



BioWorks®

How You Grow Matters™

Managing Disease and Insects in Strawberry with Biopesticides

Best practices for handling and applying biofungicides and bioinsecticides for managing diseases and pests in strawberry

Julie Graesch, BPM Insect Management, BioWorks

We Are Not the Only Organisms That Love Strawberries...

~200 species of pests are known to attack strawberries

- Insects/mites/animals/gastropods:
 - Slugs, fruit flies, chafers, root weevils, thrips, beetles, lepidoptera, mites, aphids, whitefly...
- Diseases:
 - *Xanthomonas*, *Pseudomonas*, Downy mildew, *Alternaria*, Anthracnose, *Fusarium*, *Rhizoctonia*, *Pythium*, *Botrytis*, *Phytophthora*...



www.boredpanda.com



Environmental Working Group (EWG)

- Organization dedicated to protecting human health and environment
- In 2019, >90% of produce tested + for 2 or more pesticide

The Dirty Dozen

- | | |
|-----------------|--------------|
| 1. Strawberries | 7. Peaches |
| 2. Spinach | 8. Cherries |
| 3. Kale | 9. Pears |
| 4. Nectarines | 10. Tomatoes |
| 5. Apples | 11. Celery |
| 6. Grapes | 12. Potatoes |

The Clean Fifteen

- | | |
|---------------|---------------------|
| 1. Avocados | 9. Kiwi |
| 2. Sweet corn | 10. Cabbage |
| 3. Pineapples | 11. Cauliflower |
| 4. Sweet peas | 12. Cantaloupes |
| 5. Onions | 13. Broccoli |
| 6. Papaya | 14. Mushrooms |
| 7. Eggplants | 15. Honeydew melons |
| 8. Asparagus | |

Strawberries topped the Dirty Dozen list 3 years in a row

What's on My Food?

- **STRAWBERRIES**
- 45 Pesticide Residues Found by the USDA Pesticide Data Program

Human Health Effects:

- 6 — Known or Probable Carcinogens⁴
- 16 — Suspected Hormone Disruptors
- 7 — Neurotoxins
- 6 — Developmental or Reproductive Toxins

Environmental Effects:

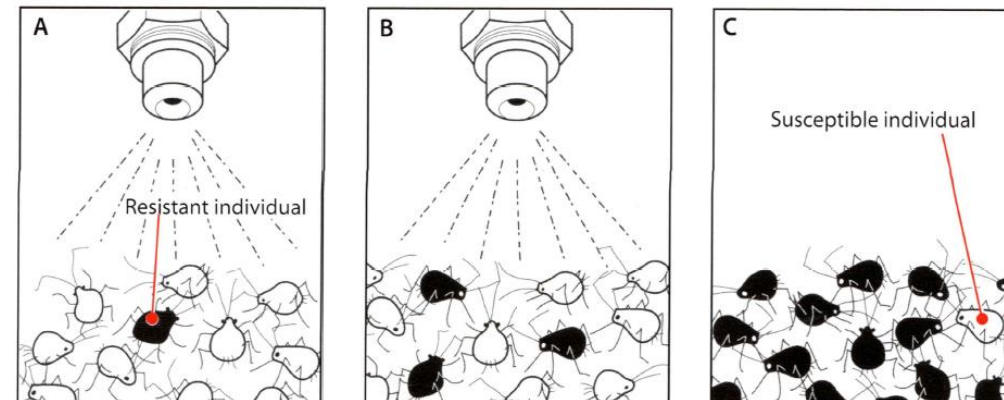
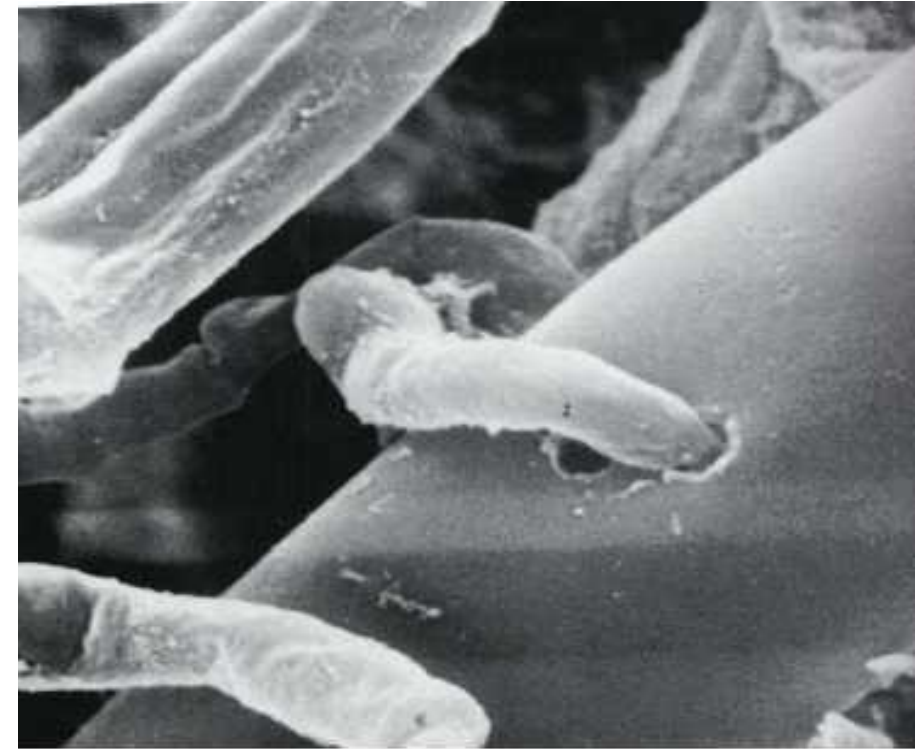
- 12 — Honeybee Toxins⁵

Pesticide Residues Found in Strawberries:

What Pesticide?	How Often is it Found? ⁶	Conventional vs. Organic	Toxicity ⁷	Other Foods with this Pesticide
Tetrahydrophthalimide (THPI)	55.3%	Conventional vs. Organic		Other Foods
Pyraclostrobin	43.5%	Conventional vs. Organic		Other Foods
Captan	42.6%	Conventional vs. Organic		Other Foods
Fenhexamid	39.3%	Conventional vs. Organic		Other Foods
Pyrimethanil	36.8%	Conventional vs. Organic	  	Other Foods
Boscalid	36.3%	Conventional vs. Organic		Other Foods
Fludioxonil	35.4%	Conventional vs. Organic		Other Foods

