



Stimulate the Seed

The Role of Biopesticides as Seed Treatments

Dr. Phyllis Himmel



*Pioneering **better** biopesticides...*



*...for a **better tomorrow.***

 **Marrone[®]
Bio Innovations**
www.MarroneBio.com

The world population is soaring and consumers are increasingly concerned about the environment, food safety, and their health. Now, more than ever, our world needs effective, sustainable agricultural solutions.

At Marrone Bio Innovations we are pioneering high-performing biopesticides to address these daunting global challenges. Our award-winning products are helping growers effectively control pests, improve plant health, and increase crop yields while reducing the environmental pesticide load, decreasing chemical residues on food, and fighting the development of pest resistance.

We are Marrone Bio Innovations and we are committed to providing better biopesticides that promote a better tomorrow.



The Role of Biopesticides as Seed Treatments

Phyllis Himmel, Ph.D.

Vice President, Research and Development

Marrone Bio Innovations

December 9, 2013

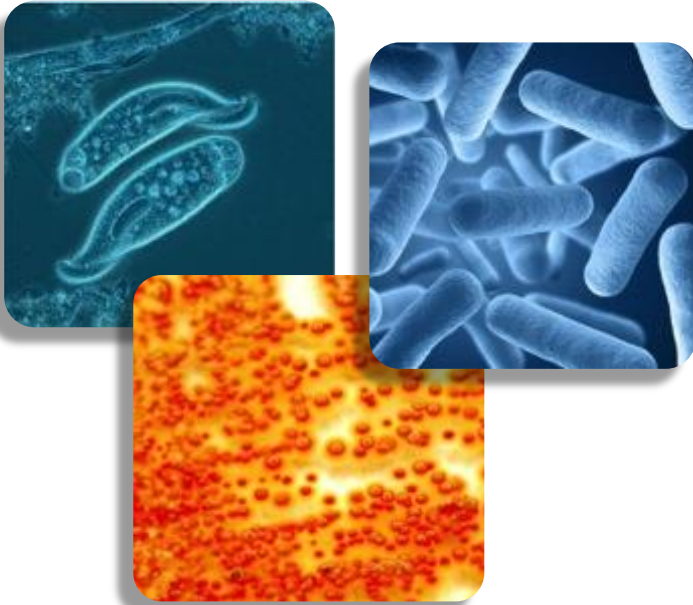




- What are & are not biopesticides?
- Why use biopesticides?
- Biopesticides as seed treatments
- MBI and biopesticide seed treatments
- Future developments

What are Biopesticides?

Microbials



Fungi, Bacteria, Viruses, and Protozoa

Biochemicals

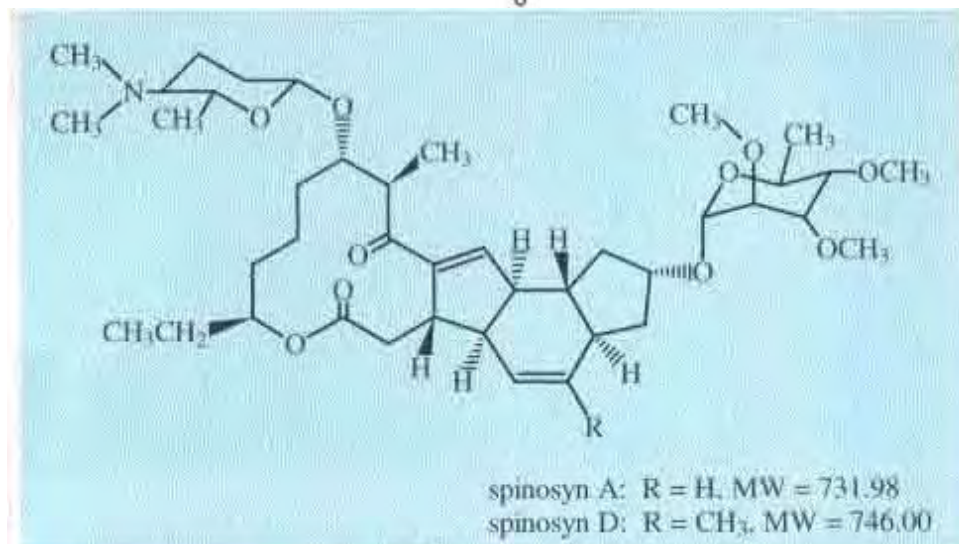
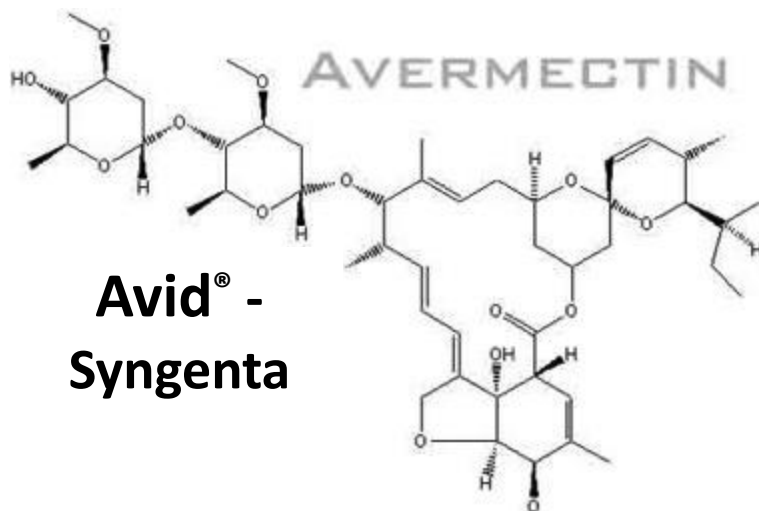


Plant Extracts, Pheromones, Soaps, and Fatty Acids

65-year history of safe use

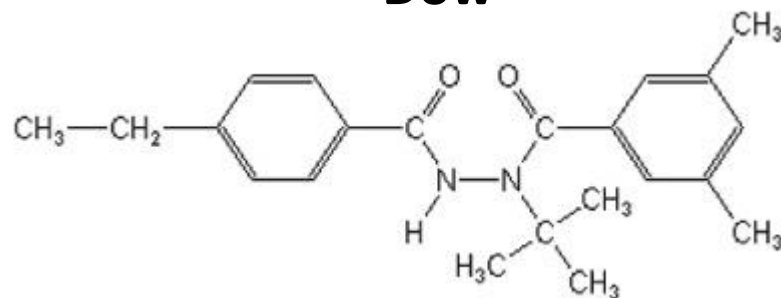
Most are used in conventional agriculture although they can be used in organic production

Successful Insecticides Synthesized from Natural Products (but are not biopesticides)

