



Natural Products

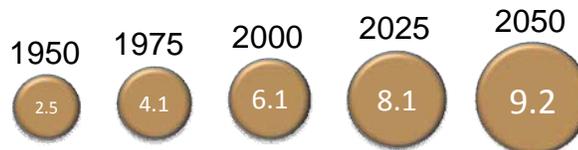
For Pest Management

Biopesticides as Environmentally Friendly Alternatives

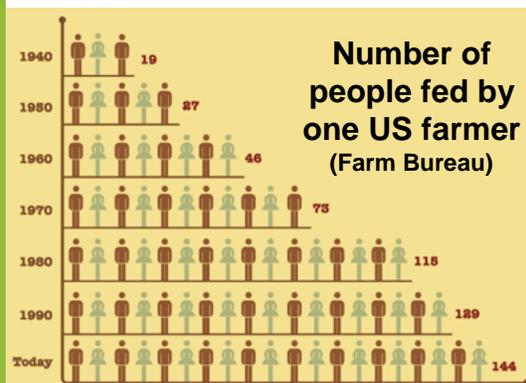
Pam Marrone, PhD
CEO and Founder



Global Trends Favor Ag Inputs



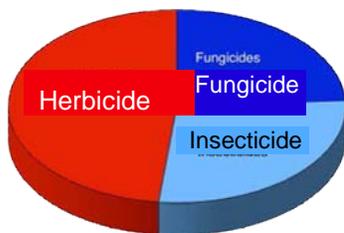
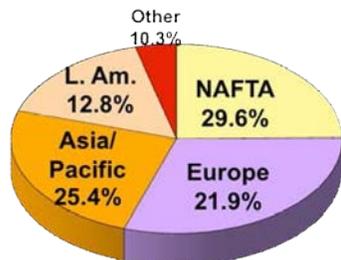
World population growth (billion) (UN)



Number of people fed by one US farmer (Farm Bureau)

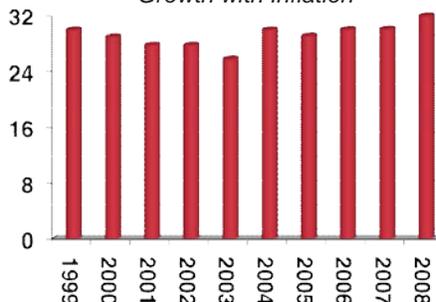
Sustainable farm practices, emission reductions, less reliance on fossil fuels and environmental responsibility are necessities

Global Chemical Pesticide Market is Mature



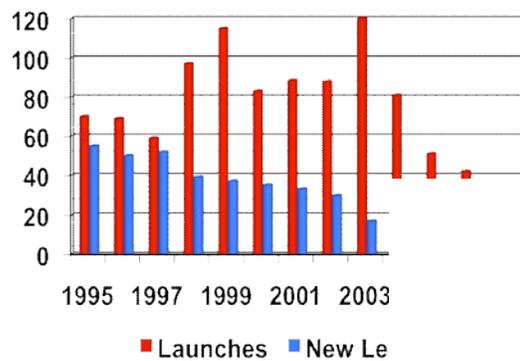
\$32 billion in 2008

Growth with Inflation

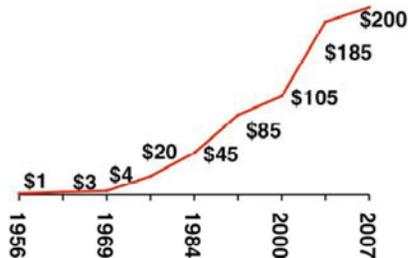


- Government phase-outs
- Pest resistance
- Export residue restrictions
- Transgenic (GM) crops
- Public concern
- Lack of new products

Fewer New Chemicals, At Higher Cost



Cost to Develop New Synthetic Chemicals (\$Million)