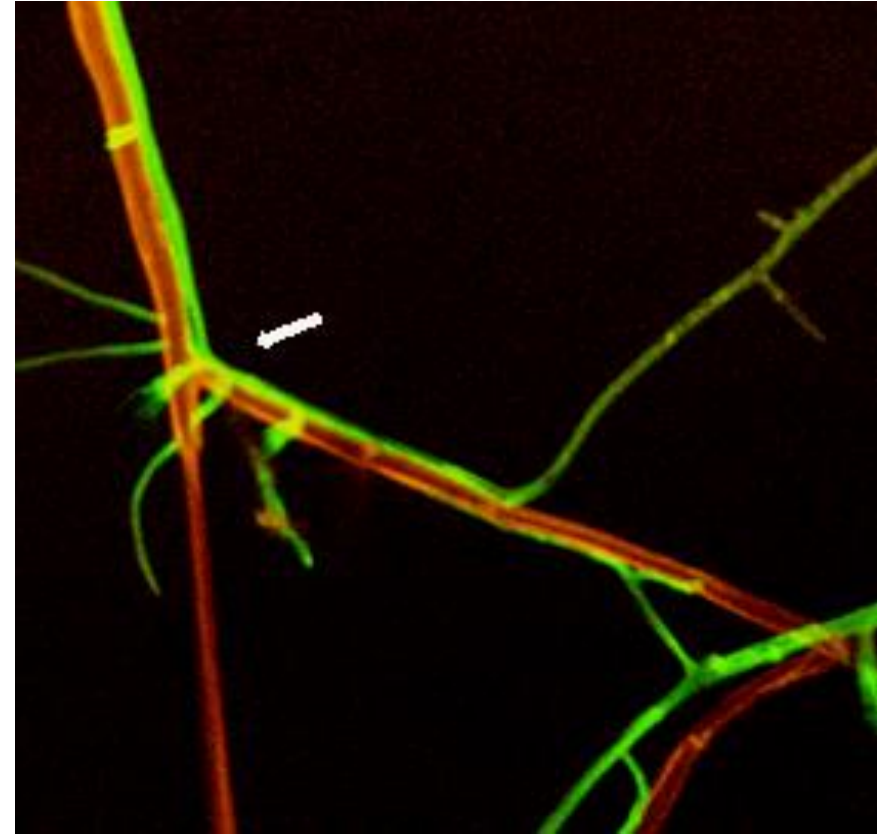
Why Biopesticides?

1. Manage pesticide residues/resistance
2. Low REIs and PHIs
3. Safer for workers, consumers, & environment
 - Many exempt from tolerances and MRLs
4. Improve plant, soil and environmental health over time with continued use
5. Consumer demand



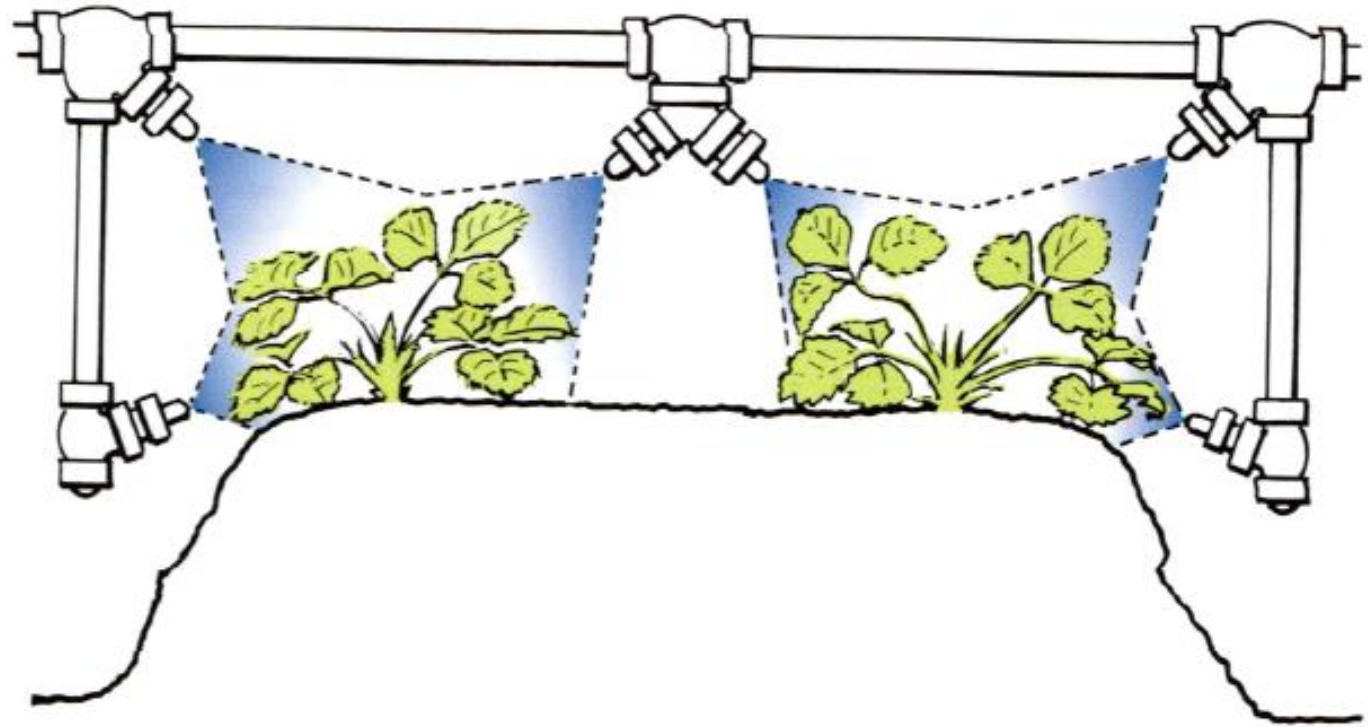
Biopesticides Can't...