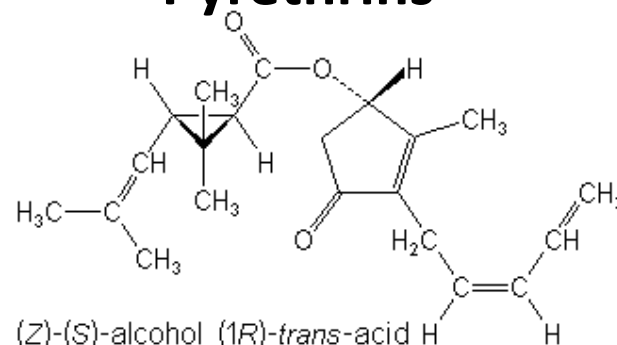


Spinosad (Entrust®, Conserve®, SpinTor®, Success®, Tracer®) – Dow Agro

**Tebufenozide (Mimic®, Confirm®)
Dow**



Pyrethrins



Commonly Used Bioinsecticides in Production Agriculture



Active	Type	Product Examples	Manufacturer
<i>Bacillus thuringiensis</i> <i>spp. aizawai</i>	Microbial, Bacteria	Agree®, XenTari®	Certis USA, Valent BioSciences
<i>Bacillus thuringiensis</i> <i>spp. kurstaki</i>	Microbial, Bacteria	Dipel®, Deliver®, Javelin®	Valent BioSciences, Certis USA
Neem oil	Biochemical, Soaps/Fatty Acids	Trilogy®	Certis USA
Azadiractin	Plant Extract	Aza-direct®	Gowan
<i>Chromobacterium</i> <i>subtsugae</i>	Microbial, Bacteria	Grandevo	Marrone Bio Innovations





Bionematicides:

Are increasingly in demand due to the lack of safe chemicals



Active	Type	Product Examples	Manufacturer
<i>Paecilomyces lilacinus</i>	Microbial, Fungi	MeloCon®	Prophyta; sold by Certis USA
Saponins of <i>Quillaja saponaria</i>	Biochemical, Plant Extract	Nema-Q®	Monterey Ag Resources
<i>Pasteuria spp.</i>	Microbial, Bacteria	Econem® Clariva®	Pasteuria Bioscience / Syngenta
<i>Myrothecium verrucaria</i>	Microbial, Fungi	DiTera®	Valent BioSciences
<i>Bacillus firmus</i>	Microbial, Bacteria	Votivo®	Bayer Crop Science


Commonly Used Biofungicides


A very successful category of biopesticides



Active	Type	Product Examples	Manufacturer
<i>Extract of Reynoutria sachalinensis</i>	Biochemical, Plant Extracts	Regalia®	Marrone Bio Innovations
<i>Potassium bicarbonate</i>	Biochemical	Kaligreen®	Otsuka Chemical Co.
<i>Trichoderma harzianum</i> T-22	Microbial, Fungi	RootShield® WP, PlantShield® HC	Bioworks
<i>Gliocladium virens</i>	Microbial, Fungi	SoilGard®	Certis USA
<i>Bacillus subtilis</i> 713	Microbial, Bacteria	Serenade®	AgraQuest (Bayer)
<i>Streptomyces lydicus</i>	Microbial, Bacteria	Actinovate®, ActinoGrow®	Natural Industries (Novozymes)
<i>Coniothyrium minitans</i>	Microbial, Fungus	Contans®	Prophyta (Bayer)

Big Companies Jump Into Ag Biopesticides (2012-2013)



 deVGen
 

\$523 million
\$123 million







\$1 billion







prophyta
\$425+ million






NATURAL INDUSTRIES





Center for Agricultural and Environmental Biosolutions






Acquires Multiple RNAi Providers




Syngenta, Novozymes Ink Deal To Commercialize Taegro



... becomes exclusive distributor of Polyversum biofungicide




American Vanguard Invests in TyraTech Natural Product Technologies

Why Biopesticides?

"Biopesticides are mainstream. We know we are all going to need a biopesticide play."

Biopesticides are increasingly required in pest management programs to meet customer needs

e.g., Exported produce; Covered vegetables in Europe – retailers demand no or few residues. SYSCO, Wal-Mart and other food companies developing sustainable farming requirements.

Biopesticides provide added benefits or fit where few chemicals exist

e.g., Nematode control; Bayer's Poncho/Votivo seed treatment, MBI's ZEQUANOX for invasive mussels in open water; GRANDEVO for resistance mgt

Biopesticides meet growing consumer demand for health and wellness

e.g., Low or no residues; to expand garden pesticides segment; address Canada's bans on cosmetic pesticides

Tightening chemical regulations and special governmental biopesticide initiatives

e.g., Europe's Sustainable Use Directive, Canada bans, etc.; programs to accelerate biologicals in EU, Brazil, India, others

Biopesticides are one of the fastest growing input segments

e.g., 10-16% CAGR

What's in the EPA pipeline for biopesticides?

A robust pipeline is a MUST for the success of biopesticides

Microbials in EPA registration work plan for 2013

http://www.epa.gov/pesticides/biopesticides/regtools/biopesticides_2013_workplan.pdf

- *Bacillus subtilis* QST-713
- *Bacillus thuringiensis* SUM-6218
- *Bacillus thuringiensis* SDS-502
- *Burkholderia rinojensis* A396 → **NEW!!**
- *Pasteuria* spp. pH3
- *Gliocladium roseum* 321U
- *Bacillus pumilus* BU F33



Lots of known microorganisms
with known activity

Specialty Crops = 'Tip of the Iceberg'



Biopesticides were first deployed on specialty crops to manage residues

Specialty crops



Now starting to see movement into row crops, starting with microbial seed treatments; potential for other segments

**Cereals, Oilseed,
Sugar, Fiber, Forage
Grains**

Seed Treatment

L & G; T & O; Forestry

Post Harvest

Animal Health

Public Safety

ETC.

Biopesticides as Seed Treatments



- Multiple modes of control for pest resistance management.
- Use less product on seeds and therefore less expensive than foliar and soil applications
- Can be used alone or in combination with additional chemistries in priming, pelleting and film coating processes
- Documented synergy with many conventional chemistries. Most new biopesticidal seed treatments are deployed in “stacked” sets of active ingredients for improved pest management
- Improve seedling emergence , stand establishment, vigor and pest control.
- The earliest successful biopesticidal seed treatment is still on the market: *Bacillus subtilis* (Bt) (Gustafson) and remains one of the most widely used biopesticide seed treatments.



Kodiak® HB is a dry biological seed treatment.

