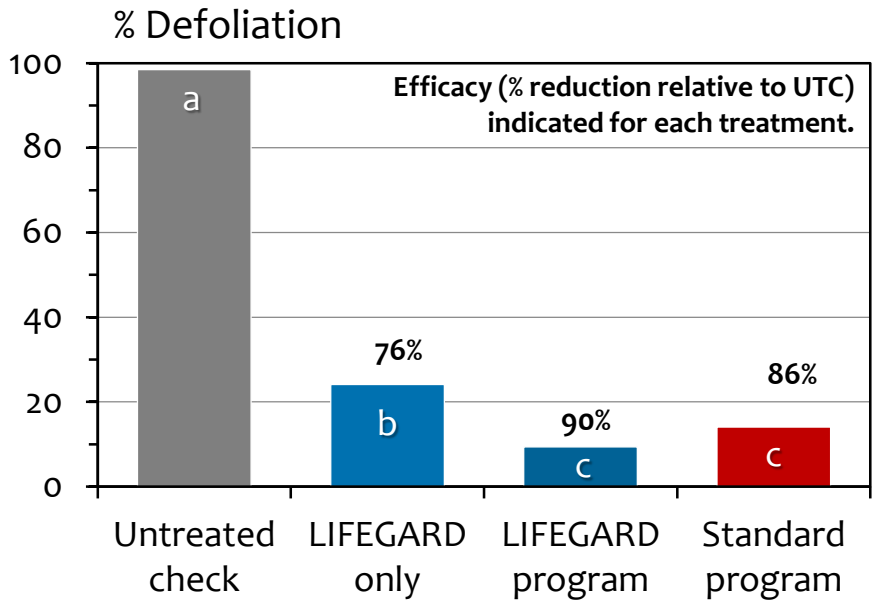
Tomato

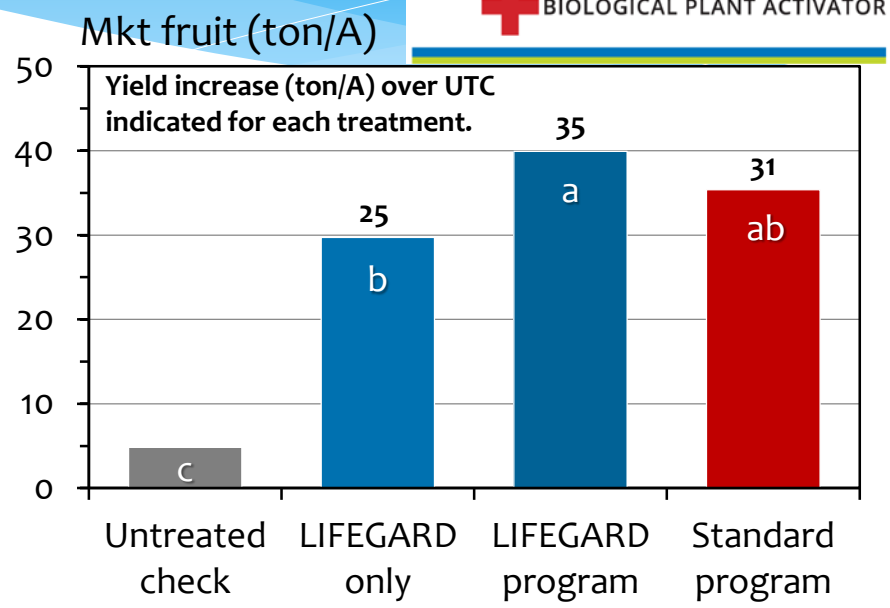


- Variety: Charger
- Treatments: 13 applications made at 90 gal/ac from Sep 23 to Dec 13
- AUDPC values calculated from 2 rating dates; Dec 9, and Dec 15
- Disease severity was considered light despite two inoculations (Oct 26 and Nov 4)
- Cooperator: Pam Roberts, Univ FL

Tomato Early & Late Blight

LIFEGARD™ WG
BIOLOGICAL PLANT ACTIVATOR





Untreated check

LIFEGARD

Standard program

K. Ivors, NC State University, Mills River, North Carolina

Thank you!

Greg Rogers
Elkon, MD
443-967-4010