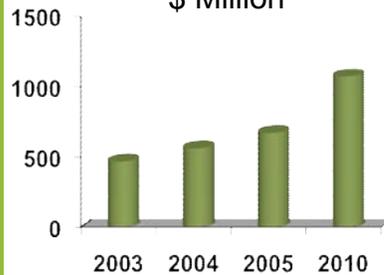


Source: Ag Chem New Compound Review (Vol 25) 2007

Biopesticides \$1 billion by 2010

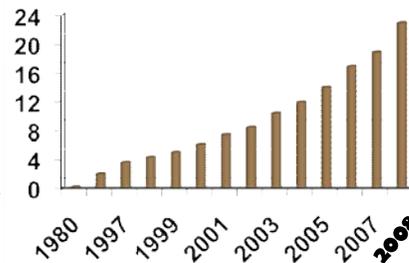


Global Biopesticides
\$ Million



Source: BCC Research

US Organic Food
\$ Billion



Source: Organic Trade Association

But most biopesticides are used in conventional ag!



Why Biopesticides?

- ✓ Natural world is underexplored for discovery of new pesticides
- ✓ >50% pharmaceuticals vs. 11% pesticides derived from plants and microbes
 - Aspirin – Pain
 - Taxol - Anti-tumor
 - Quinine, Artemisinin - Anti-malaria
 - Penicillin, streptomycin, etc. – Antibiotics
 - Digitalis - Cardiotonic
- ✓ Consumers driving market to natural products



But Just Because it is Natural Does Not Mean it is Safe

**But natural products registered as biopesticides
have a 50 year history of safe use, starting with Bt**

- ✓ All registered biopesticides are exempt from tolerance (can use right up to harvest)
- ✓ Most have >5000 mg/kg rat oral, dermal, inhalation ✓ Most have 4-hour (EPA's minimum) re-entry period ✓ Do not contaminate ground and surface water
- ✓ Are not ozone disruptors; do not emit VOCs
- ✓ Do not persist in the environment
- ✓ Use the safest (=food grade) inerts

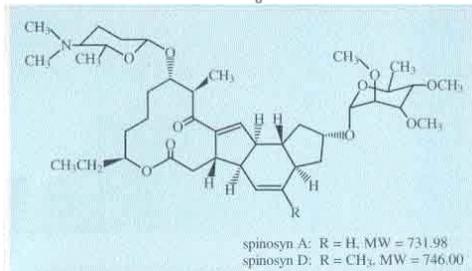
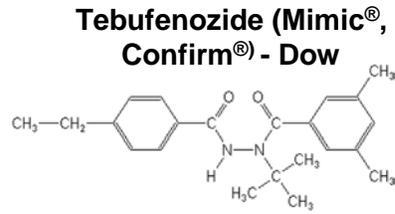
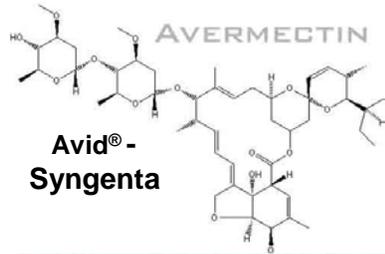


What are Biopesticides?

- EPA term for certain types of natural products used to control pests, plant diseases and weeds
- NOT all natural products are biopesticides
- Some natural products are registered by the EPA as chemical pesticides (if they act on nervous system of the pest)



Successful Insecticides from Natural Products - NOT Biopesticides



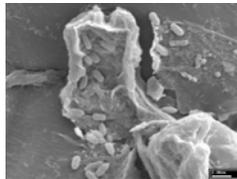
Spinosad (Entrust®, Conserve®, SpinTor®, Success®, Tracer®) – Dow Agro



What are Biopesticides?

MICROBIALS (e.g., bacteria, virus, fungus)

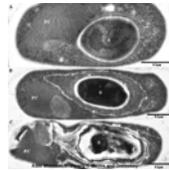
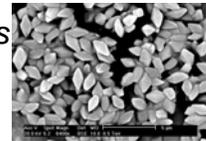
Bacteria: e.g., *Bacillus*, *Pseudomonas fluorescens*



Bacillus subtilis
on powdery mildew spore
(Biofungicide)



Bacillus thuringiensis
(Bioinsecticide)

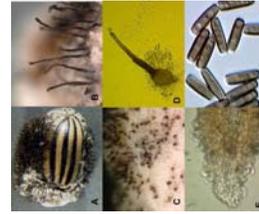


What are Biopesticides?