Contains *B. subtilis* (6×10^9 viable spores per gm) for suppressing soilborne fungal diseases caused by *Fusarium*, *Rhizoctonia*, *Alternaria* and *Aspergillus* in cotton, peanuts, corn and ornamentals

Continued ...



Robust Rhizobial Inoculant

Minimum guaranteed count of 10 billion (1.0×10^{10}) colony forming units (CFUs) of *rhizobia* per ml.

Highly effective and infective multi-strain

Bradyrhizobium japonicum produced fresh for each growing season for maximum freshness and performance.



VAULT^{HP}
the right choice

Patented Rhizobia Growth Enhancer

After planting, patented biological performance enhancer works with *rhizobia* to stimulate root nodulation.

BioStacked[®]

Powerful INTEGRAL Biofungicide

Extends suppression of yield-robbing *Rhizoctonia* and *Fusarium* fungal diseases.

Complements other systemic fungicides to help promote better root structure and vigor.

More vigorous roots mean improved nutrient uptake for added yield potential.





Poncho/VOTiVO employs a dual conventional - biological modes of action with a unique bacteria strain that lives and grows with young roots, creating a living barrier that prevents important nematode species from reaching the roots.

Poncho/VOTiVO also provides control of many critical early season insect pests.

ACTIVE INGREDIENTS:

Clothianidin 40.3%

Bacillus firmus-1582 8.1%

OTHER INGREDIENTS: 51.6%

KEEP OUT OF REACH OF CHILDREN

CAUTION

Contains 4 .17 pounds clothianidin per U .S . gallon Contains 0 .84 pounds Bacillus firmus per U .S . gallon

(contains a minimum of 2 X10⁹ cfu/ml)

EPA Reg. No. 264-1109

Additional Products as Seed Treatments



SERENADE® and SONATA® *Bacillus subtilis* with fungicidal activity against soilborne diseases caused by Fusarium, Rhizoctonia and Pythium that impact seed germination and plant growth in a wide range of crops including soybeans, cotton, corn, wheat and vegetables.

Both products are made by AgraQuest now a division of Bayer Crop Sciences. Both are labeled for many diseases in a wide range of fruits and vegetables.





Harpin proteins are natural plant compounds that can stimulate plant defense system responses.

N-Hibit™ is a seed-treatment containing harpin protein that is sold in the United States for management of soybean cyst nematode (SCN).



Plant Health Care agreement with Monsanto: to use this product in Monsanto's soybean seed treatments against soybean cyst nematodes

Today RNAi strategies in combination with expressed BT proteins are being used to manage Corn Root Worm resistance to BT alone



Marrone Bio's Discovery & Development Process

Marrone Bio Innovations, Inc. Overview

Company Highlights

- Founded April 2006 in Davis, CA
- **3** commercial products, **1** add'l approved, **2** add'l submitted for EPA approval
- Library of **18,000+** proprietary microorganisms
- 160+ employees (19 Ph.D.; 67 in R&D)
- Strategic investors: **DSM, Syngenta, Mitsui**
- Building fermentation facility in Bangor, MI
- Revenues in first half 2013 exceeds all of last year
- Listed on NASDAQ as MBII August 2, 2013

Commercial Products Today



Marquee Partners / Distributors



Robust Pipeline

- Opportune™ bioherbicide EPA approved
- Venerate™ bioinsecticide and MBI-011 bioherbicide submitted for EPA approval
- Nematicides, additional herbicides, and plant health products in development
- More than 200 patents issued and pending

Developing a Successful Biopesticide is Challenging

Challenging Environment for Potential New Entrants

Technical Capability

Intellectual Property

Grower & Field Specialist
Relationships

Team Expertise and R&D Culture

Management Skills to Lead
Development Process

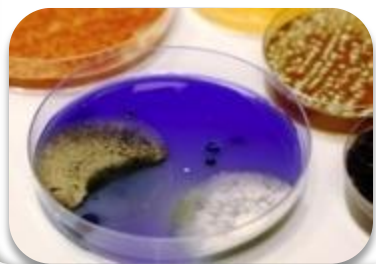
- Technical and market competencies are ***difficult and expensive to replicate***
- Range of necessary scientific & management skills are ***poorly understood and in short supply***
- Each microbe/plant extract is ***different with unique challenges*** so developing an ***entire pipeline*** is difficult
- ***Universities do not train*** for formulation chemistry and ***the combination of skills*** needed for the development & commercialization of biopesticides
- Field application experience is integral; ***limited number of field specialists have properly evaluated biological products***

MBI: Discovery and Development



Isolation

Samples from around the world from areas of high biodiversity are collected and cultured.



Fermentation

Purity is confirmed and water extracts of fermentation broths are prepared for bioassays.



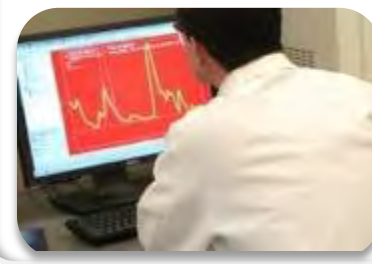
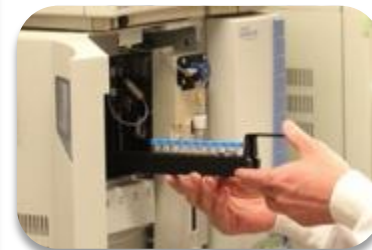
Biological Testing

Biological testing against weeds, insects, plant pathogens, nematodes, algae, and for growth promotion are performed.



Natural Product & Analytical Chemistry

Identify pesticidal compounds; eliminate harmful strains. Develop analytical assays for mfg QC.



Development - Delivering High Quality, Usable Products

Getting to market ...