- Offer 100% protection
- Work at high disease/insect pressures
- Cure/eradicate insect/diseases
- Last indefinitely
 - Environmental extremes
 - UV and temperature
 - Frequent applications, especially on foliage



Factors Affecting Biopesticide Efficacy: Coverage

- **Incorrect timing** and **poor coverage** are primary causes of biopesticide failure
- Directed spray nozzles



Factors Affecting Biopesticide Efficacy: Shelf Life

- Typically shorter than chemicals
 - Many are living organisms
- Know storage requirements
 - Storage location
 - Storage temperature

Disease Control

Product	Frozen (below 32°F)	Refrigerated (below 40°F)	Room (70-75°F)	Outdoors (above 75°F)
BotryStop [®]	Do not freeze ¹	12 mo	7 days	Do not store outdoors
CEASE [®]	Not Needed ²	Not Needed	3 yrs	Store cool
MilStop [®]	Not Needed ³	Not Needed	Store cool and dry	Store cool and dry
PlantShield [®] HC ⁴	8 mo	6 mo	4 mo	1 mo or less
PreFence [™]	12+ mo (unopened)	6 mo	14 days	Store refrigerated
RootShield [®] Granules in media	3 mo	5 mo	5 mo	2 mo or less
RootShield [®] Granules ⁴	12 mo	9 mo	6 mo	2 mo or less
RootShield [®] WP ⁴	8 mo	6 mo	4 mo	1 mo or less
RootShield [®] PLUS ⁺ Granules ⁴ in media	3 mo	5 mo	5 mo	2 mo or less
RootShield [®] PLUS ⁺ Granules ⁴	14 mo	12 mo	6 mo	2 mo or less
RootShield [®] PLUS ⁺ WP ⁴	12 mo	10 mo	4 mo	1 mo or less
RootShield [®] AG ⁴	8 mo	6 mo	4 mo	1 mo or less
RootShield [®] Home & Garden ⁴	8 mo	6 mo	4 mo	1 mo or less
RootShield [®] Seed Treatment ⁴	8 mo	6 mo	4 mo	1 mo or less
TurfShield [®] PLUS ⁺ WP ⁴	12 mo	10 mo	4 mo	1 mo or less
T-22 HC ⁴	8 mo	6 mo	4 mo	1 mo or less

¹From the time of manufacture. ²Up to 3 freeze/thaw cycles will not harm product – check integrity of formulation if more than 3 freeze/thaw cycles occur (not tested beyond 3 cycles). ³Freezing will not harm product. ⁴From the time product leaves BioWorks' warehouse

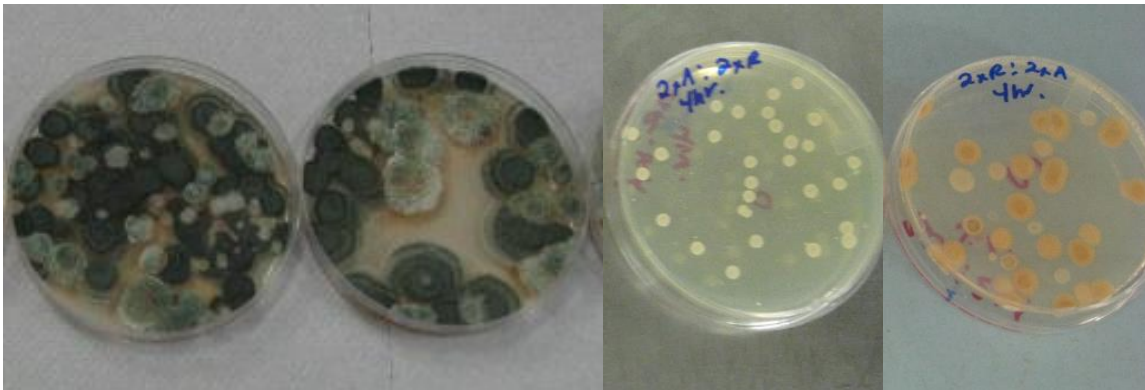
Insect Control

Product	Frozen (below 32°F)	Refrigerated (below 40°F)	Room (70-75°F)	Outdoors (above 75°F)
BotaniGard [®] 22WP	Not needed ¹	Not Needed	12 mo ²	Store below 85°F
BotaniGard [®] ES	Do not freeze ³	Not Needed	18 mo ²	Store below 85°F
BotaniGard [®] MAXX	Do not freeze ³	Not Needed	12 mo ²	Store below 85°F
Molt-X [®]	Not Needed ¹ (keep at 20°F or above)	Not Needed	15 mo ²	Store above 20°F, below 85°F
Mycotrol [®] WPO	Not needed ¹	Not Needed	12 mo ²	Store below 85°F
Mycotrol [®] ESO	Do not freeze ³	Not Needed	18 mo ²	Store below 85°F
NemaShield [®]	Do not freeze	About 4 weeks	Do not store at room temp.	Do not store outdoors
NemaShield [®] HB	Do not freeze	About 4 weeks	Do not store at room temp.	Do not store outdoors
SuffOil-X [®]	Do not freeze	Not Needed	2 yrs	Store cool

¹Freezing will not harm product ²From the time of manufacture ³One time freeze/thaw will not harm product – check integrity of formulation if repeated freeze/thaw occurs

Factors Affecting Biopesticide Efficacy: Chemical Compatibility

1. Physical compatibility
 - Jar test
 - Avoid multiple inputs
2. Spore viability



Insecticides / Miticides Tank Mix Compatible (Continued)			
Brand Name	Active Ingredient	Maximum Tested Rate	Compatibility
TetraCURB [®]	Rosemary oil	8 qt/100 gal	Yes
Thiodan [®] 3EC	Endosulfan	22 oz/100 gal	Yes
Thiodan [®] 3EC	Endosulfan	660 ml/400 L	Yes
Triact [®]	Azadirachtin	2% by volume	Yes
Trilogy [®] 90EC	Azadirachtin	2 gal/100 gal	Yes
Vendex [®]	Fenbutatin oxide	16 oz/100 gal	Yes
Vendex [®]	Fenbutatin oxide	480 ml/400 L	Yes
Venerate	<i>Burkholderia</i> spp. strain A396	4 qt/100 gal	Yes
Vydate [®]	Oxamyl	2 qts/100 gal	Yes