MICROBIALS (e.g., bacteria, viruses, fungi)



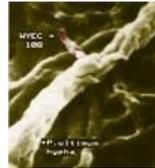
Fungi: e.g., *Trichoderma*,
Gliocladium for root diseases



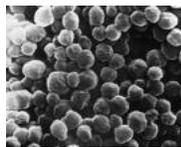
Beauveria for insect control



Actinomycetes: e.g., *Streptomyces*



Streptomyces lydicus
Biofungicide



What are Biopesticides?

BIOCHEMICALS (e.g. plant extracts (antifeedants, pheromones, fatty acids, potassium bicarbonate, plant growth regulators)



Many insecticide products from the seeds of the neem tree



Kaligreen®, Milstop® biocarbonates



Fatty acids



Mating disruption pheromones are heavily used in western fruit and nut production

Biopesticide Registration

US EPA and CAL-DPR

EPA: Biopesticides & Pollution Prevention Division

- ✓ GM crops (PIPs=Plant Incorporated Protectants)
- ✓ Microbials (e.g., bacteria, virus, etc.)
- ✓ Biochemical (e.g. plant extracts, pheromones, fatty acids) **NON TOXIC MODE OF ACTION TO THE PEST** (suffocation, desiccation, antifeedant, mating disruption – No insect nerve toxins)



US EPA and CAL-DPR Biopesticide Registration

Tiered Data requirements; Start with Tier I:

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

California requires efficacy data!



25-B Exempt Products

Some products don't require EPA registration because they are used in food or considered safer – e.g. :

- ✓ Clove, cedar, cinnamon, peppermint, wintergreen, castor, thyme, lemongrass, citronella, sesame, soybean cottonseed, linseed, garlic oil; Sodium lauryl sulfate
- ✓ Some of these 25-B pesticide products have dubious efficacy

36 states regulate 25-B products (but not CA)



Organics Demystified



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



Organic Materials Review Institute (non-profit) seal: list of approved pesticides and fertilizers



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



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

Pesticides - Lawns and Landscapes

- ✓ U.S. households with a yard/garden spent \$13.6 bil 2008 on fertilizers and insect & weed controls.
- ✓ 55% of all U.S. households with a yard/garden (45 mil), purchased one or more types of insect & weed control in 2007.
- ✓ Currently 12 mil U.S. households use all-natural organic gardening methods.
- ✓ ~17 mil households say they **definitely** will use all-natural/organic gardening methods in the future.
- ✓ Another 22 mil say they **probably** will use all natural/organic gardening methods in the future.



Environmentally Friendly Gardening

- ✓ 57% of all U.S. households said it's important that lawns & landscapes be maintained in an environmentally friendly way
- ✓ But only 21% of households scored high on environmentally friendly landscapes and lawns
- ✓ Only 3% were **extremely knowledgeable** about how to maintain their lawns & landscapes in an environmentally friendly way
- ✓ 70% said they were **somewhat, not very, or not at all** knowledgeable.



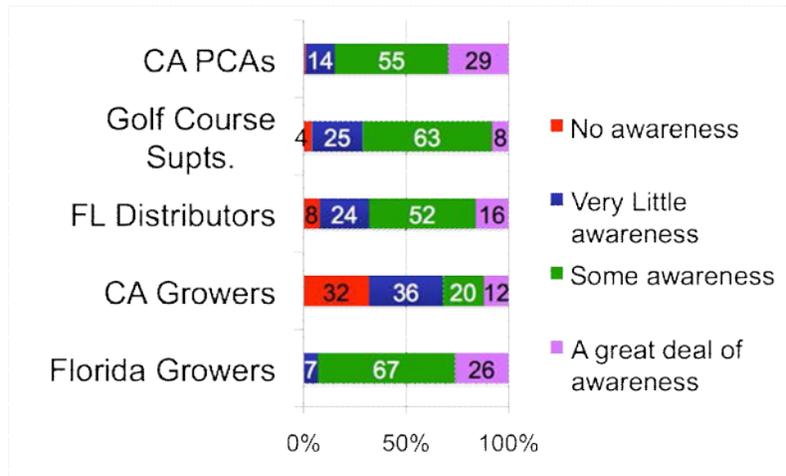
Why People Use or Don't Use Environmentally Friendly Methods