Goal –

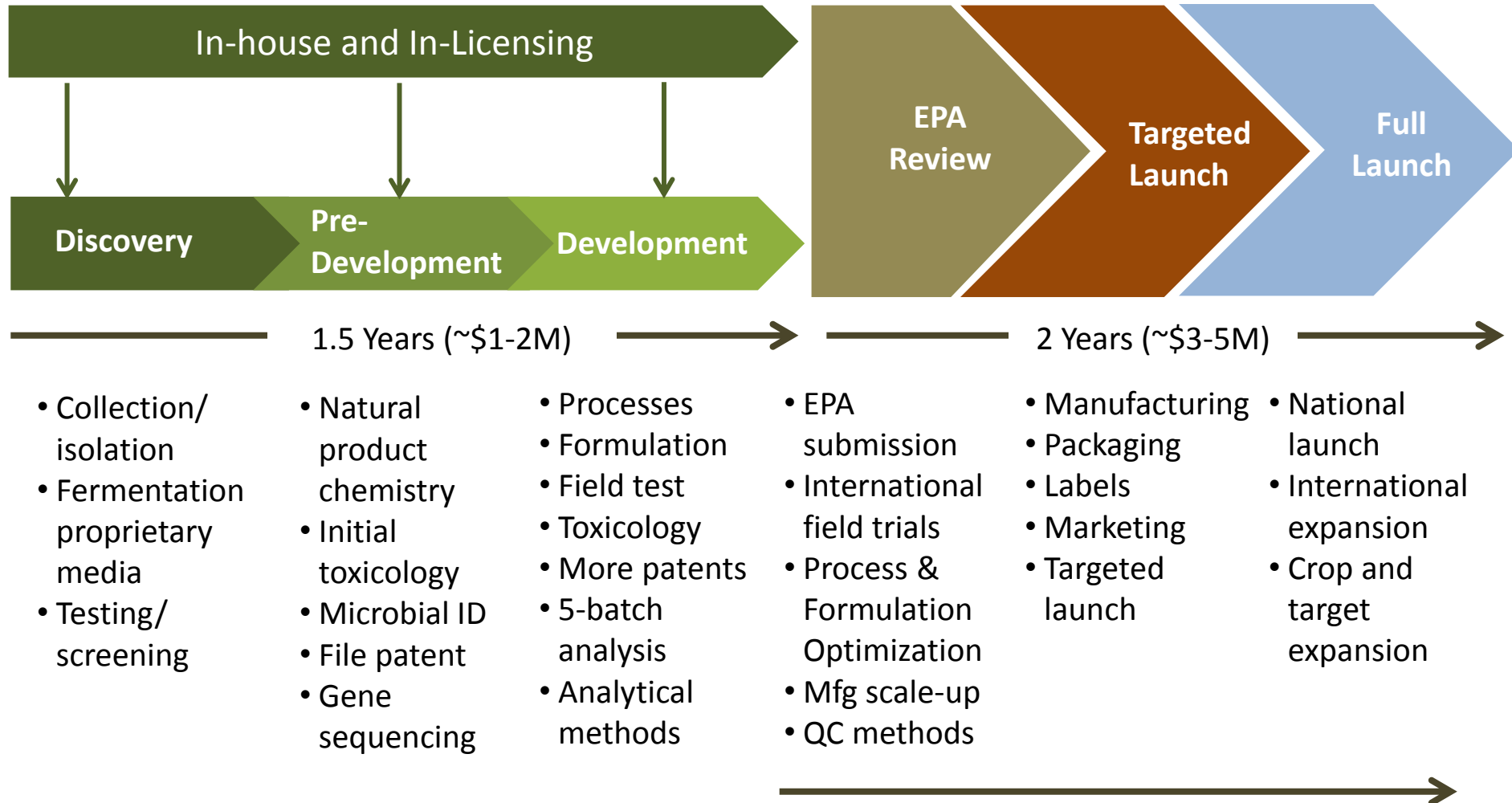
- **Cost-effective**
- **Value-added**
- **Consistent efficacy**
- **Easy to use**

How -

- Optimize processes
- Scale up—pilot & manufacturing
- Field trials
- Registration package
- User-friendly formulations & packaging
 - Wettable powder, granule, liquid suspension, seed treatments, etc.



Getting a Product to U.S. Launch



MBI: Delivering The Next Generation of Biopesticides



*Biofungicide that works as well
as or better than chemicals;
Enhances chemicals to increase
yields in row crops*



*Broad spectrum microbial
insecticide with novel chemistry
and novel mode of action*



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



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

*Suite of novel
microorganisms that
enhance plant growth
(MBI-506, -110, -303,
-401)*

*Two new nematicidal
bacteria that produce new
classes of chemistry
(MBI-302, -303)*

*A new systemic herbicide
with novel chemistry
(MBI-010)*



MBI: Delivering The Next Generation of Biopesticide Seed Treatments



Biofungicide that works as well as or better than chemicals; Enhances chemicals to increase yields in row crops



Broad spectrum microbial insecticide with novel chemistry and novel mode of action



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



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

Suite of novel microorganisms that enhance plant growth (MBI-506, -110, -303, -401)

Two new nematicidal bacteria that produce new classes of chemistry (MBI-302, -303)

New systemic herbicides with novel chemistries (MBI-005, MBI-010)

New Discoveries Show Promise as Seed treatments for Plant Health Enhancement Nematode and Pathogen Control



BIOSTIMULANTS

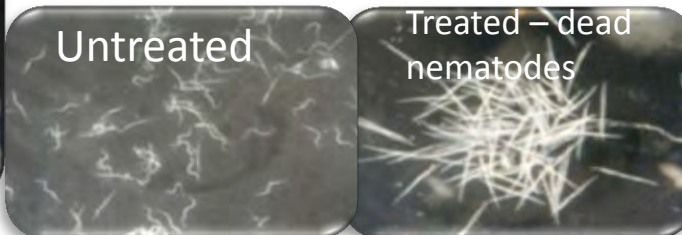
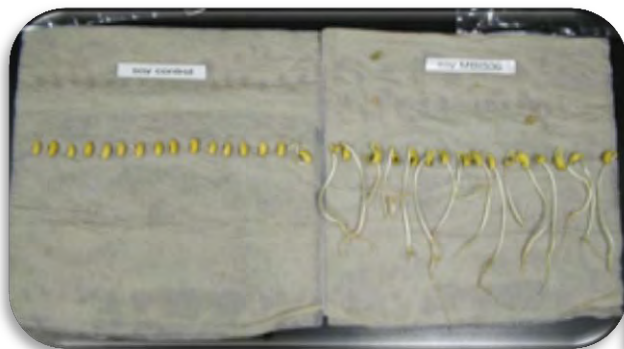
- Promote ...
 - P uptake
 - Root & foliar growth
 - Drought tolerance
 - Disease resistance
 - Yield increases
- Collaborator discovery; MBI has first right of refusal for multiple crops including corn, rice, wheat, and soy

BIONEMATICIDE

- Novel bacteria species
- Kill broad spectrum of plant parasitic nematodes
- Perform as well as chemical nematicide in lab
- Evidence of plant growth and yield enhancement
- Toxicity testing (near complete)—showing low risk to beneficial nematodes

BIOFUNGICIDE

- Giant knotweed extracts: multiple modes of activity to manage pest resistance
- Control of PM, DM, leaf spots, bacterial diseases, seedling damping off - ISR
- Synergizes with chemical fungicides to improve performance
- Increases yields & seed germination, stimulates roots



