



Approaches to Developing Bio-fungicides for Foliar and Soil Applications

Tim Johnson, PhD - VP Product Development

Quebec - 2018

Safe Harbor Statement

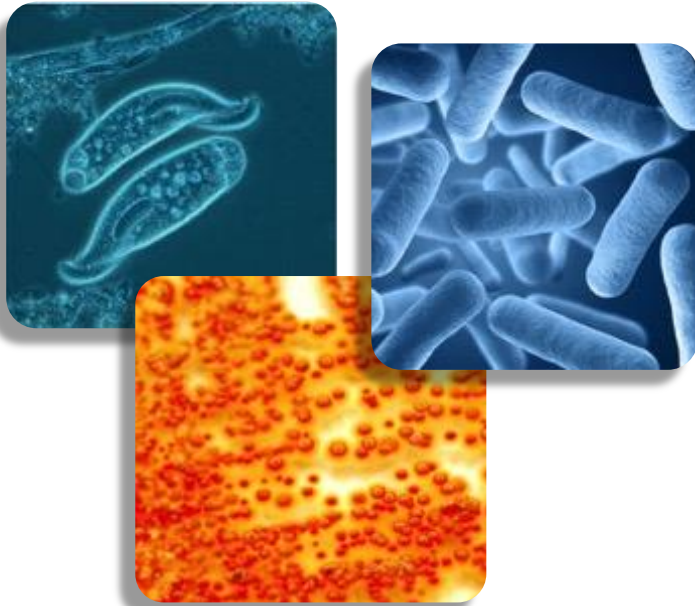


This presentation may include forward-looking statements. These statements reflect the current views of the Company's senior management with respect to future events and financial performance. These statements include forward-looking statements with respect to the Company's business and industry in general, including statements regarding potential market size of Company products, anticipated product development costs, target geographic markets, and future goals. Statements that include the words "expect," "intend," "plan," "believe," "project," "forecast," "estimate," "may," "should," "anticipate", "target", "goals" and similar statements of a future or forward-looking nature identify forward-looking statements for purposes of the federal securities laws or otherwise. Forward-looking statements address matters that involve risks and uncertainties, such as the timing of and costs associated with the launch of products, the difficulty in predicting the timing or outcome of product research and development efforts and regulatory approvals. Accordingly, there are or will be important factors that could cause the Company's actual results to differ materially from those indicated in these statements. The statements made herein speak only as of the date of this presentation.

US-EPA Biopesticide Categories



Microbials



Fungi, Bacteria, Viruses, and Protozoa

Biochemicals



Plant Extracts, Pheromones, Soaps, and Fatty Acids

***A 70 year history of safe use of biopesticides
Faster and less expensive EPA registration than synthetic chemicals***

Marrone Bio Innovations Products



The industry's 1st effective plant-extracted fungicide; Increases yields/quality on multiple crops



Industry's only biological solution for invasive mussels; highly effective & selective



Reduces sun & water stress, increasing yields & quality



Breakthrough efficacy against downy mildews, white molds & Botrytis



First broad spectrum microbial insecticide since Bt (50+ yrs); Novel chemistry & mode of action



New species of insecticidal bacteria with novel compounds as potent as the best chemicals



Reduces broad spectrum of root-feeding nematodes to increase yields/quality

**MBI's Portfolio
Approach to
Existing & Unmet
Market Needs**

MBI also distributes these biological products in the U.S.



Different Approaches to Biofungicide Development



- Live organisms for colonizing roots and blossoms that function through competitive displacement or competitive inhibition
- Live organisms that infect and kill the fungal disease organism
- Live organisms that produce anti-fungal biochemicals such as lipo-peptides during fermentation

Different Approaches to Biofungicide Development



- Plant extracts that trigger induced or systemic acquired resistance
- Live organisms that trigger systemic acquired resistance
- Live organisms that produce biological fumigant gases

Different Approaches to Biofungicide Development



- Live organisms for colonizing roots and blossoms that function through competitive displacement or competitive inhibition
 - Botector[®]/Blossom Protect[™]
 - Two isolates of *Aureobasidium pullalans* for control of *Botrytis cinerea*, *Monilinia laxa*
 - BioSave10[®]
 - *Pseudomonas syringae* for control of post-harvest diseases of pome fruit

Different Approaches to Biofungicide Development



➤ Botector®/Blossom Protect™

- Two isolates of *Aureobasidium pullalans* for control of *Botrytis cinerea*, *Monilinia laxa*, *Erwinia amylovora*

➤ BioSave10®

- *Pseudomonas syringae* for control of post-harvest diseases of pome fruit
- Advantages – very disease specific
- Disadvantages – very disease specific, may not be tank-mix compatible with other commonly used products. May have a short shelf-life and require specific storage requirements.

Different Approaches to Biofungicide Development



- Live organisms that infect and kill the disease organism
 - AQ 10[®] - spores of *Ampelomyces quisqualis*, a hyperparasite of powdery mildew mycelium and conidiophores for use on grapes, vegetables and strawberries. Low application rate of 35-70 grams per hectare.
 - ✓ Advantages – disease specific, good shelf-life, low use rate
 - ✓ Disadvantages – disease specific, tank-mix compatibility

Different Approaches to Biofungicide Development



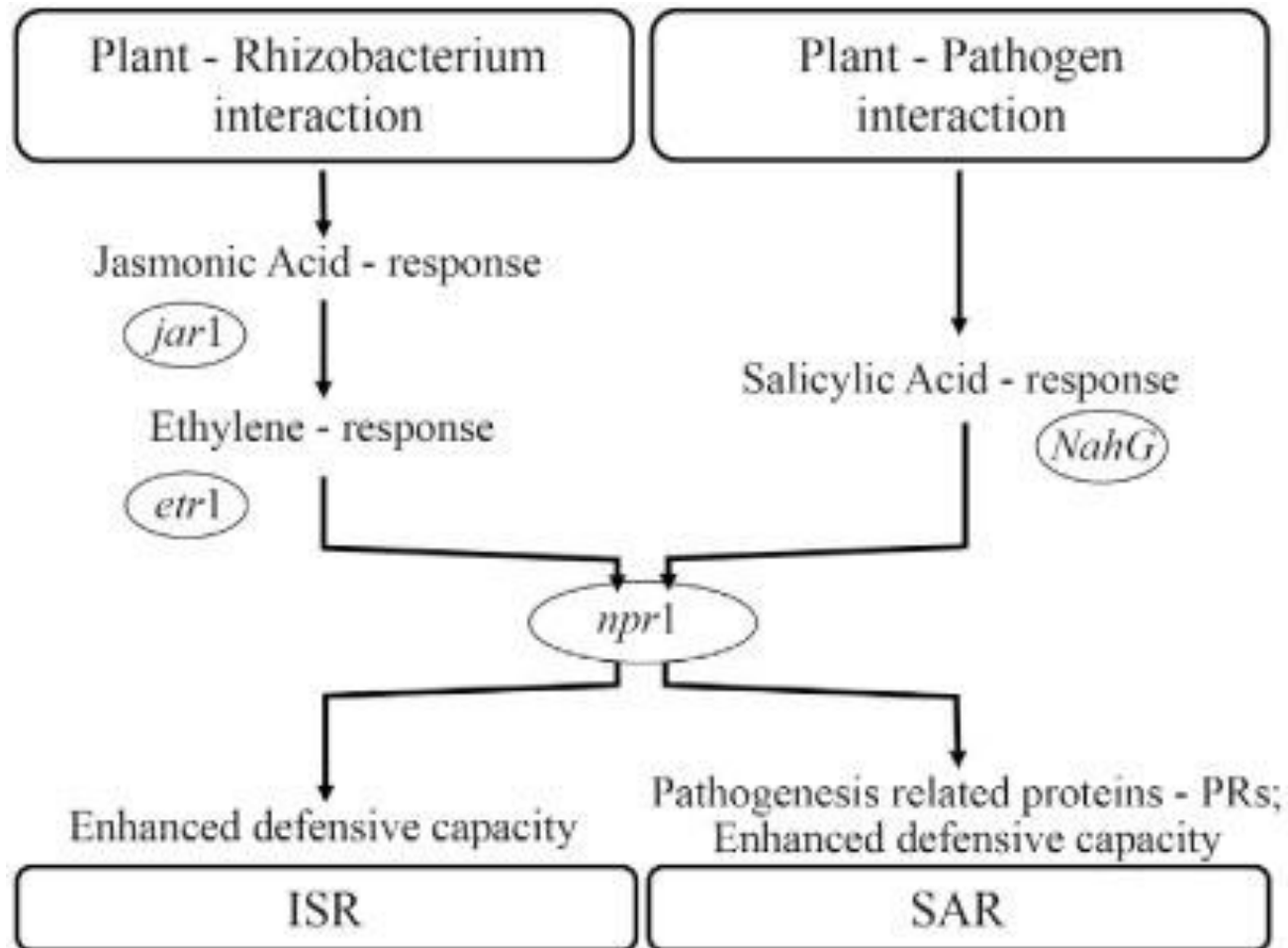
- Live organisms that produce anti-fungal biochemicals such as lipo-peptides during fermentation
- A range of *Bacillus*-based fungicides!! So many, are they really all the same?