- ✓ Top 5 reasons to **USE** are:
- ✓ Better for the environment (73%)
- ✓ Reduce risk of exposure to chemicals (59%)
- ✓ Reduce water pollution through fertilizer runoff (54%)
- ✓ Fits with my way of life/philosophy of living (43 %)
- ✓ Better (nutritionally) for my family and me (40%)

- ✓ Top 5 reasons **NOT** to use
- ✓ Too expensive (41%)
- ✓ Don't think it works (30%)
- ✓ Need more info about how to garden organically (25%)
- ✓ Never considered/thought about these methods (24%)
- ✓ Can't find the right products to buy (24%)



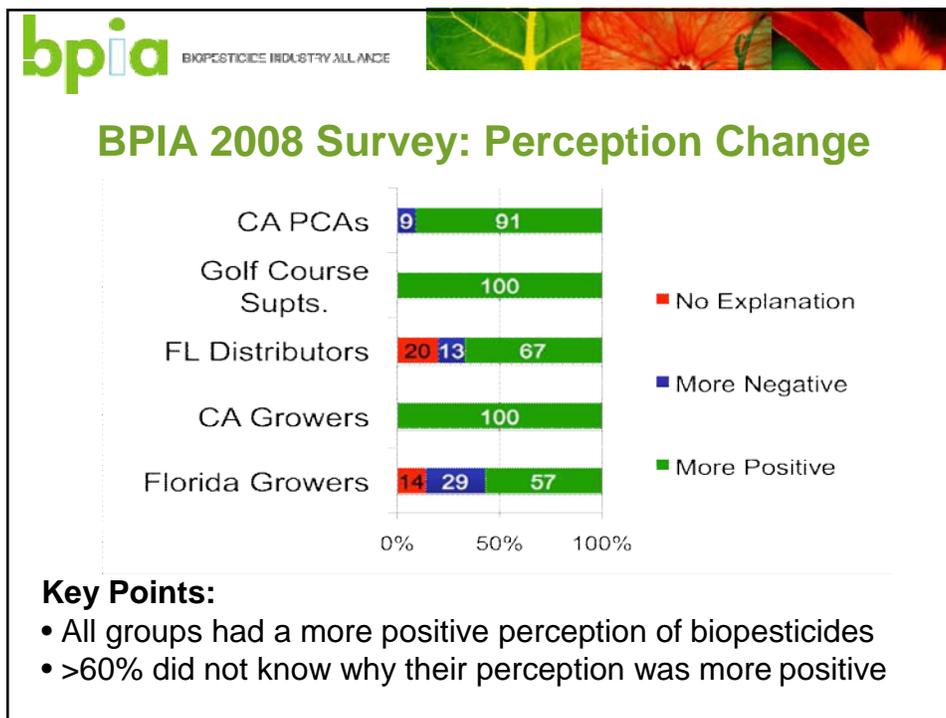
Awareness of Biopesticides (2008)



Main Reasons Biopesticides ARE Used (2008)

	CA Pest Control Advisors (n=69)	Golf Course Supts. (n=40)	Florida Distributors (n=26)	CA Growers (n=30)	Florida Growers (n=30)
Environmentally Safe	48%	63%	54%	60%	64%
All Other Replies	35%		27%	16%	11%
Operator Safety	12%	42%	8%	4%	21%
Safe/Benefits Insects	14%		8%	12%	36%
Public Perception	22%	8%	15%	20%	4%
More Natural/Safe	16%	4%	8%	24%	14%
Crop Safety	17%		12%	4%	25%
Organic Farming	25%		12%	16%	4%
Product Effective	13%	13%	15%	8%	4%
Don't Know	3%	25%	4%	8%	4%
Target Specific	9%				7%
Economic Benefits	3%		4%		4%