Regalia + azoxystrobin on soybean seed in *Rhizoctonia solani* infested soil

Treatment	Emergence%	
Non-inoculated control	90.1	a
Inoculated control	4.9	c
Inoc. MBI-106 1:200(0.03175g/kg)	7.4	c
Inoc. MBI-106 1:300(0.02117g/kg)	11.1	c
Inoc. MBI-106 (0.03175g/kg)+azo.	90.1	a
Inoc. MBI-106 (0.02117g/kg)+azo.	92.6	a
Inoc. azoxystrobin (0.0298g/kg)	86.4	a
Inoc. drench Regalia ME 0.5% 90ml/pot	37.0	b
Non-inoc. drench Regalia ME 0.5% 90ml/pot	86.4	a
n=3 reps(81 plants/trt) Lsd 0.05 level	p<0.0001	

Regalia + Fludioxonil

on soybean seed in *Rhizoctonia solani* infested soil

Treat#	Treatment	Emergence%		Bio mass (g)	
2*	Inoculated control	7.4	c	0.8	c
3	Inoc. MBI-106 1:10(0.635g/kg)	9.9	c	1.4	c
4	Inoc. MBI-106 1:200	16.0	c	2.9	c
5	Inoc. MBI-106 1:10+fludioxonil	61.8	a	17.0	a
6	Inoc. MBI-106 1:200+fludioxonil	50.6	a	12.5	b
7	Inoc. fludioxonil 0.16 floz/100lb	35.8	b	8.7	b
	n=3 reps(81 plants/trt) Lsd 0.05 level	p<0.0001		p<0.0001	

*Treatment 1 (Non-inoculated control) was contaminated.

Regalia + Fludioxonil on soybean in *Rhizoctonia solani* infested soil



MBI-106 1:200+
Fludioxonil

Fludioxonil

MBI-106 1:10+
Fludioxonil

Regalia + Mefenoxam (Apron) on soybean seed in *Pythium ultimum* infested soil



Treat#	Treatment	% Emergence		Biomass(g)	
1	Non-inoculated control	74.1	a	16.9	a
2	Inoculated control	2.5	c	0.3	d
3	Inoc. MBI-106 1:100 (0.0635g/kg)	0.0	c	0.0	d
4	Inoc. MBI-106 1:200(0.03175g/kg)	3.7	c	0.5	d
5	Inoc. MBI-106 1:100+mefenoxam (Ridomil) 1/2 rate	70.4	a	16.0	ab
6	Inoc. MBI-106 1:200+mefenoxam (Ridomil) 1/2 rate	64.9	a	14.5	b
7	Inoc. mefenoxam (Ridomil) 1/2 rate (Apron label=0.15g ai/kg)	46.9	b	12.3	c
	n=3 reps(81 plants/trt) Lsd test at p=0.05 level	p<0.0001		p<0.0001	

Soybean Seed Treatments – Plant Height



Soybean Cyst Nematode Control
(*Heterodera glycines*)
Average Plant Height (cm)
Auburn University, 2013

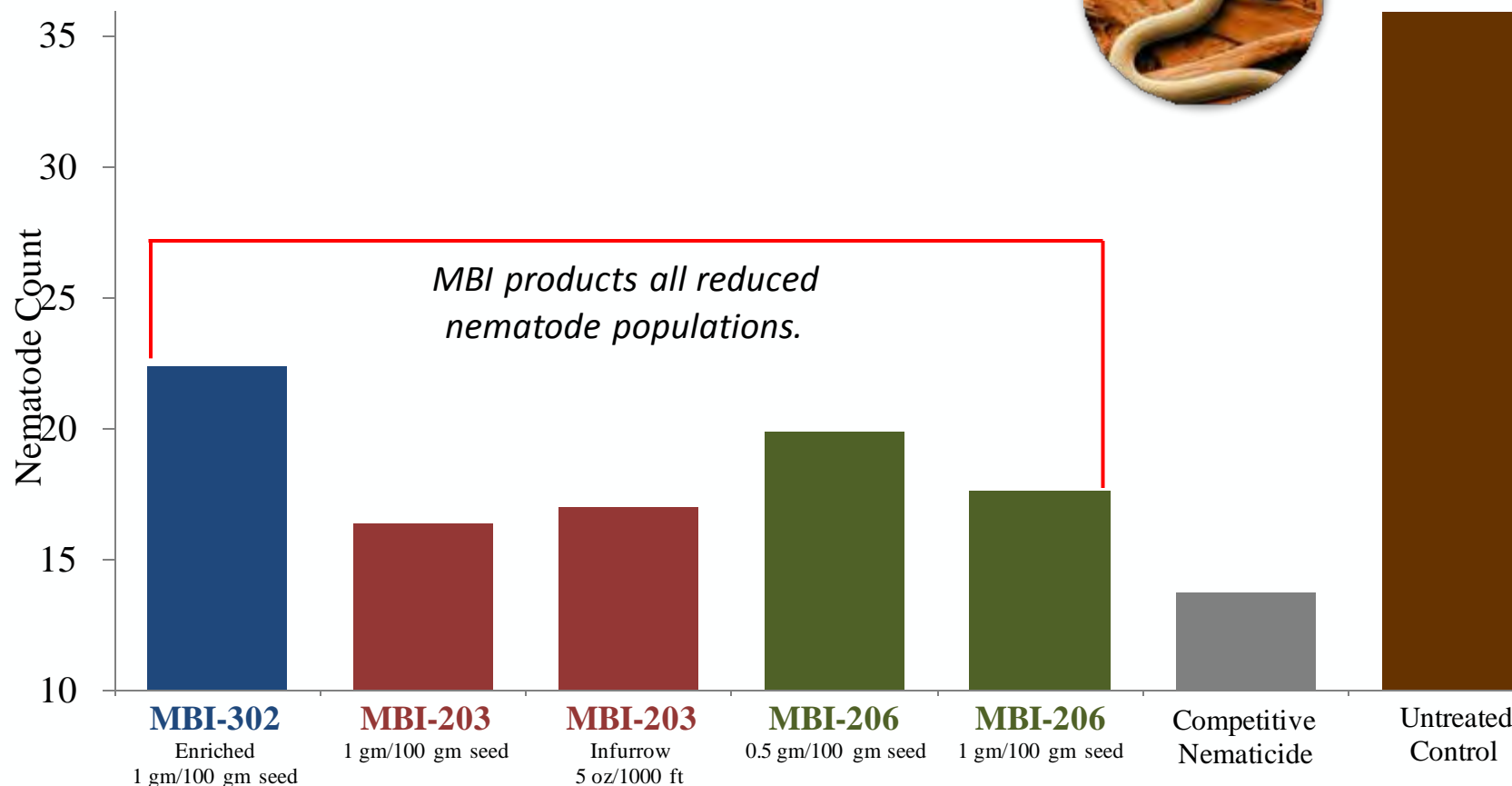


- Treatments applied at planting on Jun 3.

