Marrone® Bio Innovations

Biologicals for IPM Programs

Pam Marrone, PhD

smart. natural. solutions.

Aug 2017 • NASDAQ: MBII

Boost yield and quality

Manage resistance

Harvest flexibility

Worker-friendly

Fewer New Chemicals – Higher Cost

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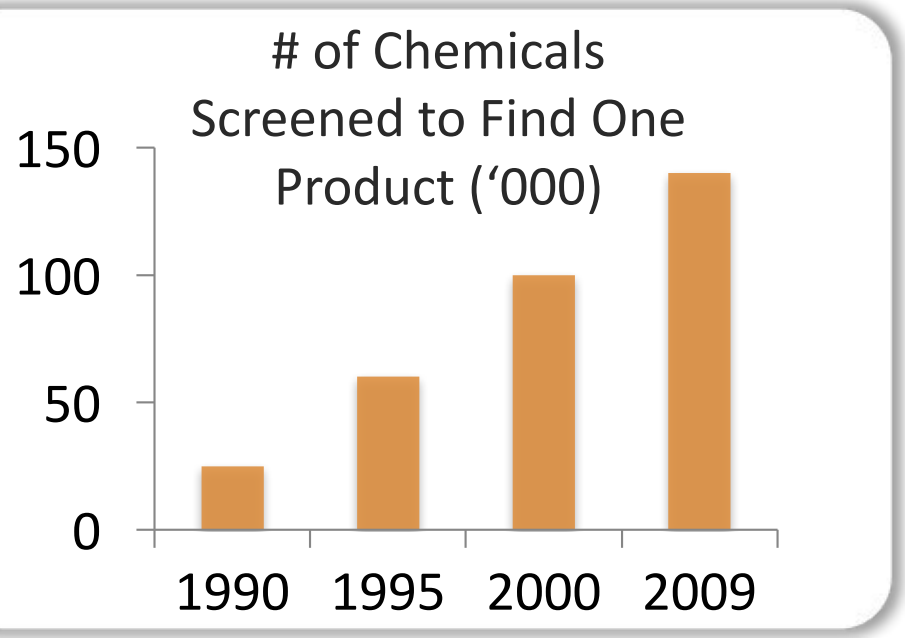
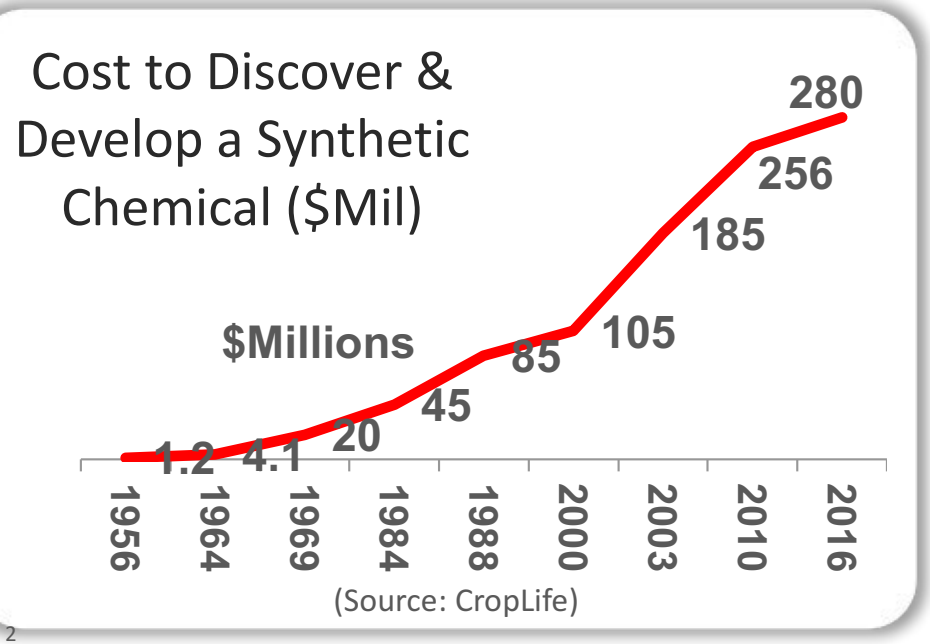
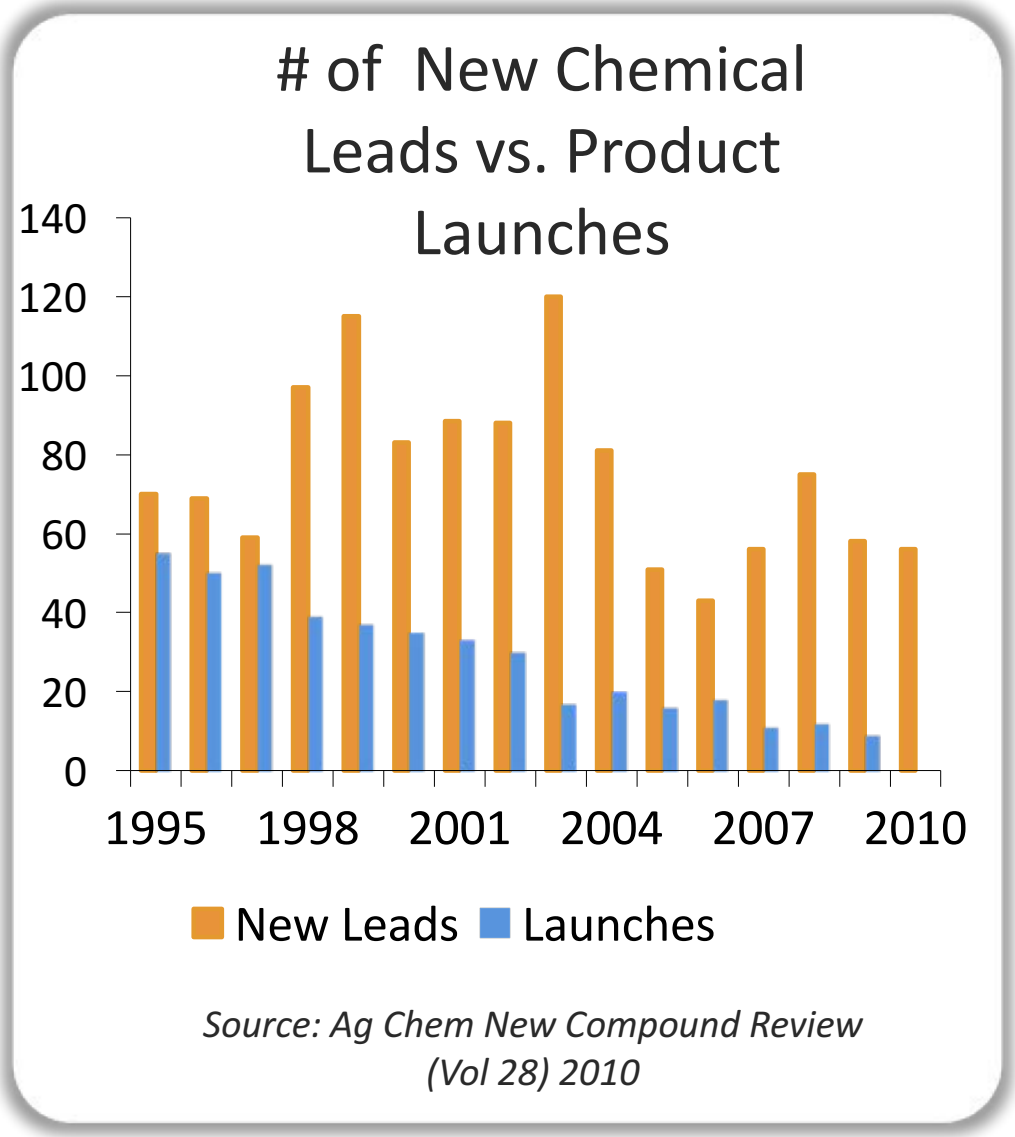