Main Reasons Biopesticides <u>ARE NOT USED</u>					
	CA Pest Control Advisors	Golf Course Supts.	FL Distributors	CA Growers	FL Growers
	(n=69)	(n=40)	(n=26)	(n=30)	(n=30)
Not as Effective	52%	42%	73%	68%	39%
Higher Cost	36%	42%	31%	44%	43%
Lack of Awareness	39%	38%	18%	32%	43%
Don't Know	6%	17%	8%	24%	7%
Lack of Research	4%	21%	12%	8%	4%
Limited Availability	6%	8%	8%	4%	18%
Too specific	7%	17%	4%		7%
All Other Replies	26%		12%		
Old Habits	3%		7%	4%	14%
Works Too Slowly	12%		4%		11%
Public Perception			4%	4%	



Issues Impeding Biopesticide Adoption



- Perception of weaker efficacy - “snake oils” & 25-B products?
- Highly competitive marketplace
- Customer avoids risk - no reason to change
- End users lack knowledge and understanding of biopesticides
- Complex selling channel
- Capital intensive - small companies do not have funds for all the required field and demo trials and customer education

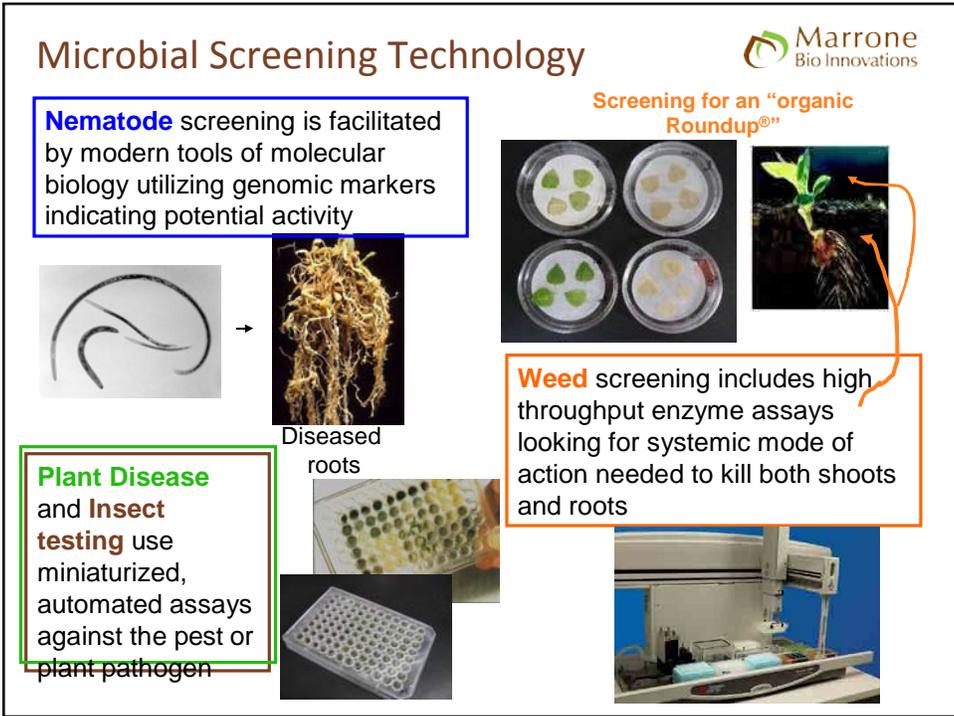
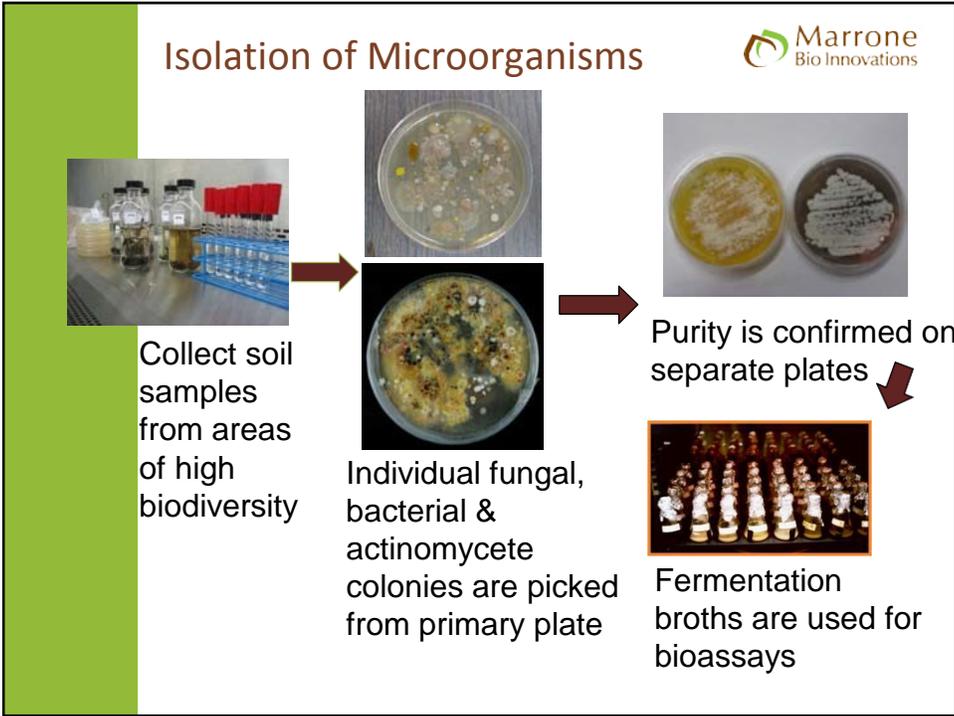