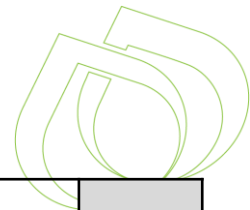
Different Approaches to Biofungicide Development



- Plant extracts that trigger induced or systemic acquired resistance
- Live organisms that trigger systemic acquired resistance

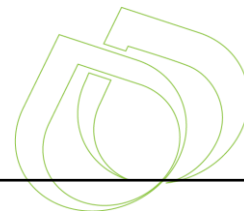
ISR/SAR are different and the same





FRAC Group P – host plant defense induction

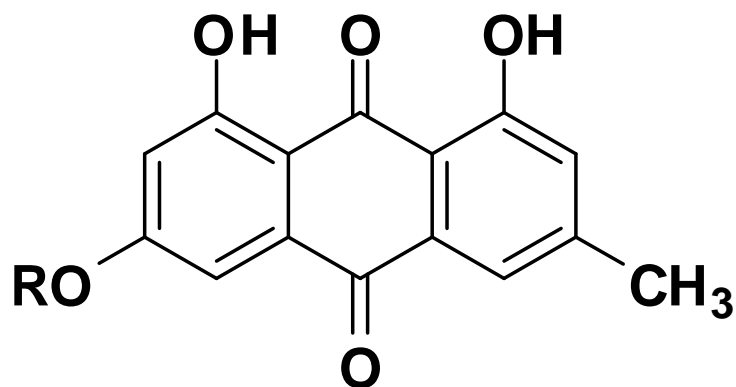
TARGET SITE AND CODE	GROUP NAME	CHEMICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
P1 salicylic acid pathway	benzo-thiadiazole BTH	benzo-thiadiazole BTH	acibenzolar-S-methyl	Resistance not known	P
P2	benzisoithiazole	benzisoithiazole	probenazole (also antibacterial and antifungal activity)	Resistance not known	
P3	thiadiazole-carboxamide	thiadiazole-carboxamide	tiadinil isotianil	Resistance not known	
P4	natural compound	polysaccharide	laminarin	Resistance not known	
P5	plant extract	complex mixture, ethanol extract	<i>Reynoutria sachalinensis</i> (giant knotweed)	Resistance not known	
P6	<i>Bacillus mycoides J</i>		<i>Bacillus mycoides J</i>	Resistance not known	



FRAC Group P – host plant defense induction

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	P6	<i>Bacillus mycoides J</i>		<i>Bacillus mycoides J</i>	Resistance not known

- A formulated plant extract from giant knotweed *Reynoutria sachalinensis*
- Amount of active ingredient - 5% in U.S., 20% in Canada under the tradename “Regalia Maxx”



R=H Emodin
R=CH₃O Physcion



Giant Knotweed in a local market in China

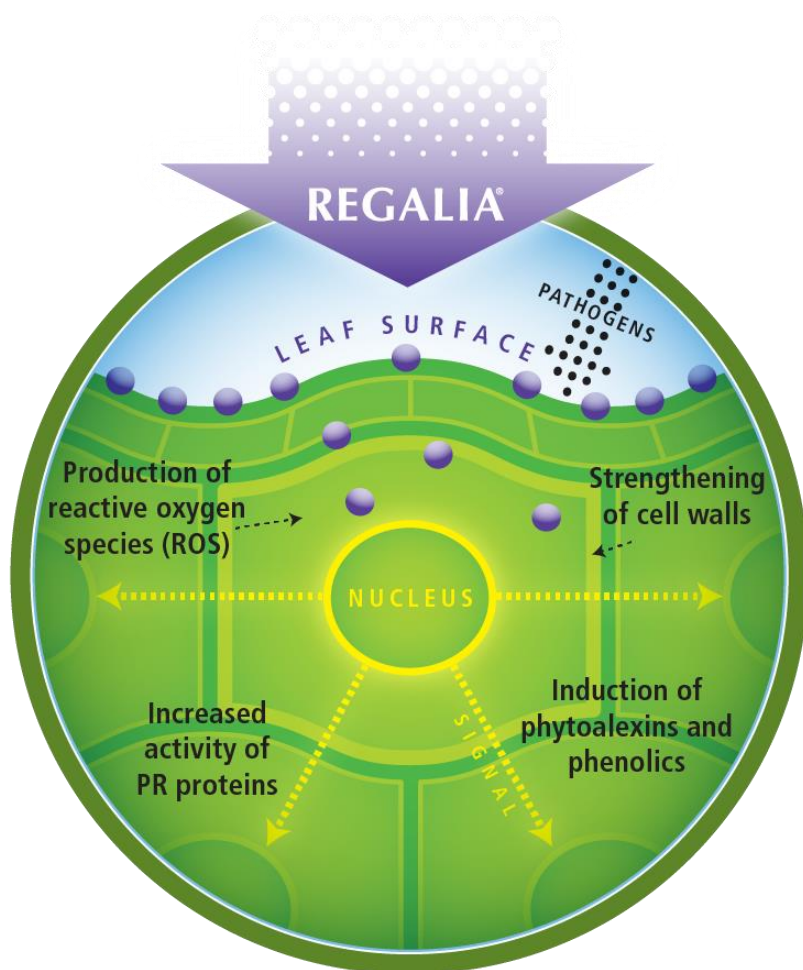


What Does It Do?



Induced Systemic Resistance (ISR)

GROUP	P5	FUNGICIDE
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- **Inhibits Pathogen Growth**

ISR triggers the production of antimicrobial compounds (phenolics, phytoalexins, PR proteins) that inhibit and restrain pathogen growth.

- **Strengthens Cell Walls**

ISR signals the plant to accumulate more lignin, which thickens and strengthens cell walls to inhibit penetration of fungal hyphae.