(Source: CropLife)



Source: Ag Chem New Compound Review (Vol 28) 2010

Biologicals Outpace Chemicals Growth

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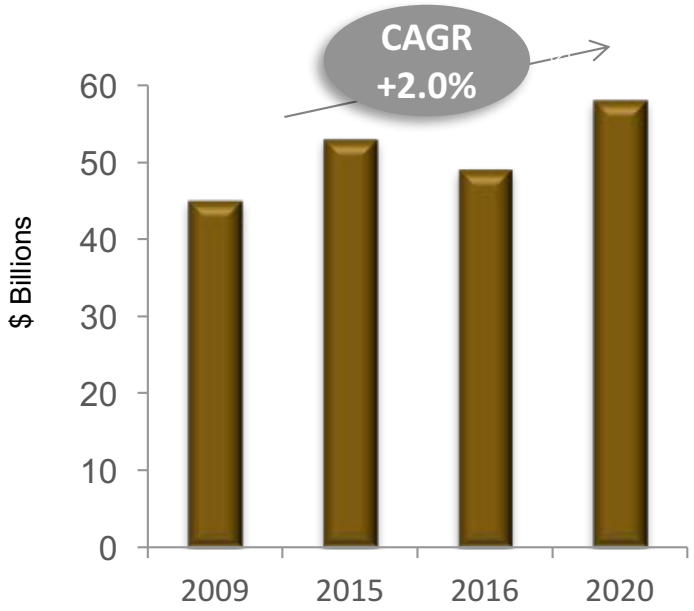
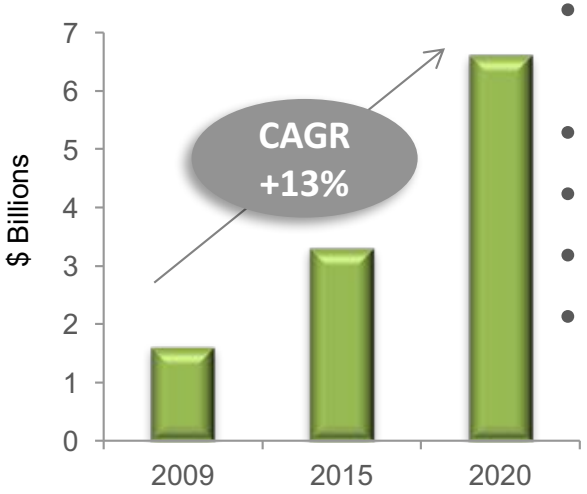
Agrichemicals