What We Do

We discover, develop, and market **effective** and **environmentally responsible** natural products (biopesticides) that fill unmet needs for weed, pest & plant disease management.

- ✓ **Products that lower the cost and increase yields in organic farming**
- ✓ **Products that improve yields and quality in conventional ag compared to chemical-only systems**

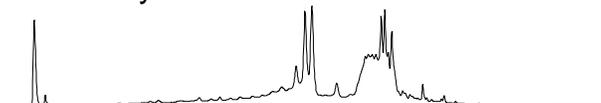




Natural Product Chemistry



- ✓ Identify pesticidal compounds produced by the microbes (HPLC w/ diode array detection, LCMS and NMR)
- ✓ Eliminate strains with harmful compounds
- ✓ Develop analytical assays based on bioactive chemistry for QC



Fermentation and Formulation



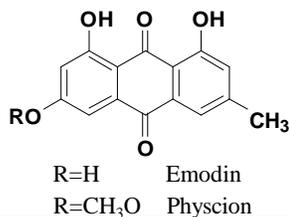
- ✓ Optimize processes
- ✓ Scale up - pilot & manufacturing
- ✓ Field trials
- ✓ Toxicology & Registration

Develop user-friendly formulations (wetable powder, WDG, liquid suspension, RTUs) & packaging

Regalia® for Plant Disease Control



- ✓ Source: Extract from edible knotweed *Reynoutria spp.*
- ✓ Effective control of mildews, blights, rusts.
- ✓ EPA registration as biochemical biopesticide.
- ✓ Hundreds of field trials prove performance.
- ✓ Novel mode of action: **Induced Systemic Resistance** – increase of “good” plant compounds.



New Microbial Insecticide



- ✓ Licensed from Lab of Phyllis A.W. Martin (USDA ARS). Isolated from forest soil. Patent pending.
- ✓ New species of *Chromobacterium (substugae)*.
- ✓ Must be ingested for activity. Death in 1-3 days.
- ✓ Activity is from >30 synergistic compounds (identification in progress).
- ✓ Broad spectrum control of sucking and chewing insects
- ✓ Nontoxic to rats (>5000 mg/kgs)
- ✓ Non pathogenic.
- ✓ Submission to the EPA ~3rd Q 2009.