Subsection b. Pre- and Post- Application

Insecticides / Miticides Tank Mix Pre- and Post- Application Compatible			
Brand Name	Active Ingredient	Maximum Tested Rate	Compatible
Asana [®] XL	Esfenvalerate	30 oz/100 gal	Yes, some clabber ¹
Avid [®]	Abamectin	24 oz/100 gal	Yes, some clabber ¹
Avid [®]	Abamectin	240 ml/400 L	Yes, but spray immediately
Citation [®]	Cyromazine	2 gal/100 gal	Yes
Cygon [®]	Dimethoate	24 oz/100 gal	Yes, with ES, not 22WP
Cymbush [®]	Cypermethrin	14 oz/100 gal	Yes
Danitol [®] 2.4ES	Fenpropathrin, pyrethroid	38 oz/100 gal	Yes, WP 5% viability loss
Dibrom [®] 8E	Naled (62%)	1 pint/100 gal	2 days before
Distance [®]	Pyriproxyfen	12 fl oz/100 gal	3 days B/A ²
Enstar [®] AQ	S-Kinoprene	32 fl oz/100 gal	1-day B/A ²
Gnatrol [®] WDG	<i>Bacillus thuringiensis</i> , subsp. <i>israelensis</i> , strain AM 65-52	26 oz/100 gal	Apply BotaniGard 4 days after
Metasystox R-2 [®]	Oxydemeton-methyl	3 qts/100 gal	4 Days B/A ²
Metasystox-R [®]	Oxydemeton-methyl	3.3 L/400 L	4 Days B/A ²
Microthiol [®]	Sulfur 80%	2 oz/100 gal	2 Days B/A ²
Molt-X [®]	Azadirachtin	10 oz, 20 oz/100 gal	Yes
Monitor 4 [®]	Methamidophos	32 oz/100 gal	Yes
M-Pede [®]	Potassium salts of fatty acids	2%/400 L	Yes, mix BotaniGard first
M-Pede [®]	Fatty acids	2 gal/100 gal	Yes, mix BotaniGard first
Neemazad 1% EC	Azadirachtin		4 Days B/A ²
Neemix 4.5 [®]	Azadirachtin	2 qt/100 gal	Yes
Neemix 4.5 [®]	Azadirachtin	1 gal/100 gal	4 Days B/A ²

Biopesticides & Dipping

- Immediately before planting
- *Trichoderma*, *Beauveria bassiana*, horticultural oils, beneficial nematodes, plant proteins
- Direct and total coverage
 - Reduces pest pressure
 - Allow plants to quickly acclimate
 - Minimize transplant shock

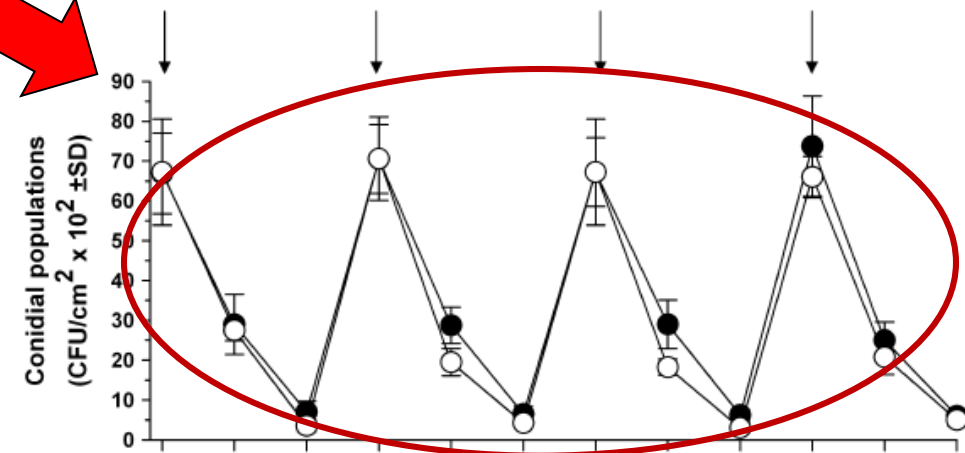
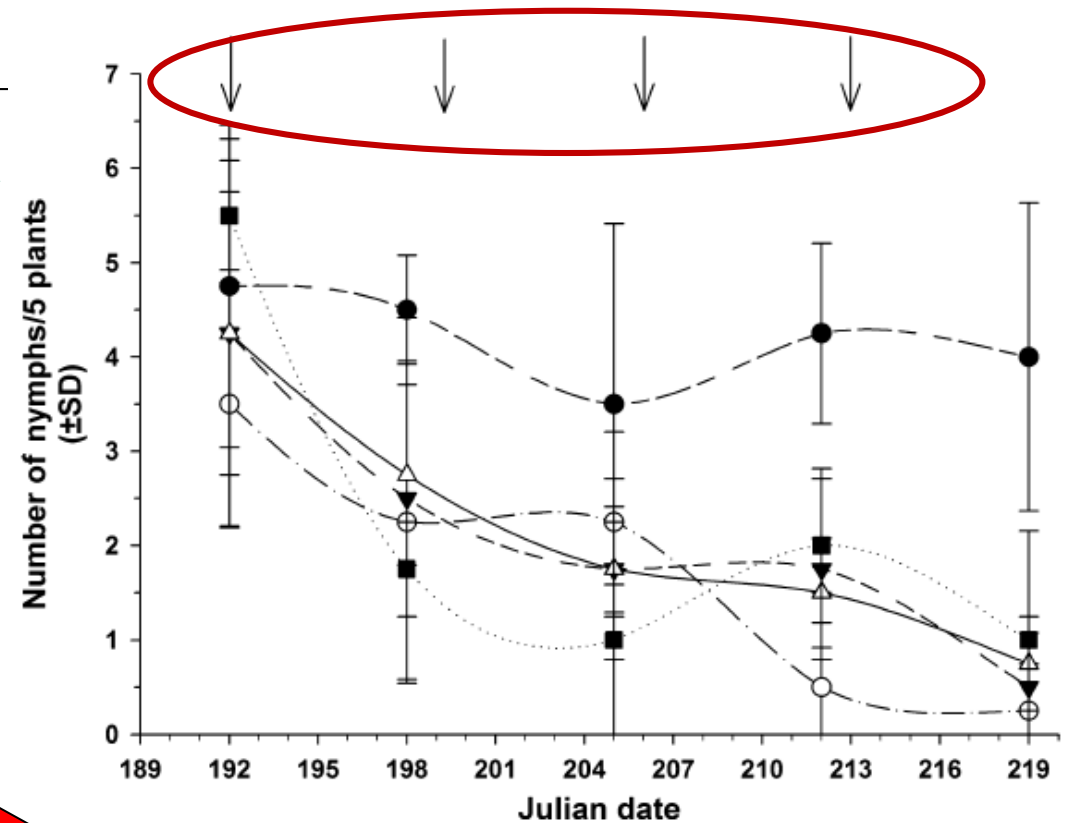