- Global regulatory restrictions
- Pest resistance
- Slow growth
- $~280 mil, 12 yrs to develop 1 chemical pesticide



Biopesticides



- Higher yields/quality
- No residues
- No resistance
- Worker safety
- Low cost to develop (<$10 mil, 4 yrs)

Source: Blended numbers and CAGRs from BCC Research, marketsandmarkets, Agropages and Phillips McDougall

Categories of Biologicals

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Biopesticides
Crop Protection

Biostimulants
Crop Enhancement

Biofertilizers
Crop Nutrition

Many, many companies are going into biostimulants, but fewer venture into biopesticides because of the higher technical and regulatory barriers to entry

Biopesticide Categories

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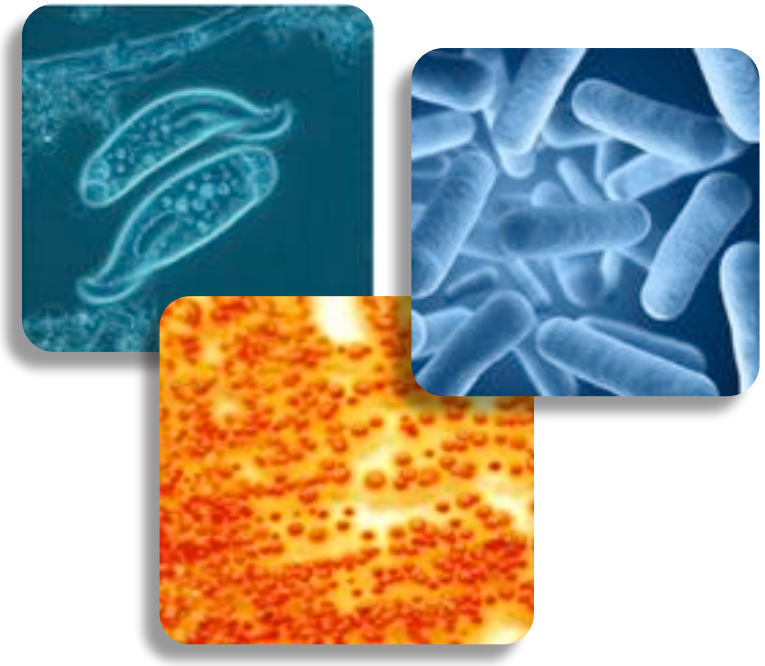
Microbials



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

US EPA Biopesticide Registration

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Biopesticide Pollution Prevention Division (BPPD)

Tiered Data requirements; Start with Tier I:

- Rat Acute Studies - Oral, Inhalation, Intravenous, Dermal; Rabbit Eye; Guinea pig skin sensitization
- Product chemistry, 5-batch analysis
- Microbiology/QC: no human pathogens
- Ecological effects (non-target birds, fish, *Daphnia*, honeybees, lacewings, ladybeetles, parasitic wasps)
- Endangered species review
- Exemption from tolerance petition (for food use)

California requires efficacy data!

Organic Labels

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For
Organic Production

National Organic Program (NOP) seal for organic pesticides (active & inert ingredients)

OMRI™ Listed

Organic Materials Review Institute (non-profit) seal: list of approved pesticides and fertilizers
[NOT REQUIRED – optional listing!]