- Treatments evaluated on July 30.

Soybean Seed Treatments – Nematode Counts

Soybean Cyst Nematode Control (*Heterodera glycines*) Nematode Count Auburn University, 2013



*MBI products all reduced
nematode populations.*

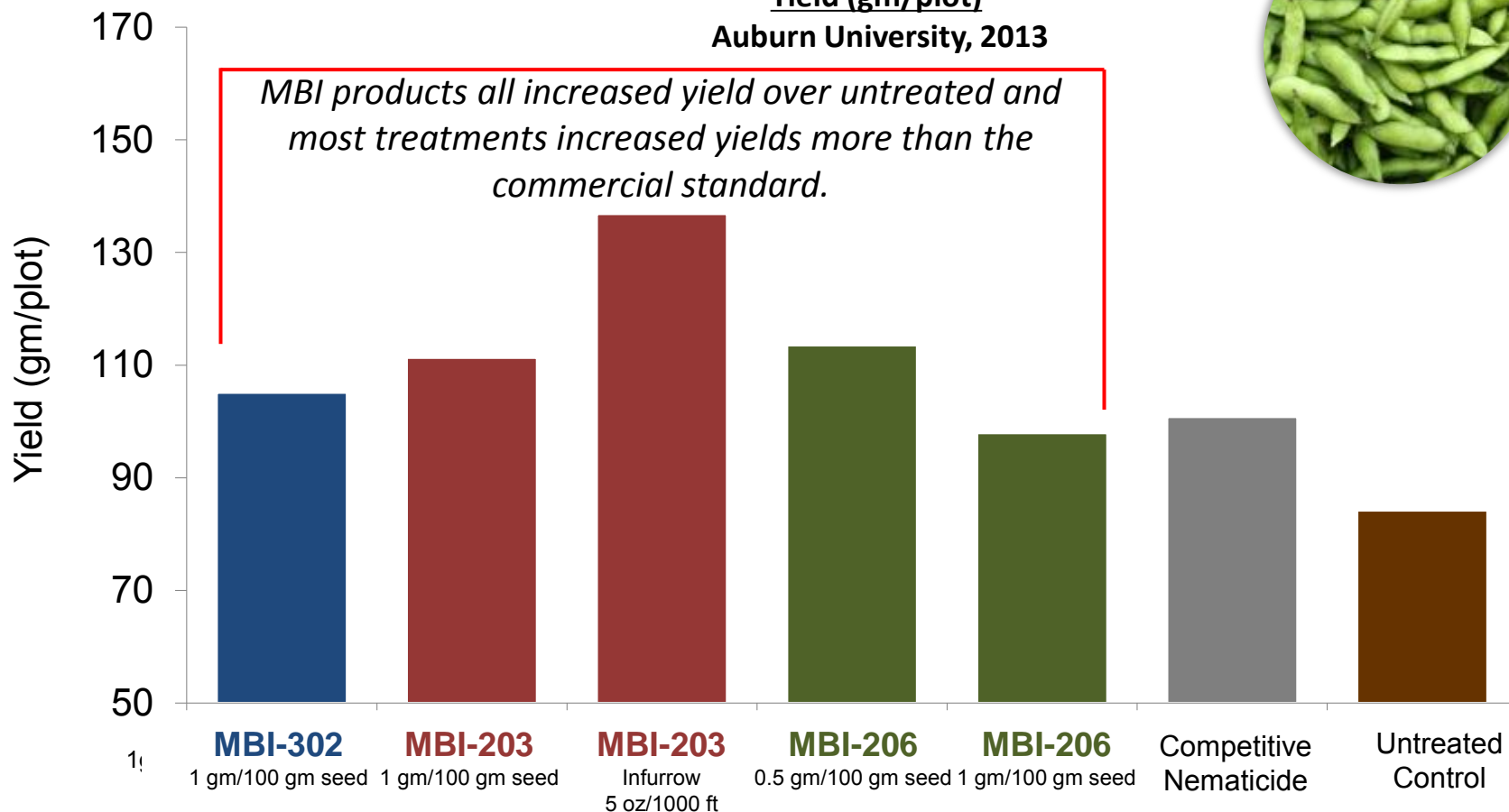
- Treatments applied at planting on Jun 3.

- Treatments evaluated on July 30.

Soybean Seed Treatments – Yield



Soybean Cyst Nematode
(*Heterodera glycines*)
Yield (gm/plot)
Auburn University, 2013



- Treatments applied on Jun 3.
- Yield evaluated on Oct 8.

Future Developments



- Expect an explosion of microbes that colonize roots and enhance plant growth (biostimulants) to reach the market
 - Fewer regulatory barriers if not making yield or pesticidal claims
 - Challenge will be differentiating products backed by strong science with replicated efficacy data packages from “snake oils”
- Regulated biopesticides will continue to come to market at the current pace due to regulatory and technical gating barriers
- Should universities start biological formulation chemistry curricula and short courses in biopesticide development?
- Many biopesticides for the near term will continue to be from small companies built around a single technology and in-licensed from public institutions
- 10-15 years from now the landscape will be different as more teams have developed multiple products and everyone will need the full range of capabilities in-house



www.marronebio.com

NASDAQ: MBII



Forward Looking 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 launches, target geographic markets, factors for the barriers to entry into the market, and strategies for growth. Statements that include the words "expect," "intend," "plan," "believe," "project," "forecast," "estimate," "may," "should," "anticipate" 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.



ABOUT MARRONE BIO

Public company [NASDAQ: MBII]
110+ employees
Headquarters in Davis, CA

Three commercial product lines:
Regalia®, Grandevo®, and Zequanox®

Launching in 2014 ...
Venerate™ bioinsecticide and
Opportune™ bioherbicide

Robust product pipeline includes ...
insecticides, nematocides, herbicides,
and plant health candidates