Efficacy of *Beauveria bassiana* against the tarnished plant bug in Strawberry

- INRS-Institut Armand Frappier, Canada
- 4 weekly applications
- Populations declined after each application
- Bb conidia die from UV exposure
 - Importance of regular applications



Western tarnished plant bug (Lygus bug) killed by *Beauveria bassiana*. (Photo by Surendra Dara)





Managing Strawberry Pests with Chemical Pesticides and Non-Chemical Alternatives

Surendra Dara, 2016

- *B. bassiana* provided management for *L. hesperus* when used in combination with azadirachtin or chemical pesticides
- Microbial pesticides in combination/rotation with chemical pesticides can reduce the volume of chemical pesticides

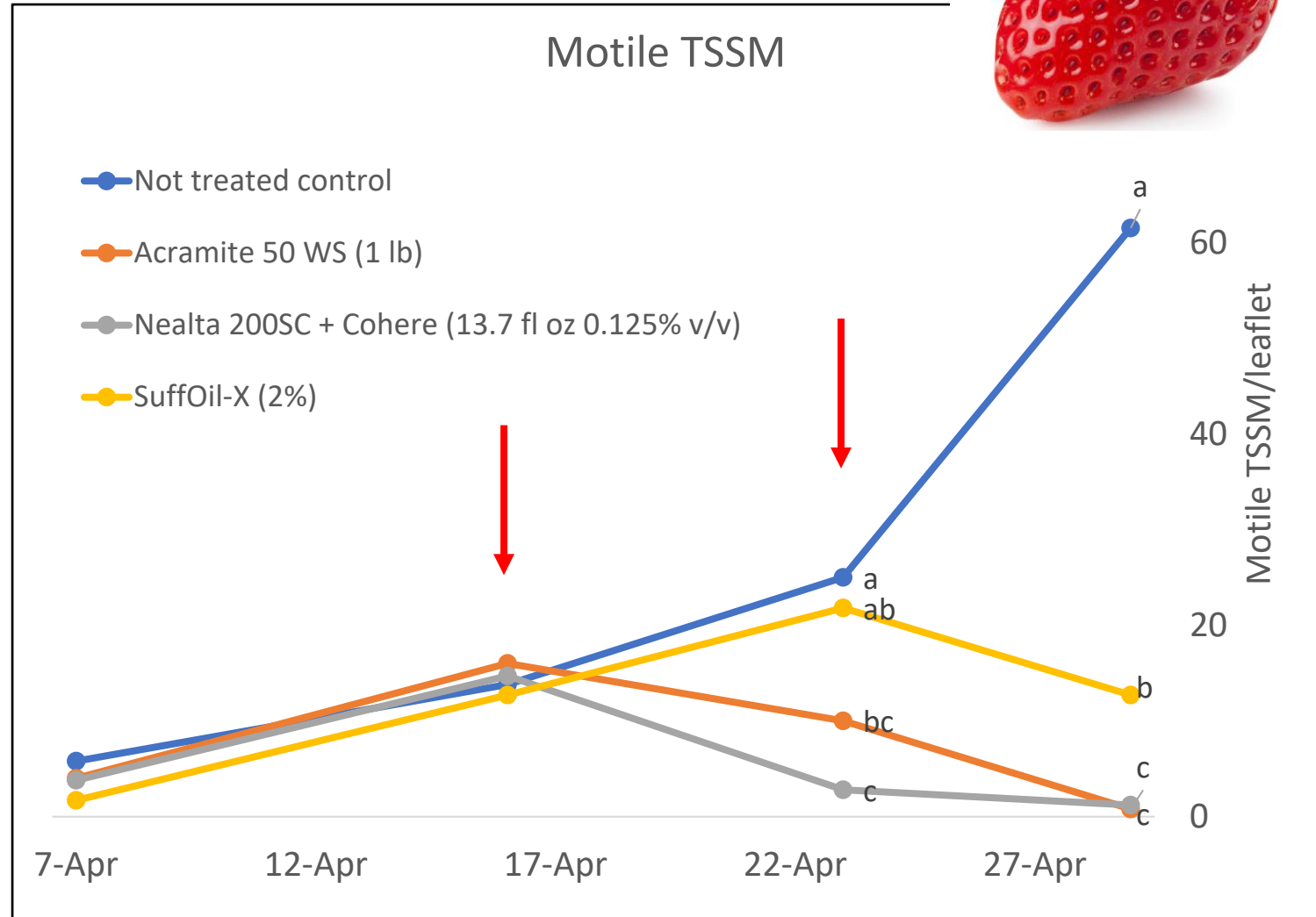
Table 1. List of active ingredients used in 2013 field study and their application rates per hectare.