USDA ORGANIC

Organic seal for FOOD (National Organic Program Regulations – how crops are grown and food is processed)

Certified California Organic Farmers CCOF

CCOF: Legal agreement with USDA's NOP to certify organic farms and processors

Successful Pesticides from Natural Products

None of these are biopesticides; they are registered as chemicals

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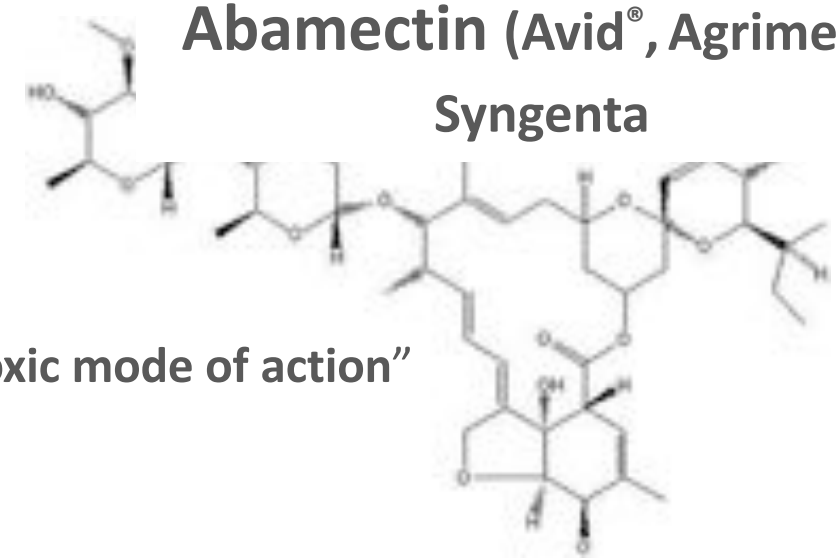
Abamectin (Avid®, Agrimek®)

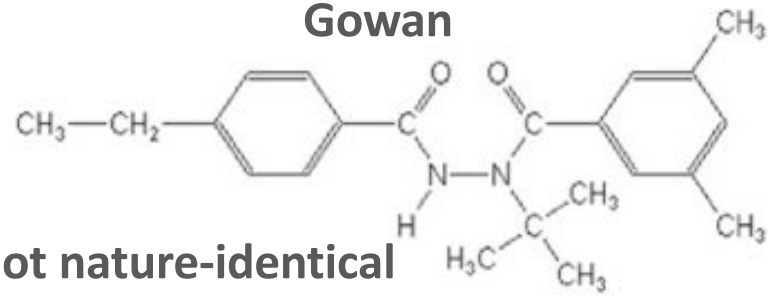
Syngenta



"Toxic mode of action"

Tebufenozide (Mimic®, Confirm®)

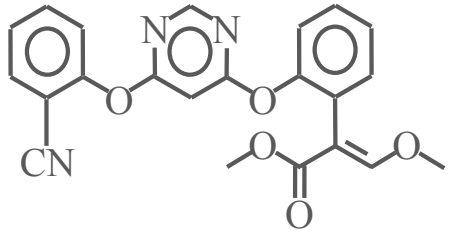
Gowan



Not nature-identical
(modified from natural molting inhibitor)

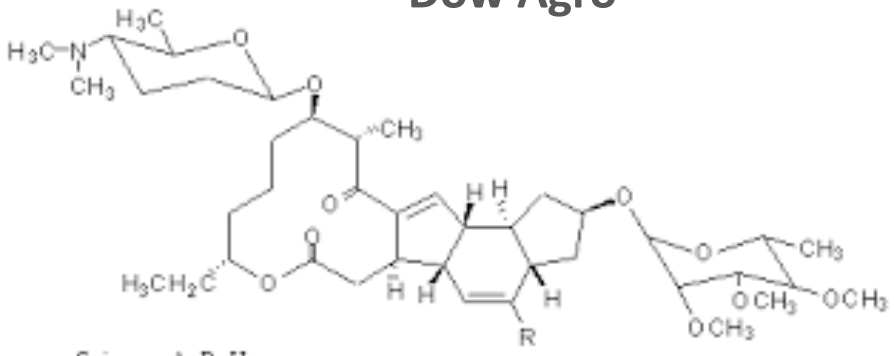
Azoxystrobin (Quadris®, Abound®)

Syngenta



Not nature-identical (modified from original mushroom compound)

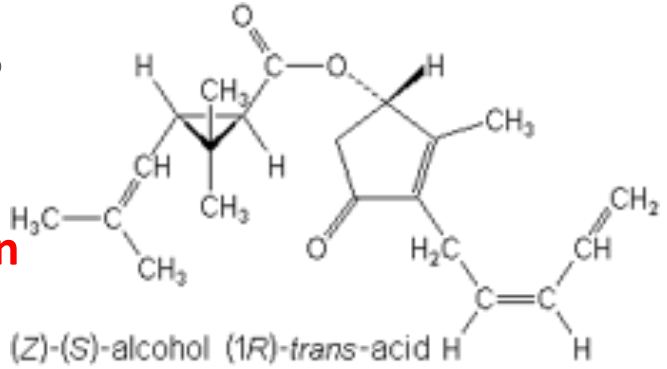
Spinosyn/Spinosads (Conserve®, SpinTor®, Success®, Tracer®, Entrust® (organic formulation) – Dow Agro