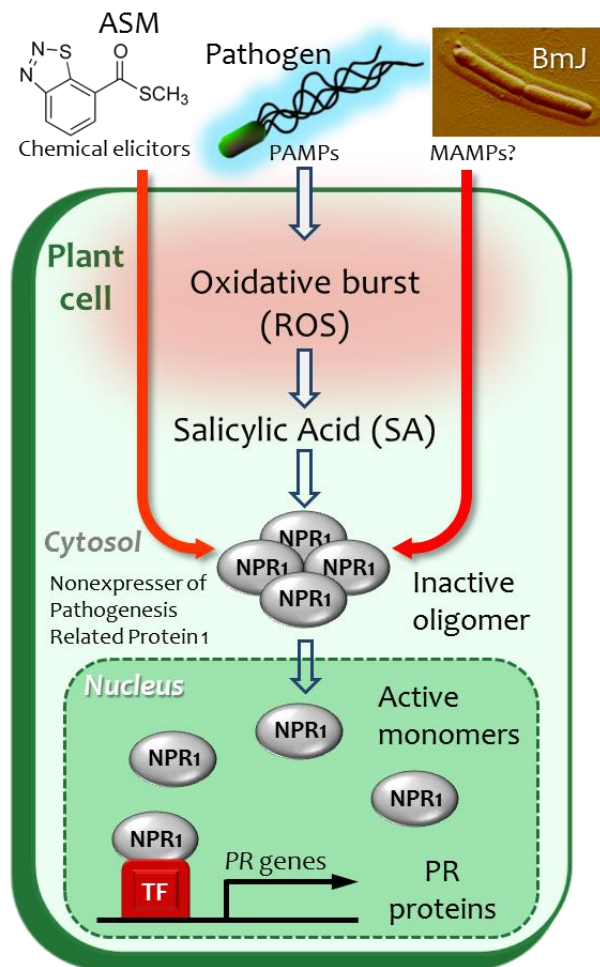
- **Promotes Plant Growth**

Independent of disease control, increases leaf chlorophyll content.

Labeled Crops in Canada – Regalia Maxx



Crop	Disease	Application
Hops	Downy mildew	Field
Tomato/pepper	Powdery mildew, Botrytis, Xanthomonas	Field, GH
Cucurbits	Powdery mildew	Field, GH
Cucurbits	Downy mildew	GH
Stone fruit	Powdery mildew, Monilinia	Field
Blueberry	Monilinia, Fruit rots	Field
Grape	Powdery mildew, Botrytis	Field
Strawberry	Powdery mildew, Botrytis	Field
Wheat	Septoria	Field
Ornamentals	Powdery mildew, downy mildew	Field



Adapted from:
Bargabus et al, 2002. Physiol. Mol. Plant Pathol. 61: 289-298
Bargabus-Larson & Jacobsen, 2007. J. Sugar Beet Res. 44: 17-33.
Fu & Dong, 2013. Ann. Rev. Plant Biol. 64: 839-863.

- Active ingredient: Viable endospores of *Bacillus mycoides* isolate J (BmJ).
- No direct antagonistic effects on plant pathogens.
- Mode of action: Live BmJ elicits SAR by directly activating the signal protein NPR1, independent of salicylic acid (SA).
 - Similar to acibenzolar-S-methyl (ASM).
 - **FRAC P6:** Microbial inducer of plant resistance.
 - Activated NPR1 translocated into nucleus, upregulates transcription of pathogenesis-related (PR) genes.
 - Causes plant to produce its own antimicrobial compounds (PR proteins).
- No phytotoxicity in >20 years of field trials.

Labeled Crops in Canada

Crop	Disease	Application
Tomato/pepper	<i>Alternaria solani</i> , <i>Phytophthora infestans</i> , <i>Xanthomonas</i> , <i>Pseudomonas</i>	Field, GH
Potato	<i>Alternaria solani</i> , <i>Phytophthora infestans</i> , <i>Sclerotinia</i>	Field
Spinach	Downy mildew- <i>Peronospora</i>	Field, GH
Sugar beet	<i>Cercospora</i>	Field



MBI-110EP

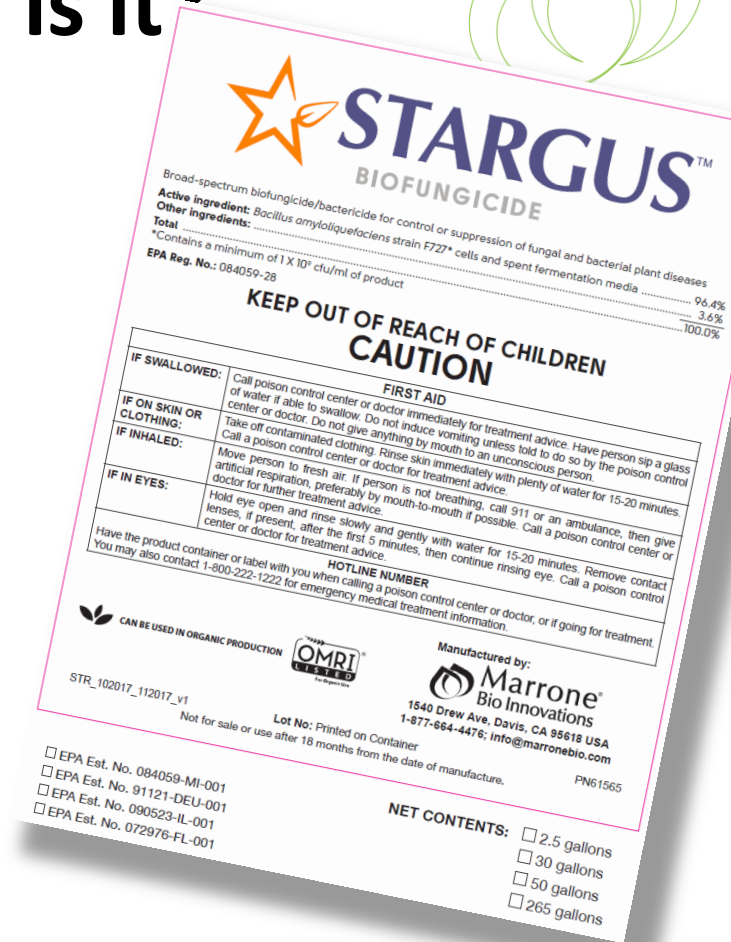
Foliar control of white molds (*Sclerotinia*), downy mildews, and *Phytophthora* plus in-furrow application for soil-borne diseases on vegetables and potatoes.

***Registration in Canada is pending**

STARGUS™ Fungicide. What is it?

STARGUS™ is a....

- Liquid fungicide used at 2-8 L/HA
- Active ingredient is a proprietary isolate of *Bacillus amyloliquifaciens* (strain F727)
- Preventive fungicide from peptides produced during fermentation
- Possible SAR activator
- Controls certain foliar and soil borne diseases

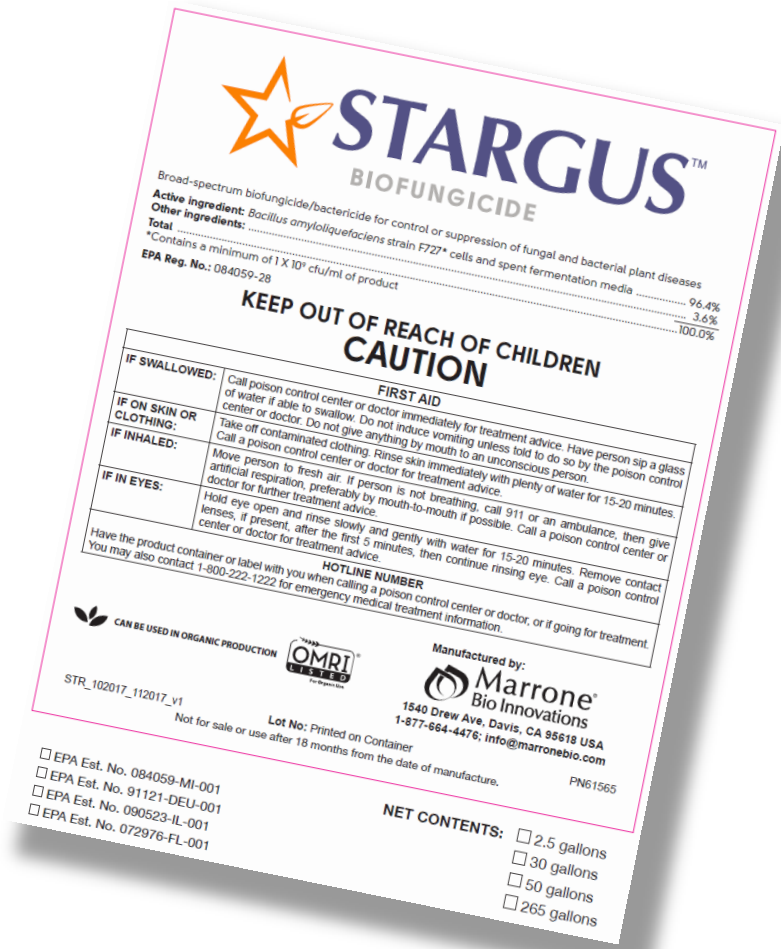


STARGUS™ Fungicide. What is it?