Treatment	1st application (rate/acre)	2nd application (rate/acre)	3rd application (rate/acre)
1	Untreated	Untreated	Untreated
2	Acetamiprid (Assail 70 WP) 210.2 g	Acetamiprid 210.2 g	Acetamiprid 210.2 g
3	Flonicamid (Beleaf 50 SG, FMC Corp.) 196.2 g	Flonicamid 196.2 g	Bifenthrin + avermectin B1 (Athena, FMC Corp.) 1242.3 ml
4	Bifenthrin + avermectin B1 1242.3 ml	Bifenthrin + avermectin B1 1242.3 ml	Flonicamid 196.2 g
5	Novaluron 877 ml + bifenthrin 1.1 kg	Novaluron 877 ml + bifenthrin 1.1 kg	Piperonyl butoxide + pyrethrins (EverGreen Crop Protection EC 60-6, Valent USA) 1169.3 ml
6	Novaluron 877 ml + bifenthrin 1.1 kg	<i>B. bassiana</i> (BotaniGard ES, BioWorks, Inc.) 4.7 L + azadirachtin (Molt-X, BioWorks, Inc.) 584.6 ml	<i>B. bassiana</i> 4.7 L + azadirachtin 584.6 ml
7	<i>Chromobacterium subtsugae</i> (Grandevo, Marrone Bio Innovations, Davis, CA) 2.2 kg	<i>C. subtsugae</i> 2.2 kg	<i>C. subtsugae</i> 2.2 kg
8	<i>B. bassiana</i> 4.7 L + azadirachtin 584.6 ml	<i>C. subtsugae</i> 2.2 kg	Flonicamid 196.2 g
9	Piperonyl butoxide + pyrethrins 1169.3 ml	Piperonyl butoxide + pyrethrins 1169.3 ml	Acetamiprid 210.2 g
10	<i>B. bassiana</i> 4.7 L + low acetamiprid 105.1 g	<i>B. bassiana</i> 4.7 L + low flonicamid 98.1 g	<i>B. bassiana</i> 4.7 L + low bifenthrin + avermectin B1 730.8 ml
11	Sulfoxaflor (Sequoia, Dow AgroSciences, Indianapolis, IN) 328.9 ml	Sulfoxaflor 328.9 ml	<i>B. bassiana</i> 4.7 L + <i>C. subtsugae</i> 2.2 kg
12	Sulfoxaflor 219.2 ml	Sulfoxaflor 219.2 ml	Flonicamid 196.2 g

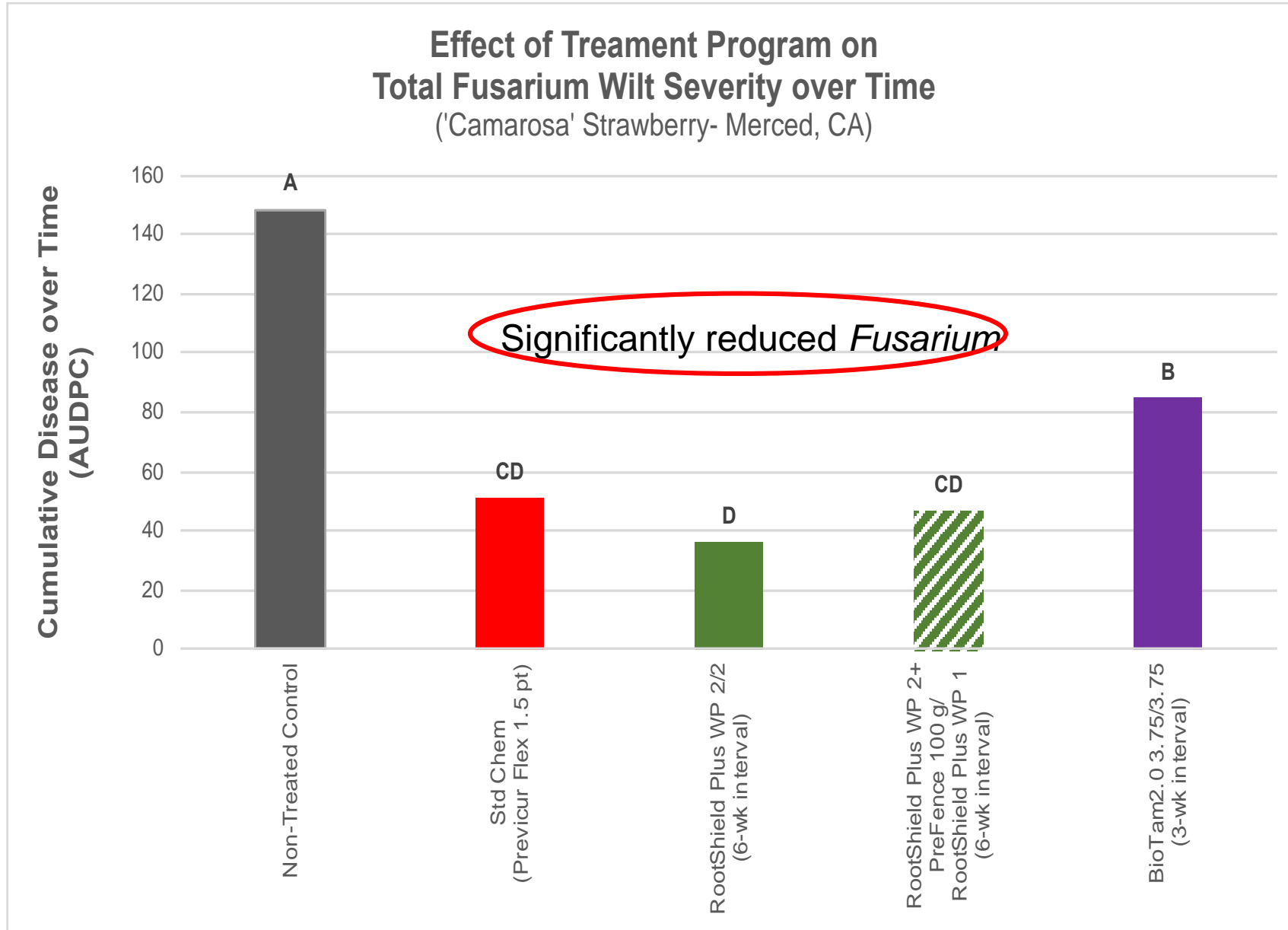


Late season control of TSSM in Strawberry 2014

- University of FL-IFAS
- 2 Treatments applied
- SuffOil-X significantly reduced TSSM