Spinosyn A, R=H
Spinosyn D, R=CH_3

"Toxic mode of action"

Pyrethrins (Pyganic®) MGK (Can be used in organic)



(*Z*)-(*S*)-alcohol (1*R*)-*trans*-acid H

"Toxic mode of action"

Biologicals Are Used Across All Production Systems and IPM Programs

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1 Organic

Biopesticide rotations and tank mixes

2 No Residues for Export

Early sprays & last spray before harvest

3 Conventional

In the tank with chemicals to enhance control, reduce resistance

Grower ROI Drives Adoption (Examples)

- $1400/Acre Increase
- >9X ROI

REGALIA® BIOFUNGICIDE

- 1000 lb/Acre Increase (+12%)
- >4X ROI

REGALIA® BIOFUNGICIDE

- 6 bushel/Acre Increase
- 2.8X ROI

REGALIA® Rx BIOFUNGICIDE

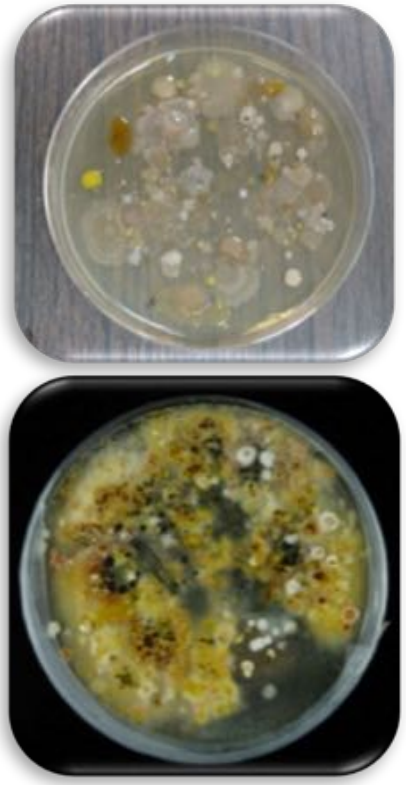
- 10 lb/Acre Increase
- Better Grade

REGALIA® BIOFUNGICIDE

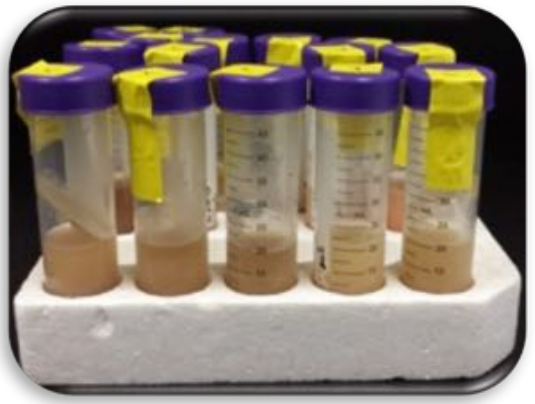
MAJESTENE® BIONEMATICIDE

Discovery: Sourcing and Isolation of Microorganisms

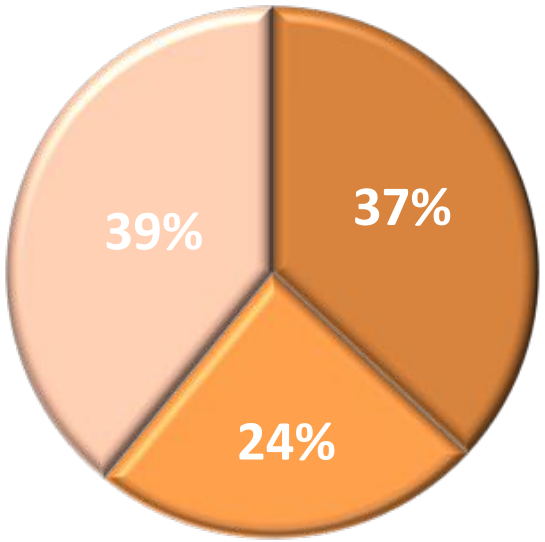
Soil and other types of samples collected from unique habitats and niches



Individual fungal, bacterial, and actinomycete colonies picked from primary plate