STARGUS™ is

- 4 hour REI
- 0 days to harvest PHI
- Exempt from residue tolerances
- NOP compliant and OMRI listed
- Broad tank-mix compatibility
- Registration in Canada is pending



STARGUS™ Fungicide. What is it?

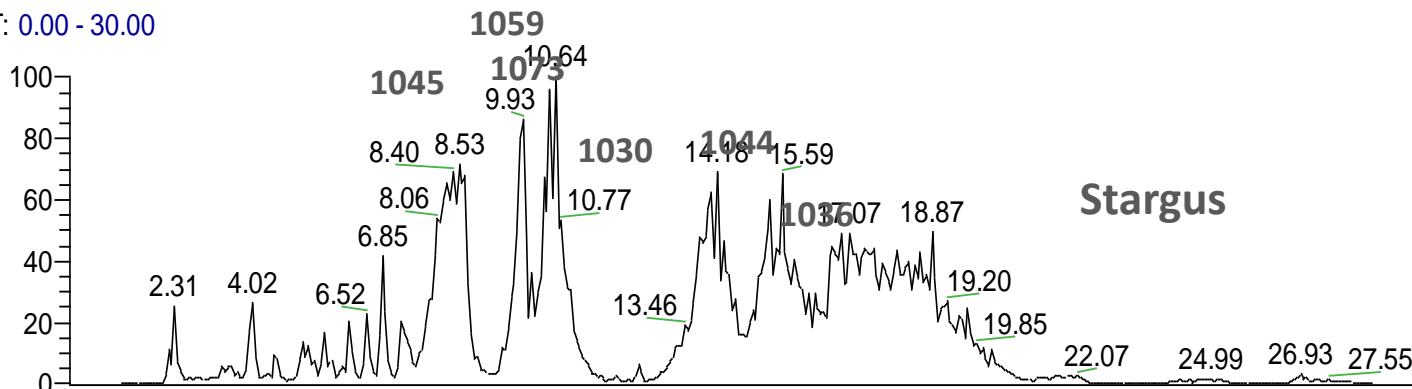


STARGUS™ is expected to be labeled in Canada on the following crops;

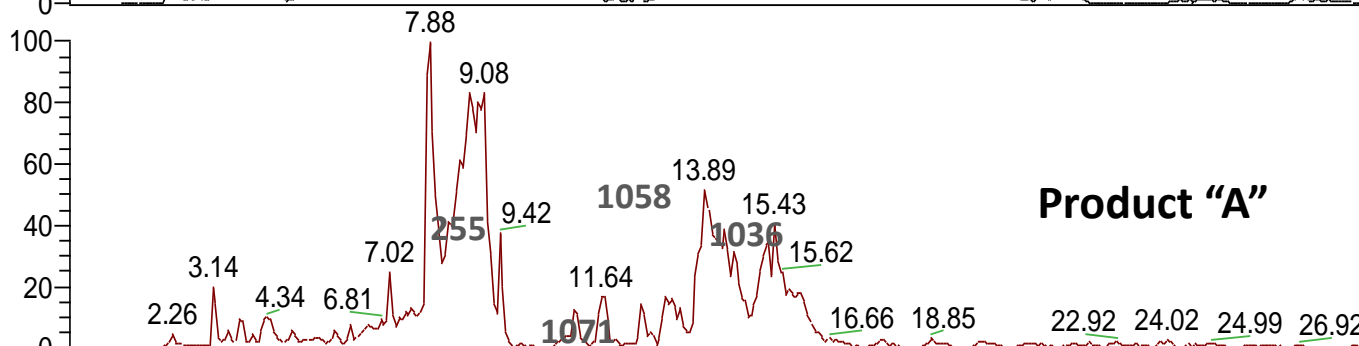
- Grapes for downy mildew and black rot at 2-6 L/HA
- Cucurbits for downy mildew at 4-6 L/HA
- Beans, sunflower and canola for white mold at 4-8 L/HA
- Potatoes for *Phytophthora eurythroseptica* at 8 L/HA

Comparison of STARGUS™ with two other *Bacillus*-based Biofungicides

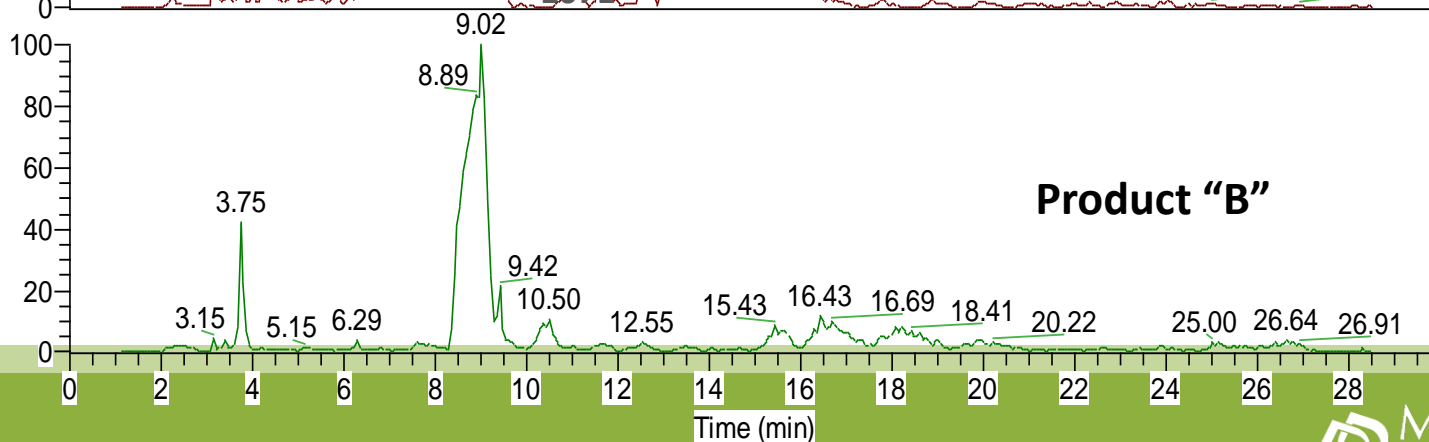
RT: 0.00 - 30.00



NL:
1.94E8
Base Peak F: + c
ESI Full ms
[100.00-1500.00]
MS f727-fl-i



NL:
4.41E8
Base Peak F: + c
ESI Full ms
[100.00-1500.00]



NL:
2.95E8
Base Peak F: + c
ESI Full ms
[100.00-1500.00]