Library of 18,000+ proprietary
microorganisms

Strategic investors:
DSM, Syngenta, Mitsui

Marquee global partners/distributors:
Syngenta, FMC, ENGAGE Agro, Scotts

More than 200 patents issued and
pending

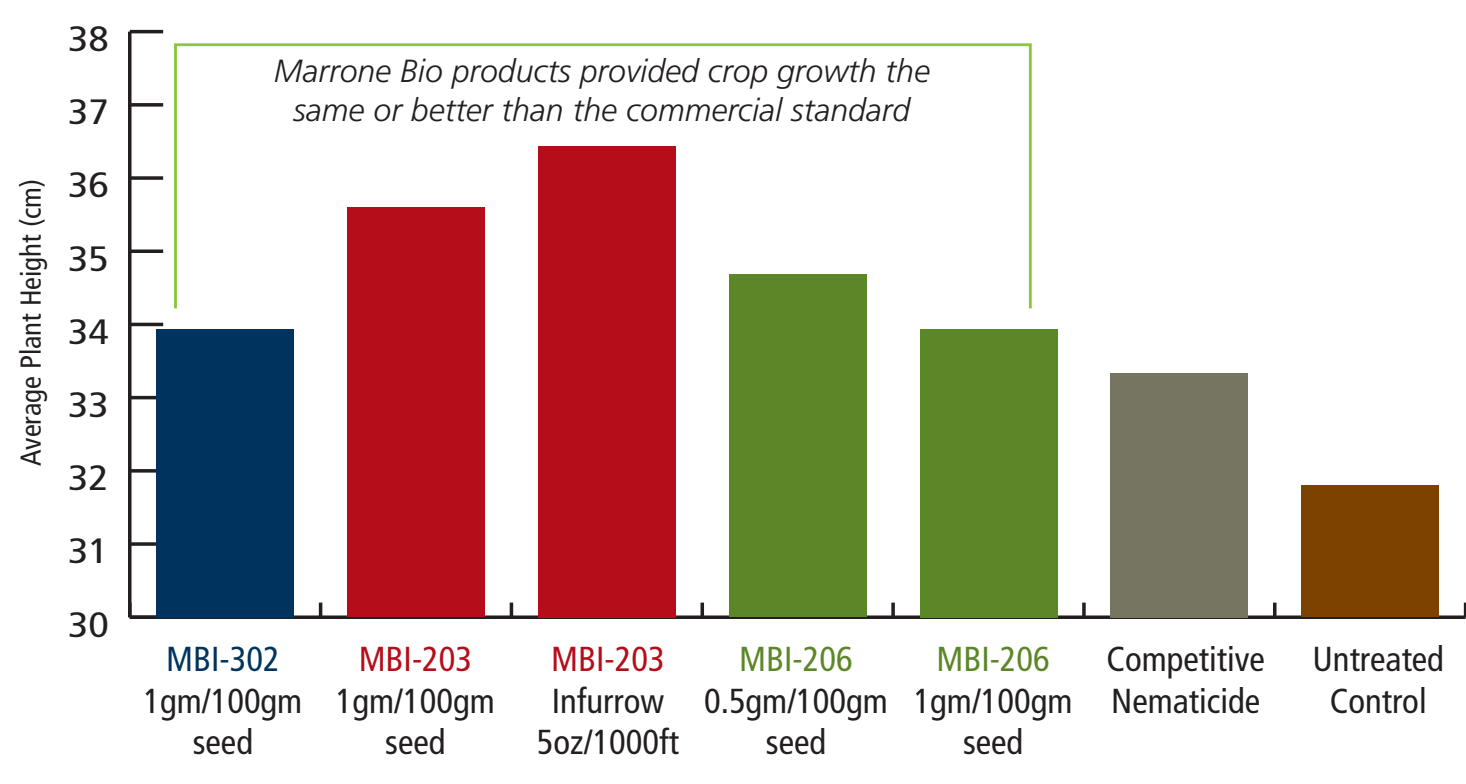
U.S.-based manufacturing plant in
Michigan