Water extracts of fermentation broths are used for bioassays



Primary Screen Testing

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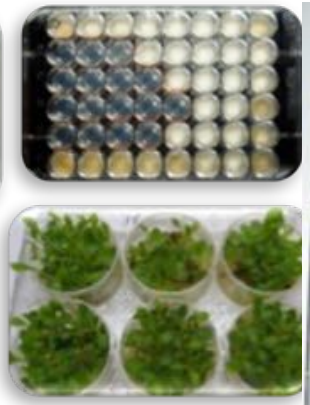
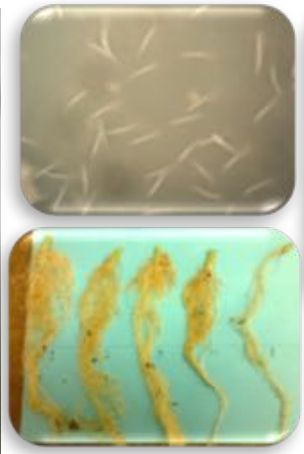
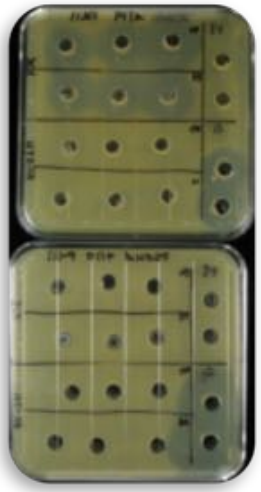
Insecticide	Fungicide	Herbicide	Nematicide	Algaecide	Bactericide	Biostimulants
Lygus ***Beet armyworm*** **Corn rootworm**	*Botrytis cinerea* *Phytophthora capsici*	Crabgrass Lettuce	*Meloidogyne spp.*	*Chlamydomonas reinhardtii*	*Xanthomonas campestris* *Pseudomonas syringae*	*Tomatoes, Corn, Radish, Soy & Others*






Determining What Causes the Pesticidal Activity

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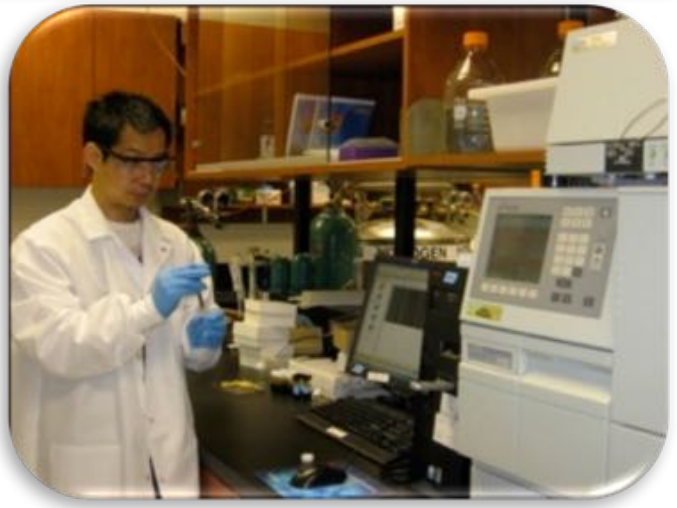
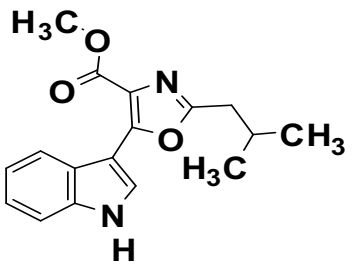
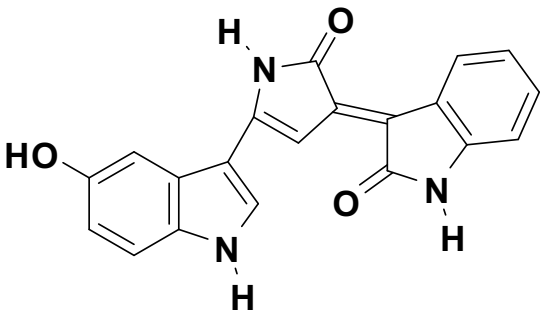
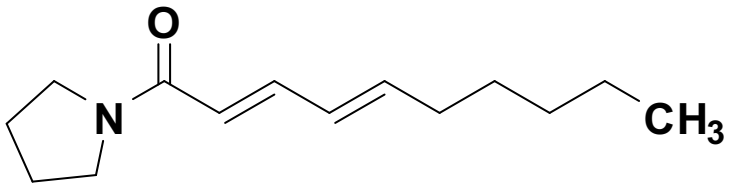
- Characterize/identify pesticidal compounds produced by the microbes or plants
- Eliminate strains with harmful compounds
- Develop analytical assays based on bioactive chemistry for Quality Control in manufacturing









Product and Process Development

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Develop user-friendly formulations (lab & pilot facilities)

Develop and scale manufacturing processes (lab, pilot & mfg facilities)