In vitro screening of MBI-110 EP - STARGUS™

< *Phytophthora capsici* >

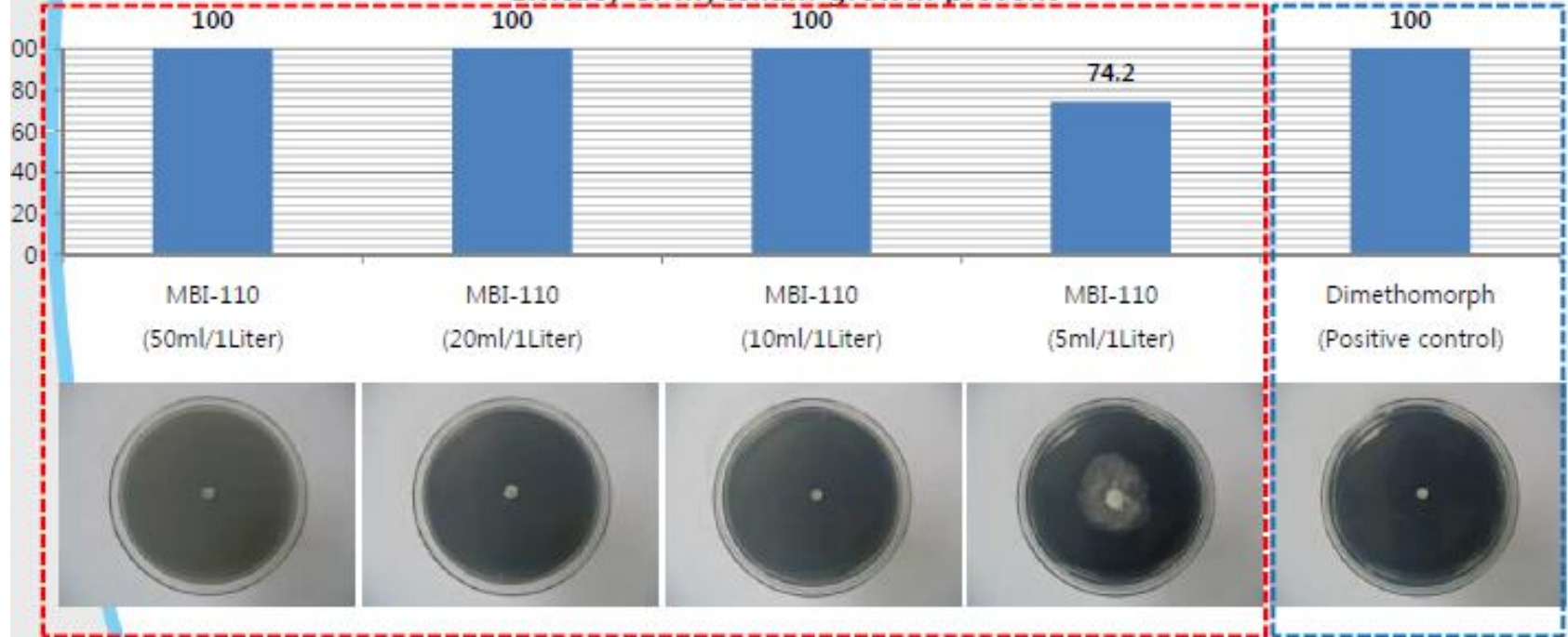


Untreatment

- Application: 2017.02.08

- Investigate date : 2017.02.11

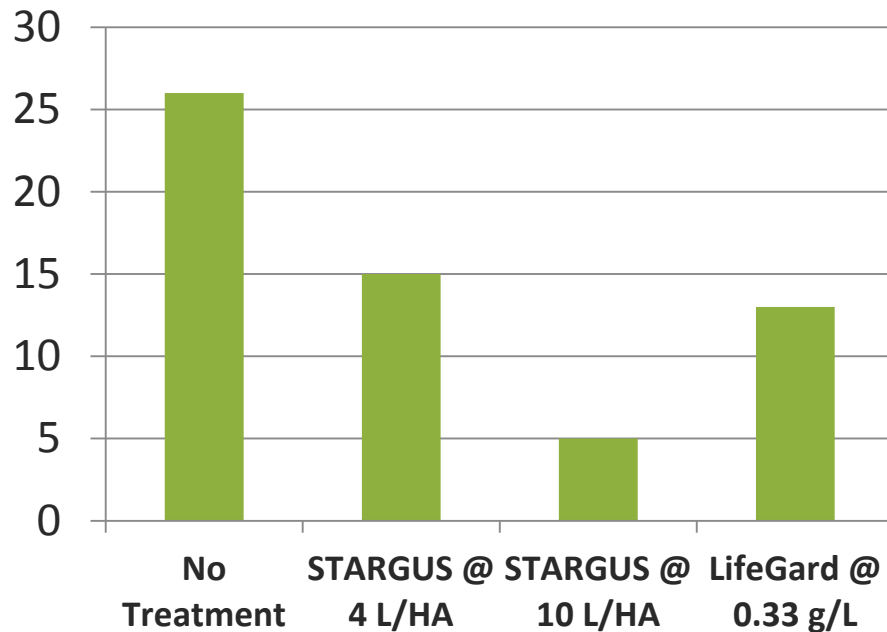
Efficacy of mycelium growth prevent



MBI-110 EP for Control of Early and Late Blight on Potato

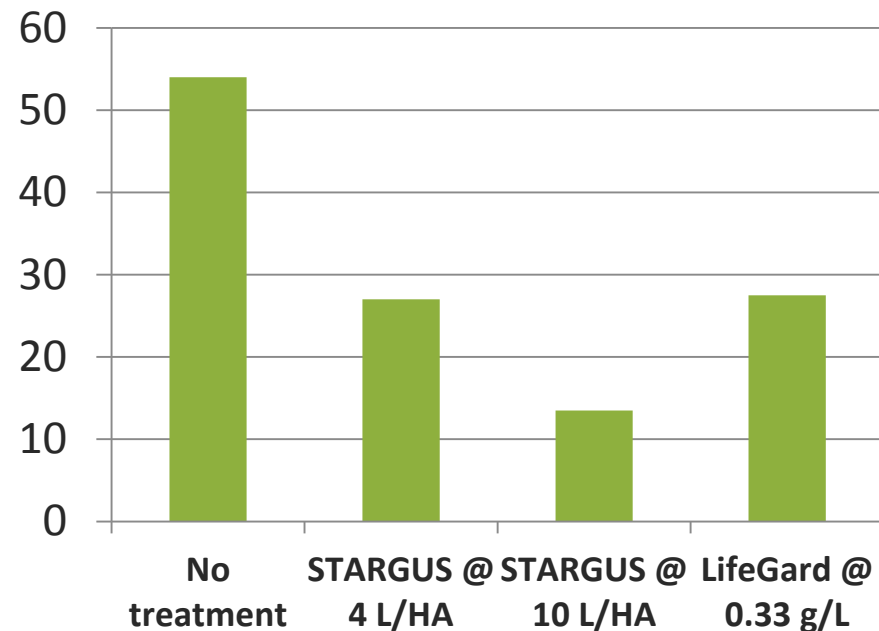


% severity 7DA-C



Early Blight

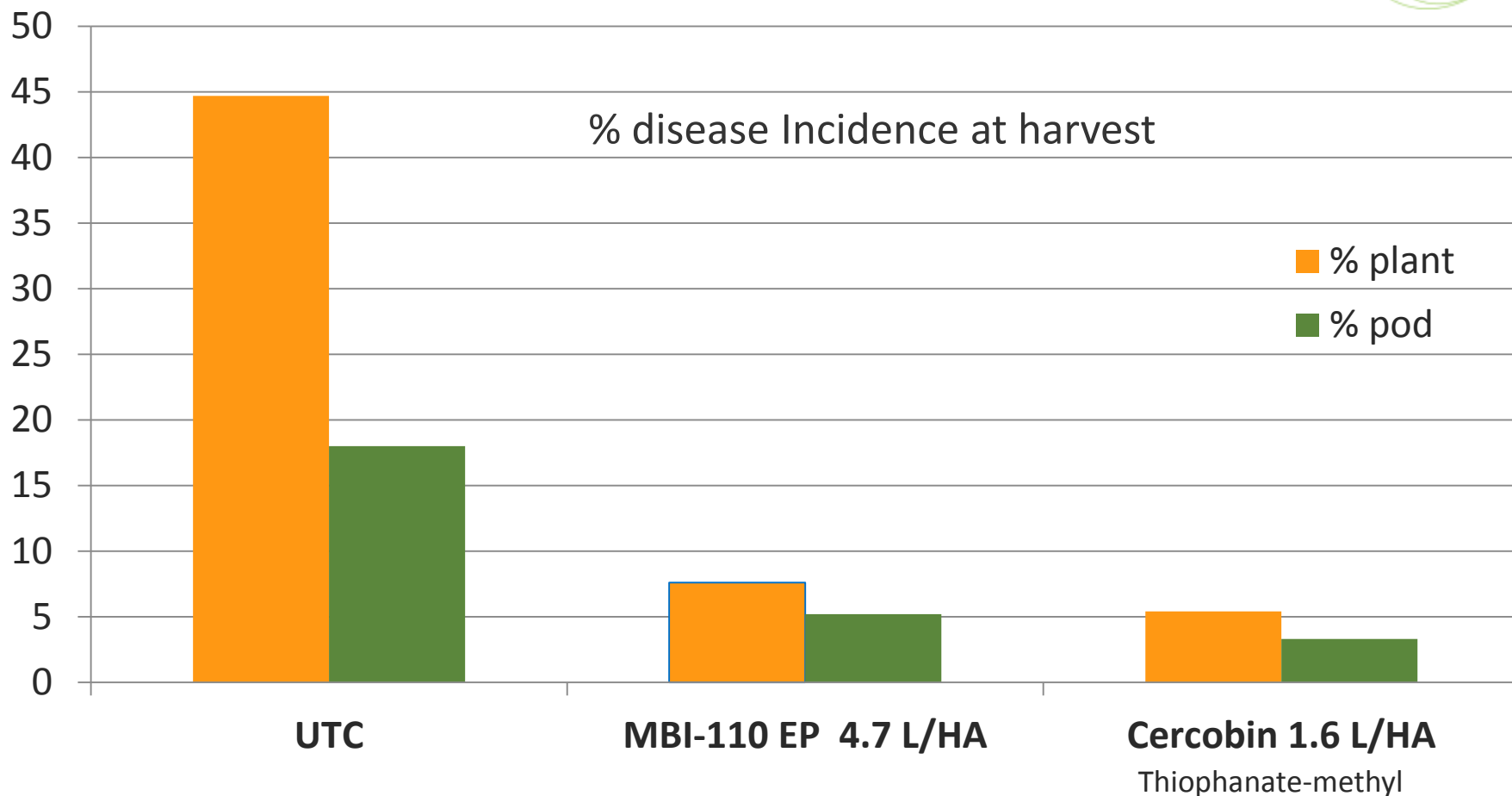
% severity 14DA-F



Late Blight

Control of White Mold on Snap Beans

Dr. S. Pethybridge, Cornell U.-2017



Two applications at 28 GPA at 10% and full bloom (7/26 and 8/1). Plots artificially inoculated. Both treatments statistically different from UTC at $P=0.05$.

Control of Fire Blight on Apples with Regalia 12 and STARGUS

Dr. Kerik Cox— Cornell-2017



Trt1	Treatment programs (amt./A)*	Timing *	Incidence of blossom blight (%)**	Blossom blight percent control (%)	Incidence of shoot blight (%)**	Fruit russet (%)
1	Non-treated	NA	94.4 ± 2.1 a	0.0	55.0 ± 3.2 a	0.0 ± 0.0
2	FireLine 17 WP 24 oz + Regulaid 3 pt	1,2,4,6	5.2 ± 2.4 d	94.5	1.4 ± 1.4 cd	0.0 ± 0.0
3	FireWall 17WP 24 oz + Regulaid 3 pt	1,2,4,6	0.0 ± 0.0 d	100.0	0.0 ± 0.0 d	0.0 ± 0.0