The Role of Biopesticides in Seed Treatment

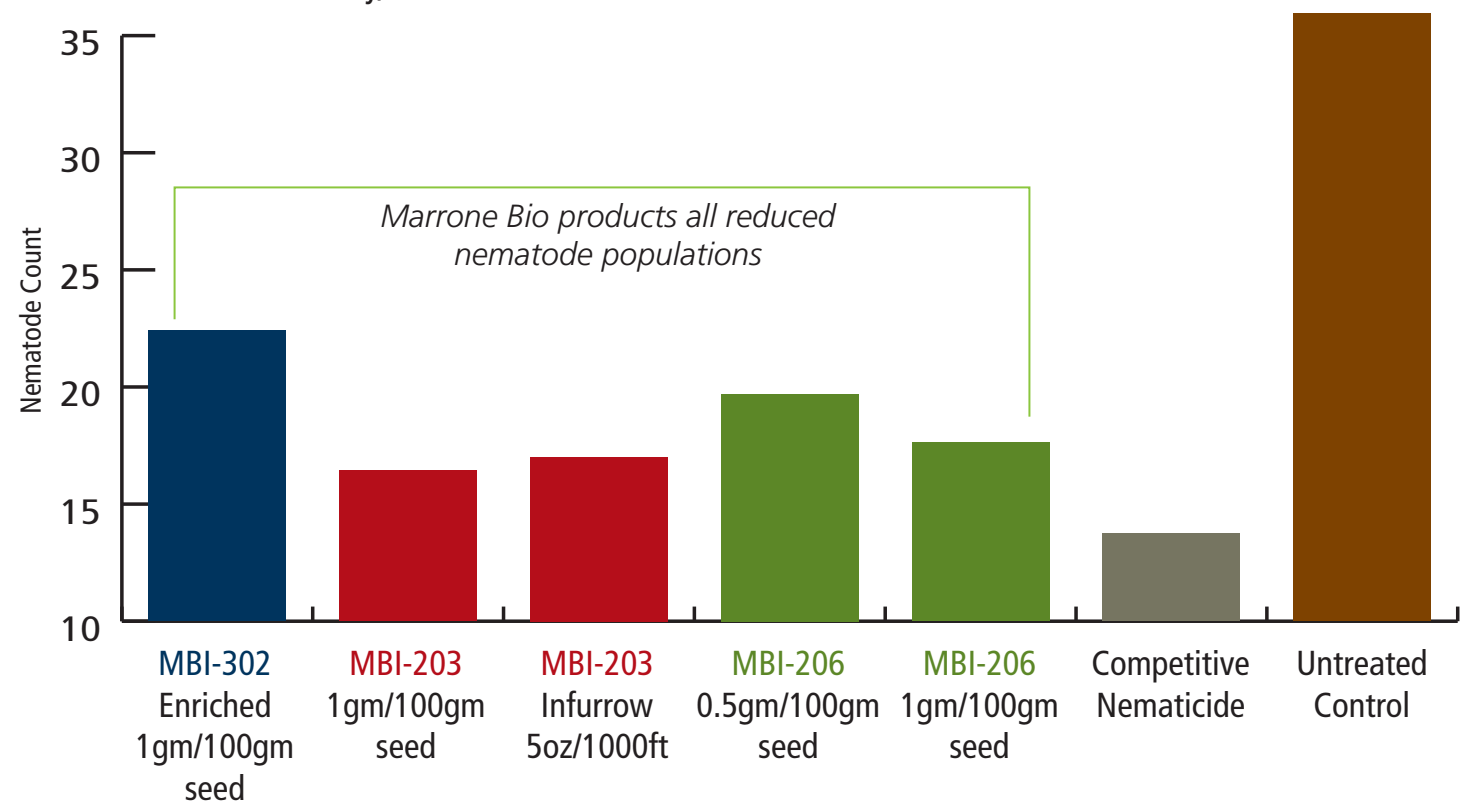


SEED TREATMENT STUDIES WITH BIOPESTICIDES FROM MARRONE BIO INNOVATIONS

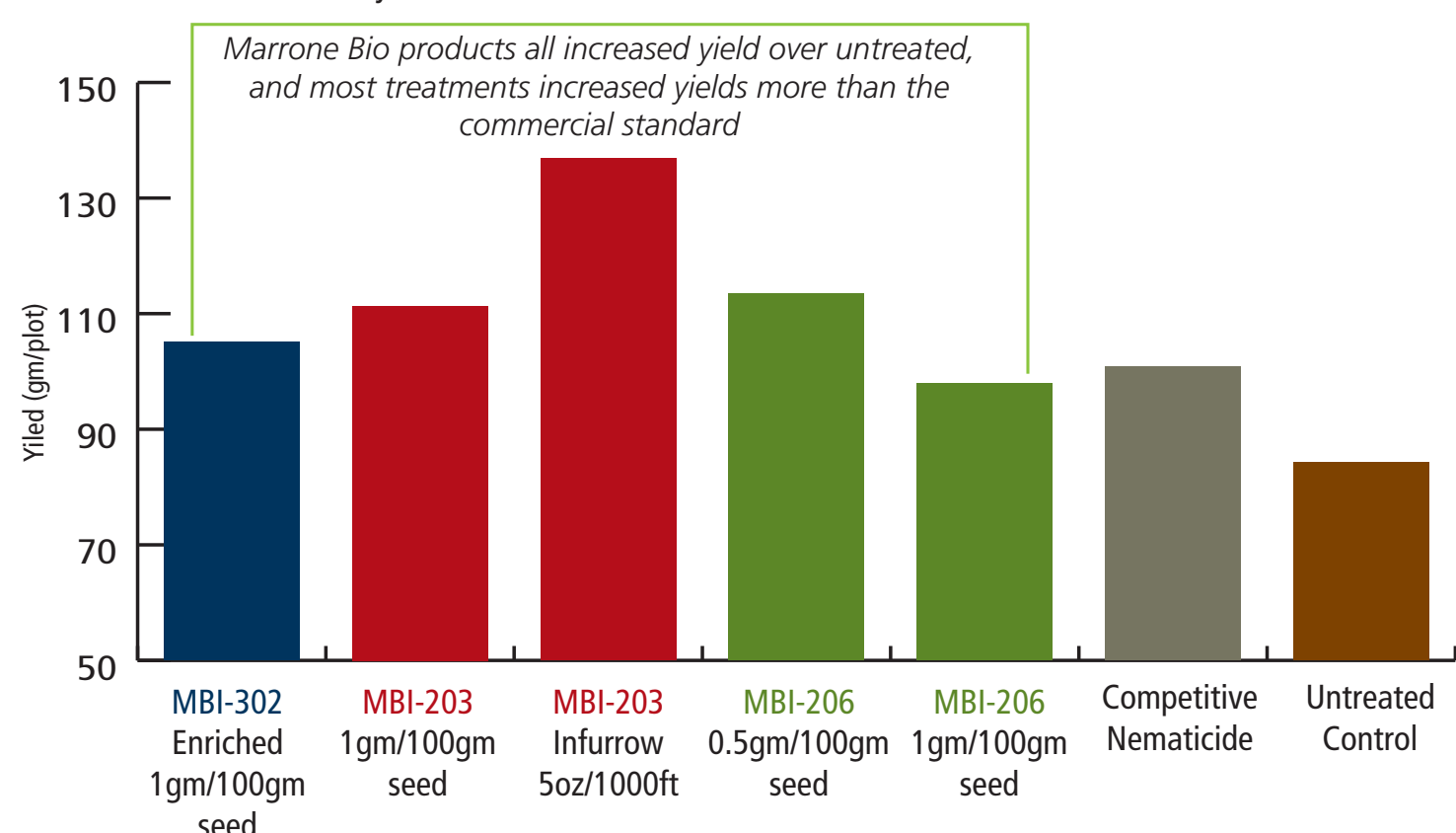
Soybean Cyst Nematode Control–Average Plant Height**
(*Heterodera glycines*)
Auburn University, 2013



Soybean Cyst Nematode Control–Nematode Count**
(*Heterodera glycines*)
Auburn University, 2013



Soybean Cyst Nematode Control–Yield**
(*Heterodera glycines*)
Auburn University, 2013



Regalia® + Mefenoxam (Apron®) on Soybean Seed
in *Pythium ultimum* infested soil

Treat#	Treatment	%Emergence	Biomass (g)
1	Non-infested control	74.1 (a)	16.9 (a)
2	Infested, control	2.5 (c)	0.3 (d)
3	Infested, MBI-106 1:100 (0.0635 g/kg)	0.0 (c)	0.0 (d)
4	Infested, MBI-106 1:200 (0.03175 g/kg)	3.7 (c)	0.5 (d)
5	Infested, MBI-106 1:100+mefenoxam 1/2 rate*	70.4 (a)	16.0 (ab)
6	Infested, MBI-106 1:200+mefenoxam 1/2 rate*	64.9 (a)	14.5 (b)
7	Infested, mefenoxam 1/2 rate*	46.9 (b)	12.3 (c)
n=3 reps (81 plants/trt) LSD test at p=0.05 level		p<0.0001	p<0.0001

*Ridomil® was used in this study and rates of mefenoxam were calculated following Apron® label rate at 0.15g ai/kg.

** Treatments applied at planting on June 3. Treatments evaluated on July 30. Yield evaluated on Oct. 8.

FUTURE DEVELOPMENTS

Expect an explosion of microbes that colonize roots and enhance plant growth (biostimulants) to reach the market...

- Fewer regulatory barriers if not making yield or pesticidal claims
- Challenge will be differentiating products backed by strong science with replicated efficacy data packages from “snake oils”

Regulated biopesticides will continue to come to market at the current pace due to regulatory and technical gating barriers.

Should universities start biological formulation chemistry curricula and short courses in biopesticide development?

Many biopesticides for the near term will continue to be from small companies built around a single technology and in-licensed from public institutions.

10-15 years from now the landscape will be different as more teams have developed multiple products and everyone will need the full range of capabilities in-house.