Conduct field trials

Develop data for the regulatory submission

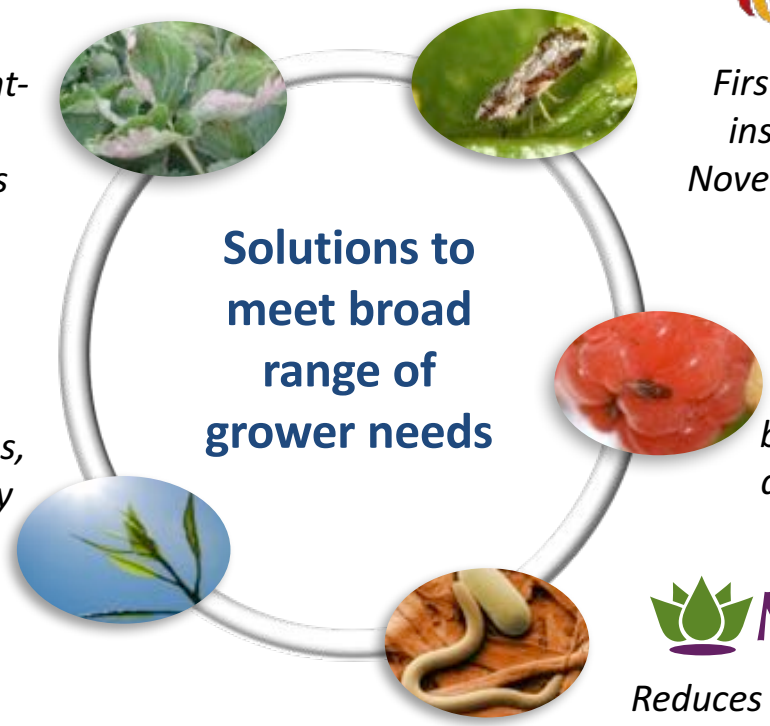
Marrone Bio Innovations Ag Products

REGALIA®
BIOFUNGICIDE

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

HAVEN®
ANTI-TRANSPIRANT

Reduces sun & water stress, increasing yields & quality



GRANDEVO®
BIOINSECTICIDE

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

VENERATE®
BIOINSECTICIDE

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

MAJESTENE®
BIONEMATICIDE

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

MBI also distributes biological products that don't have a distribution channel in the U.S.

JET-AG® BIO-TAM®

Our Near-term Pipeline

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Submit to EPA

MBI-014 Bioherbicide (New species of bacteria produces systemic compounds)

- Controls glyphosate-resistant & other herbicide-resistant weeds (e.g. palmer amaranth) with novel mode of action (Addresses the #1 need of organic farmers – weed control

Targeting 2017 Soft Launch

MBI-110 Biofungicide (Discovered in MBI's screen)

- Controls difficult plant diseases such as white mold, Fusarium Race 4 & downy mildews where there are fewer chemical and biological alternatives

MBI-601 Biofumigant (Novel genus & species of volatile gas-producing fungus)

- Alternative for methyl bromide and other chemical fumigants that are heavily restricted or being phased out
- Could be deployed for post harvest mold control on fruits and grains

Microbial Insecticides/ Acaricides

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Active	Type	Pests Controlled	Product Examples	Manufacturer
Bacillus thuringiensis spp. aizawai	Microbial, Bacteria	Diamondback moth, armyworm	XenTari®, Agree®	Valent Bio., Certis USA
Bacillus thuringiensis spp. kurstaki	Microbial, Bacteria	A broad range of caterpillars	Dipel®, Deliver®, Foray®, Biobit®, Javelin®	Valent Bio., Certis USA
Chromobacterium subtsugae	Microbial, Non-living Bacteria	Broad range of sucking & chewing insects, mites & flies	Grandevo®	Marrone Bio Innovations
Burkholderia rinojensis	Microbial, Dead Bacteria	Broad range of sucking & chewing insects, mites & Flies	Venerate®	Marrone Bio Innovations
Metarrhizium anisopliae	Microbial, Fungus	Thrips, mites, whiteflies	Met52®, GreenGuard®, Green Muscle®	Novozymes, BASF
Apopka 97 strain of *Isaria fumosorosea*	Microbial, Fungus	A broad range of sucking insects, mites & black vine weevil	PFR97®	Certis USA

Plant-extracted & Oil Bioinsecticides

Marrone Bio Innovations

Active	Type	Pests Controlled	Product Examples	Manufacturer
Neem oil	Biochemical, Soaps/Fatty Acids	A broad range of sucking insects	Trilogy®	Certis USA
Azadiractin	Plant Extract	A broad range of sucking & chewing insects	Aza-direct® (and others)	Gowan (and others)
Chenopodium ambrosioides	Terpenes (synthetically made) from Plant Extract	Sucking insects and mites	Requiem® (Not organic)	Bayer Crop Science
Citrus oil solution	Plant extract	A broad range of sucking insects	Oroboost®	OroAgri
Crop Oils	Paraffinic Oil	Sucking insects	Stylet Oil®, Supreme Oil and others	Many