6	Kasumin 2L 64 fl oz + Regulaid 3 pt	4	0.9 ± 0.9 d	99.0	2.4 ± 1.9 bcd	0.0 ± 0.0
14	Regalia12 16 fl oz	1,3,4,6	6.3 ± 3.7 cd	93.3	4.3 ± 3.2 bcd	0.0 ± 0.0
15	Regalia12 26 fl oz	1,3,4,6	22.2 ± 5.6 bcd	76.5	11.8 ± 6.5 bc	0.0 ± 0.0
17	STARGUS 32 fl oz	1,3,4,6	6.9 ± 3.7 cd	92.7	3.5 ± 1.3 bcd	0.0 ± 0.0
18	STARGUS 64 fl oz	1,3,4,6	17.1 ± 1.7 bcd	81.9	7.8 ± 4.0 bcd	0.0 ± 0.0

Control of Bacterial Blight on Peaches

Dr. Kari Peter, PSU-2017



Cultivar Sweet Dream

Treatment	Timing	Fruit	
		% incidence	% area infected
Untreated	--	71 a	8.4 a
FireLine 12 oz.	SS – 7C	42 bc	4.5 cd
STARGUS @ 2 qt.	SS – 7C	46 bc	2.5 d-f
Regalia 12% @ 32 fl. oz.	SS – 7C	52 b	4.1 c-e
Serenade ASO @ 4 qt.	SS – 7C	68 a	7.6 ab
Double Nickel @ 2 qt.	SS – 7C	51 b	5.5 bc



ENNOBLE™ Biofumigant (MBI-601)

- *Muscodor albus* strain SA13, an endophytic fungus (new genus) isolated from various trees by Dr. Gary Strobel at Montana State University
- **EPA registered**
- U.S. Commercial launch pending
- Demonstration use in 2018
- Inhibits and kills a broad range of soil inhabiting fungi, bacteria, nematodes and insects
- Produces a benign mixture of >10 volatile compounds: ester, alcohols and acid derivatives



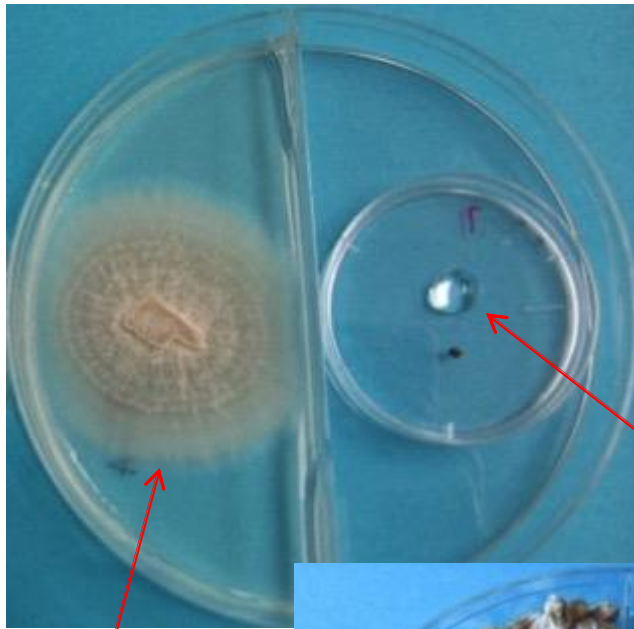
*Muscodor volatiles
completely kill
Fusarium*