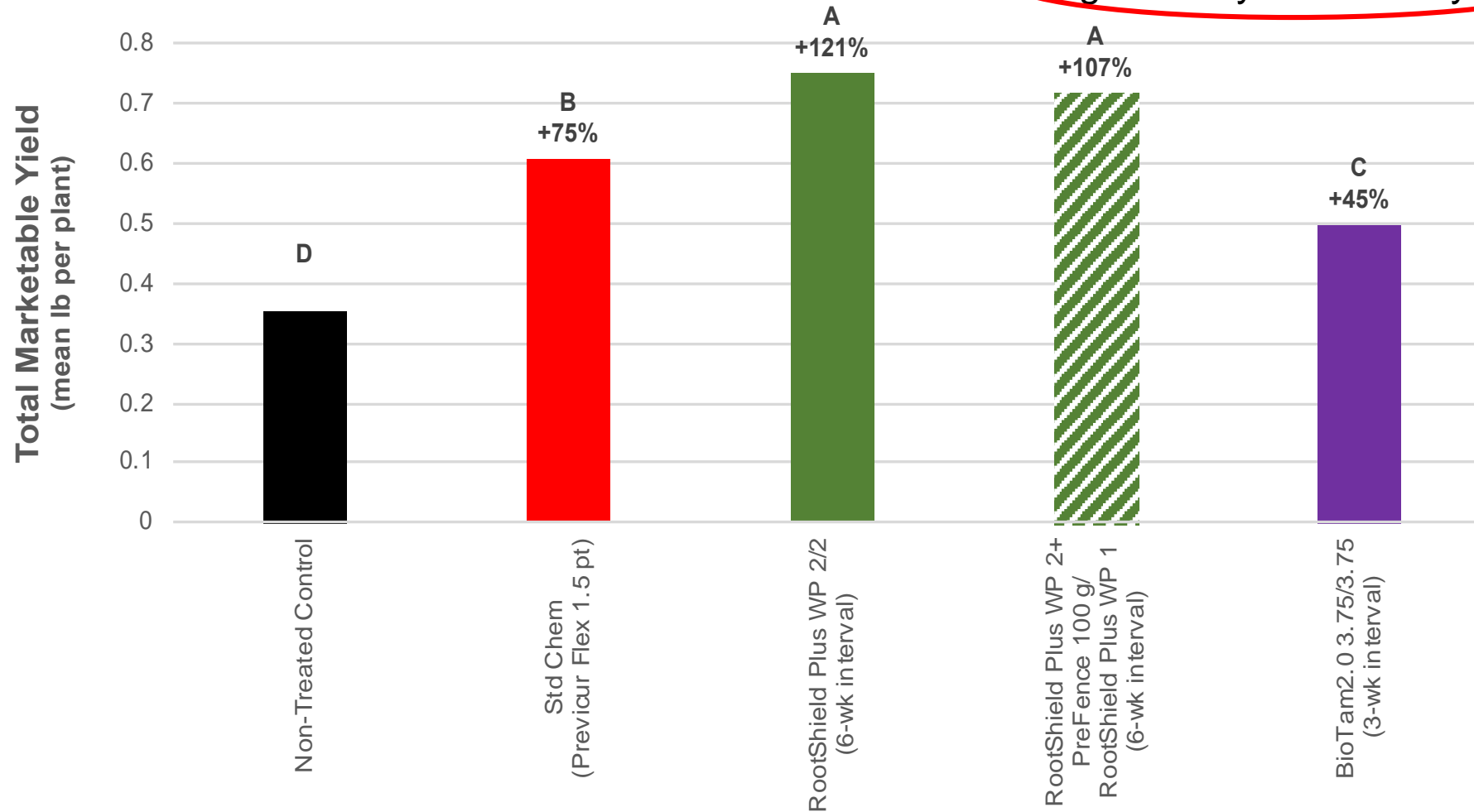
Fusarium Wilt in Strawberry



Fusarium Wilt in Strawberry



Effect of Treatment Program on
Total Marketable Strawberry Yield
(‘Camarosa’ Strawberry - Merced, CA)