Microbial Biofungicides

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Active	Type	Examples	Manufacturer
***Trichoderma harzianum* T-22**	Microbial, Fungi	RootShield® WP, PlantShield® HC	Bioworks
Gliocladium virens	Microbial, Fungi	SoilGard®	Certis USA
Trichoderma asperellum* & *Trichoderma gamsii	Microbial, Fungi	BIO-TAM 2.0®	Isagro (Marrone Bio)
***Bacillus subtilis* 713**	Microbial, Bacteria	Serenade®, Cease®	Bayer
***Bacillus amyloliquefaciens* D747**	Microbial, Bacteria	DoubleNickel® 55	Certis USA
***Bacillus pumilus* 2808**	Microbial, Bacteria	Sonata®	Bayer (Wilbur Ellis)
Streptomyces lydicus	Microbial, Actinomycete	Actinovate®, ActinoGrow®	Novozymes (Valent)
***Bacillus amyloliquefaciens* F727**	Microbial, Bacteria	Stargus™, Amplitude™	Marrone Bio Innovations
Bacillus mycoides isolate J	Microbial, Bacteria	LifeGard™ WG	Certis USA

Non-Microbial Biofungicides

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Active	Type	Examples	Manufacturer
Extract of *Reynoutria sachalinensis* (knotweed)	Biochemical, Plant Extract	Regalia®	Marrone Bio Innovations
Potassium bicarbonate	Biochemical	Kaligreen®, Milstop®	Otsuka (Brandt), Bioworks
Paraffin oil	Biochemical	Stylet Oil®, Purespray	JMS, Petro Canada
Tea tree oil	Biochemical, Plant Extract	Timorex Gold®	Stockton

Bionematicides

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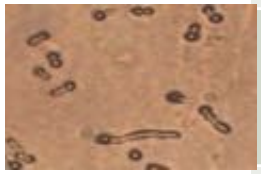
	Active	Type	Product Examples	Manufacturer
	***Purpureocillium lilacinus***	Microbial, Fungi	MeloCon®	Bayer Crop Science
	Saponins of *Quillaja saponaria*	Biochemical, Plant Extract	Nema-Q®	Brandt
	***Pasteuria nishizawae***	Microbial, Bacteria	Clariva® (Seed treatment)	Syngenta
	Myrothecium verrucaria	Microbial, Fungi	DiTera®	Valent BioSciences
	Bacillus firmus	Microbial, Bacteria	Votivo® (Seed treatment)	Bayer Crop Science
	Burkholderia rinojensis	Microbial, Killed Bacteria	Majestene®	Marrone Bio Innovations

Biopesticides – Best Uses and Benefits

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- Integrated solutions to improve overall pest control
- Can Increase Yield
- Can Enhance Plant Health/Quality
- Reduce Development of Resistance
- Manage Residues for Export (MRLs) (Zero Pre-harvest Interval)
- For Fast Re-entry (Short REIs) (Labor Management)
- Enhance Beneficials
- Reduce Pollution, Runoff

Biopesticides – NOT IF They Work, But HOW to Make Them Work

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- Increasing receptivity to biologicals, but unsure how to use them.
- More education & training on how the products work and how to integrate them into IPM programs; understand their unique modes of action
- Support from University Extension – fair and realistic field trials consistent with labels, include BOTH: a) stand alone and b) integrated into tank-mix and alternation programs
- On-farm demonstrations – block of the biopesticide in the program compared to chemical-only program

NOT to be used when all else fails.

"I tried everything but the kitchen sink so I thought I would try a biopesticide."

How to Maximize Your Biopesticide's Effectiveness – Some Variables

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- Water pH
- Water hardness
- Water volume/dilution
- Spray droplet size
- Adjuvant effect
- Impact on beneficials
- Impact on pollinators
- Tank-mix partners
- Application timing
- Application interval

We have to read the labels!

Biopesticides Can Help Meet the Challenges of Sustainable Agriculture

Marrone Bio Innovations

Integrated Pest Management

Biopesticides + Conventional Crop Protection Products

1. Increased efficacy
2. Higher yield
3. Reduced chemical load

Meeting the Challenges of Sustainable Agriculture

1. Increase Productivity
2. Promote Food Quality
3. Minimize Impact

Additional Benefits

1. Resistance Management
2. Harvest & Labor Management
3. Residue Management

Contact Us

Marrone Bio Innovations

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