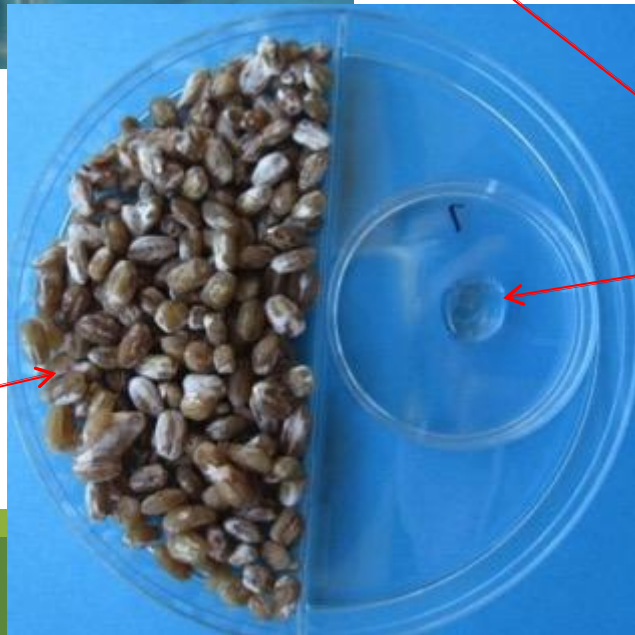
MBI-601 =

 **ENNOBLE**
BIOFUMIGANT

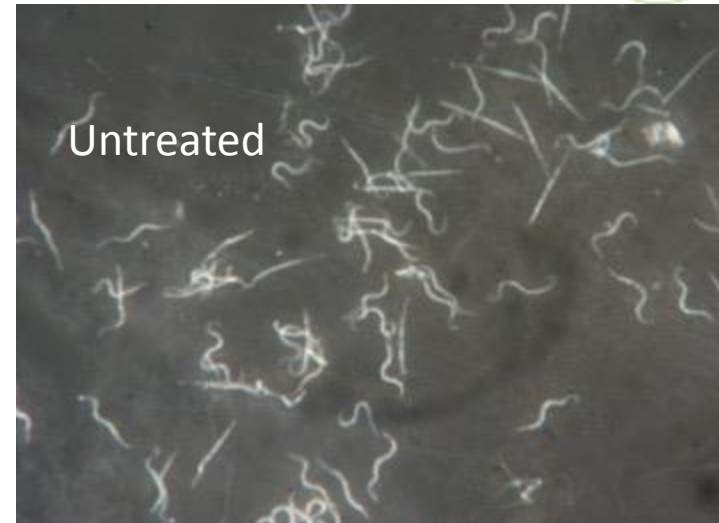
ENNOBLE Kills Plant Parasitic Nematodes



Muscodor strain
grown on PDA
medium



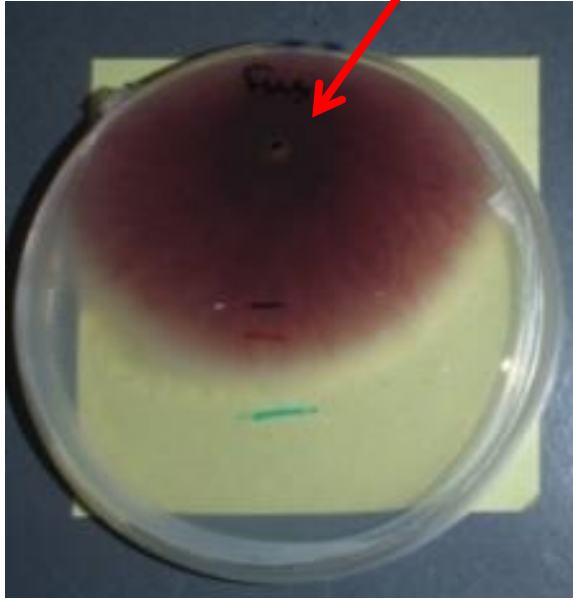
Muscodor strain
grown on barley
grains



Growth inhibition of plant pathogen by ENNOBLE



Fusarium colonies



Fusarium –
untreated control



Fusarium – *M. albus*
strain SA13

Bio-Tam[®] 2.0 - Biofungicide



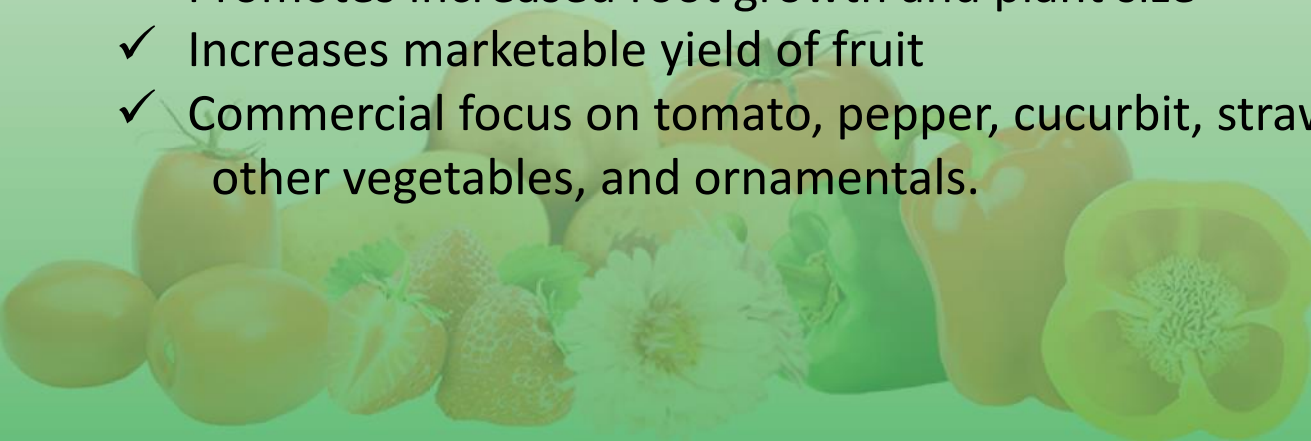
- ✓ Bio-Tam 2.0 is a formulation based on the mixture of conidiospores of two selected natural *Trichoderma* strains:
 - *Trichoderma asperellum* (formerly *harzianum* – ICC008)
 - *Trichoderma gamsii* (formerly *viride* – ICC 012)
- ✓ *Trichoderma asperellum* & *Trichoderma gamsii* are naturally occurring saprophytic antagonistic fungi found in disease suppressive soils.



Bio-Tam® 2.0 - Biofungicide



- ✓ Protects crops from attack by root rots and wide assortment of fungi.
- ✓ Useful tool for fungicide resistance management strategy
- ✓ **Soil application** for controlling/suppressing *Pythium*, *Rhizoctonia*, *Fusarium*, *Phytophthora* and many others
- ✓ Four (4) hour REI → no disruption of crop production labor schedules
- ✓ Zero (0) day PHI → no disruption of harvest schedules; crop/human safety
- ✓ OMRI® listed and meets sustainable production standards
- ✓ A new standard for *Phytophthora capsici* control (outperforms some chemical standards).
- ✓ Aids in water & nutrient uptake thus providing a yield benefit.
- ✓ Promotes increased root growth and plant size
- ✓ Increases marketable yield of fruit
- ✓ Commercial focus on tomato, pepper, cucurbit, strawberries, leafy greens, other vegetables, and ornamentals.



Why two species?