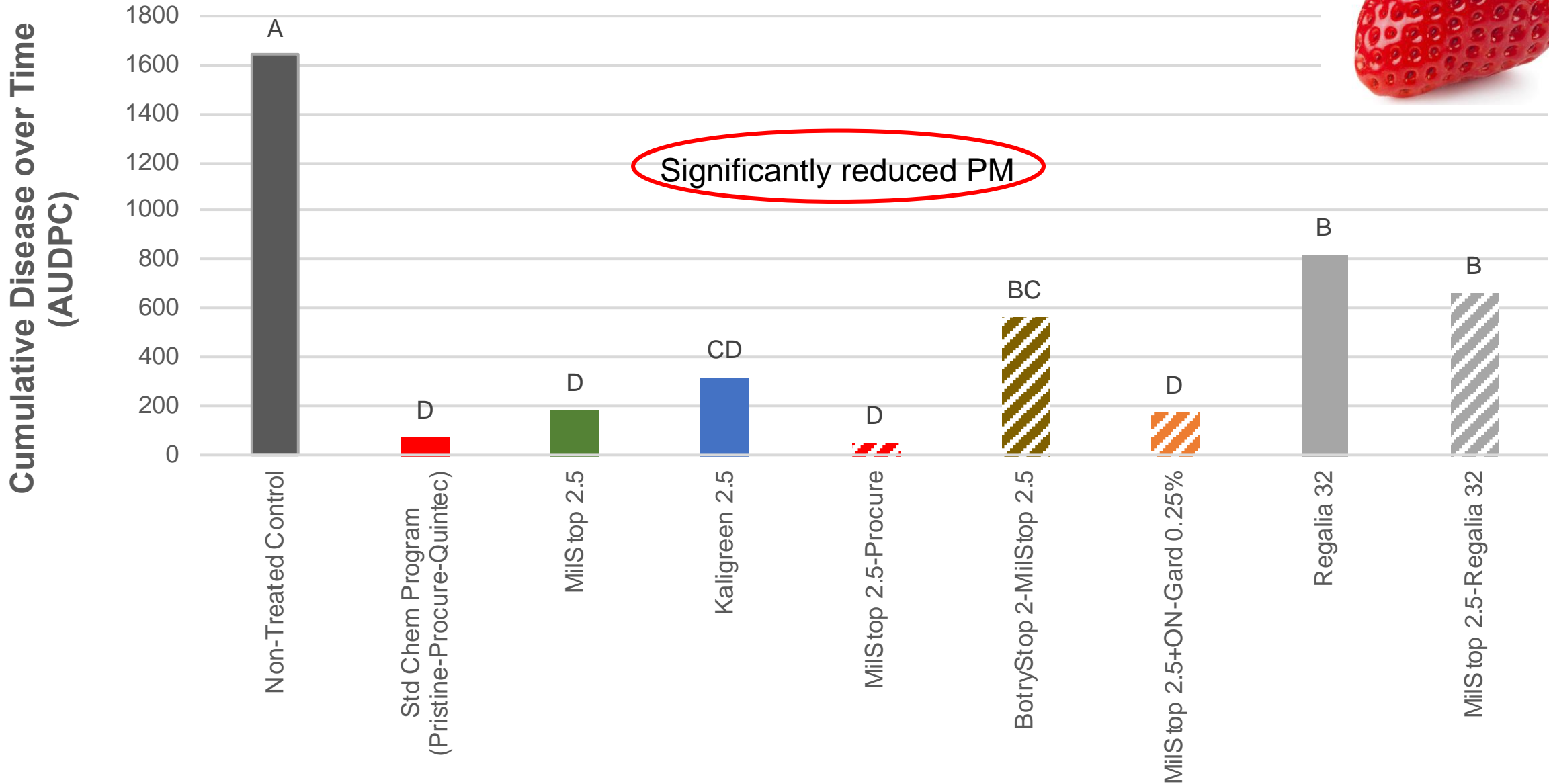


Significantly increased yield

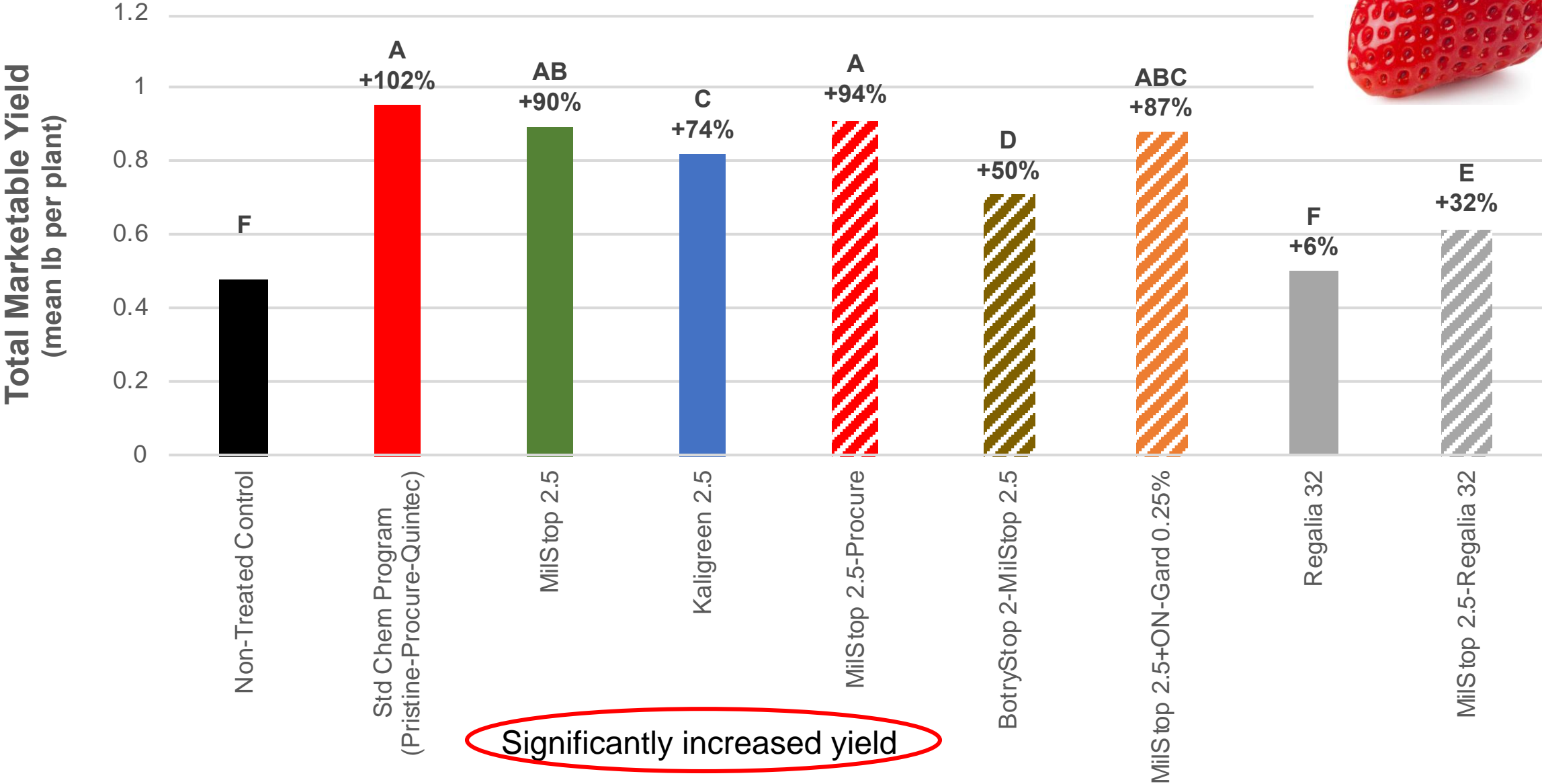
Effect of Treatment Program on Total Strawberry Powdery Mildew Severity over Time (Watsonville, CA)



Significantly reduced PM



Effect of Treatment Program on Total Strawberry Marketable Yield (Watsonville, CA)



Significantly increased yield

Take Home Message

- Biopesticides:
 - Effectively manage insects and disease when used properly
 - Reduce chemical inputs





BioWorks®

How You Grow Matters™

Julie Graesch

BPM – Insect Management

jgraesch@bioworksinc.com

Cell: 515-370-2299