- ✓ Species of *Trichoderma* have varying optimum biological adaptations with regard to:
 - the optimum pH and organic matter contained in the soil
 - optimal temperature of their environment
 - the capability to be attracted by root exudates

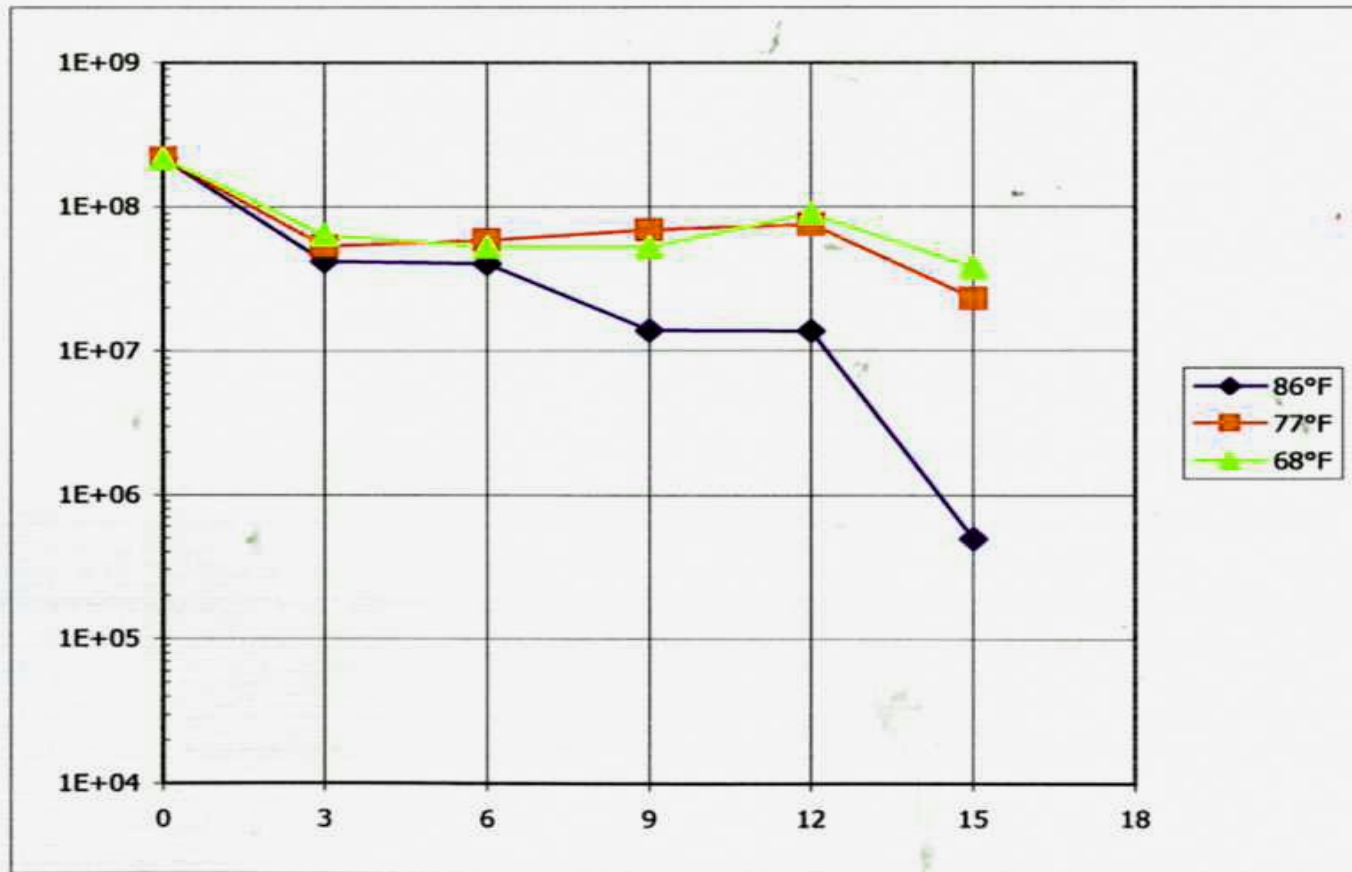
- ✓ Thus, having two *Trichoderma* species broadens the range of preferred environmental conditions and increases the possibility of success in the suppression of pathogens and protection of the crop roots under different soil and environmental conditions compared to formulations containing only one species .



Bio-Tam[®] 2.0



Effect of temperature on the shelf life of BIO-TAM



Bio Tam 2.0 Compatibility



Phosetyl Al	Compatible
Iprodione	Compatible only if $<0,2 \text{ g/m}^2$
Pencycuron	Compatible
Metalaxyl, Mefenoxam	Compatible
Cyprodinil	Compatible
Boscalid	Compatible
Clortalonil	NON COMPATIBLE
Fluazinam	Compatible
Mancozeb, Zineb	NON COMPATIBLE
Carbendazim	NON COMPATIBLE
Tolclofos methyl	Compatible
Myclobutanil	Compatible
Azoxystrobin	Compatible

	Bio-Tam	Soilgard	Rootshield WP	Rootshield GR	Actinovate AG
Mfg	Isagro	Certis	Bioworks	Bioworks	Nat Industries
A.I.	<i>T.asperellum</i> + <i>T.gamsi</i>	<i>T.virens</i> GL21	<i>T.harzianum</i> T22	<i>T.harzianum</i> T22	<i>Streptomyces</i> <i>lydicus</i>
Conc. %	2%+2%	12%	1.15%	1.15%	0.0371%
Formula	4 WP	12 G	1.15 WP	1.15 G	0.04 WSP
Shelf life	15 mo	12 mo	12 mo	12 mo	6 mo
Pkg size	5 lb	7.5 lb	3 lb bag	40 lb bag	18oz
Rate/acre	2.5-5.0 lb	3-5 lb	1-2 Lb	5-12 lb	3-12oz
Rate/100gal	2.5-7.5oz	8-32 oz	3-5 oz	5-12 lbs	3-12 oz
Rate/A 32" row in 7" band	0.5-1.6 lb/A	0.43-2.2lb/A	0.2-0.4 lb/A	1.0-2.6 lb/A	0.7-2.6oz/A
REI	4 hr	0 hr soil	0 hr soil	0 soil	1 hr soil
OMRI-organic	Yes	Yes	Yes	Yes	Yes
Uses	All crops, T&O, soil media, turf	All crops, soil	All crops, soil	All crops, soil	Row crops, turf, seed treatment, chem mixes
Chemical mixes	Yes	Limited	Some	Some	Yes

Bio-Tam 2.0 on Pepper - a

Crown rot (*Phytophthora capsici*)



Treatment	Rate	Timing	% dead plants
Untreated	-	-	97.5 c
BIO-TAM	2.5 lb/A (x 2)	7 days before sowing; at sowing	30.0 b
BIO-TAM	2.5 lb/A (x 3)	7 days before sowing; at sowing; 15 days after sowing	19.0 a
Ridomil Gold (mefenoxam)	1 (x2)	At sowing and 15 days after	17.0 a
BIO-TAM Ridomil Gold	2.5 lb/A 1	7 days before sowing At sowing	8.5 a

The Future is Bright for Biofungicides



The Rate of New Biopesticide Introduction is Accelerating

- ✓ Innovative products are targeting new pests that have been difficult to control are coming to market from both small and large agricultural companies
- ✓ Biopesticides offer flexibility, can usually be applied multiple times without worry about illegal residues and work well in programs
- ✓ Short re-entry intervals are typical
 - Tolerance Exempt – No Maximum Residue Levels (MRL)
 - Residues exempt from tolerances for export crops
- ✓ Most biopesticides are NOP Compliant and OMRI listed
- ✓ IPM compatible!

THINK SPRING!!



BIO WITH BITE

Mid-Atlantic Fruit and Vegetable

*smart.
natural.
solutions.*

January 30, 2018 • NASDAQ: MBII



Boost yield and quality



Manage resistance



Harvest flexibility



Worker-friendly