Insect Toxicity Summary



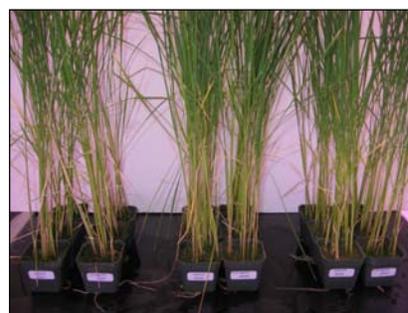
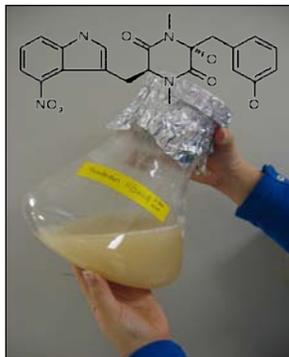
Insect Stage	Stage	Mortality	Sublethal?
CO Potato beetle	Adult	No	Feeding Inhibition
CO Potato beetle	Larva	Yes	"
<i>Diabrotica</i> spp.	Adult/Larva	Yes	-
<i>Plutella xylostella</i>	Larva	Yes	-
Gypsy moth	Larva	No	Feeding Inhibition
Sw. pot. whitefly	Adult	Yes	-
Sw. pot. whitefly	Nymph	Yes	-
S. green stinkbug	Adult	Yes	-
<i>Culex pipiens</i>	Larva	No	None seen
<i>Spodoptera exigua</i>	Larva	Yes	Feeding Inhibition
Lygus bug	Nymph	Yes	"

Selective Rice Bioherbicide



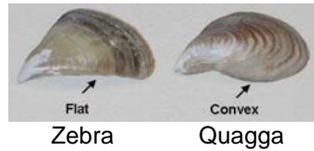
- ✓ Broad spectrum control; excellent on sedges
- ✓ *Streptomyces* compound produced by fermentation; nontoxic, non-pathogenic to rats
- ✓ EPA submission in 2009

No effect on rice





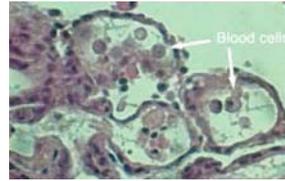
Invasive Mussels = \$ billions in economic & environmental damage



Zebra/Quagga mussels clog pipes



Pseudomonas fluorescens (dead) bacteria kill Mussels

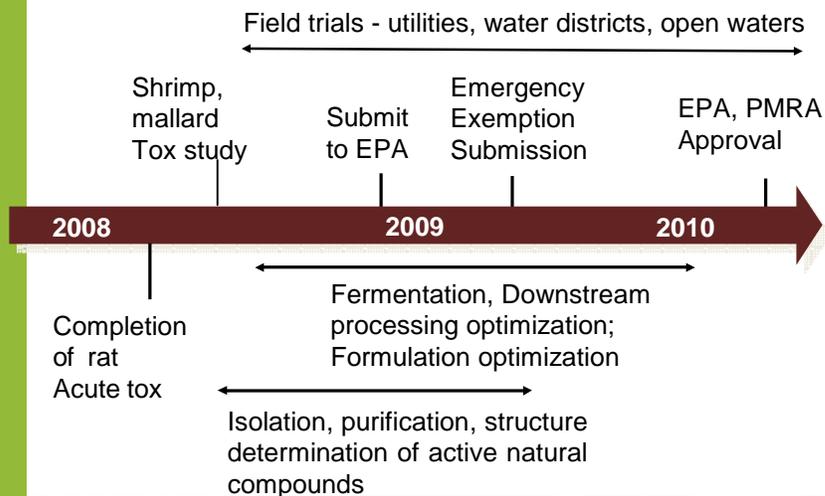


Ruptured gut cells



Replacement for chlorine; the only biological for open waters. Discovered by NYSM – MBI is exclusive partner

Development Timeline



Field Development –
Lower CO River - Davis Dam
(US Bureau of Reclamation)



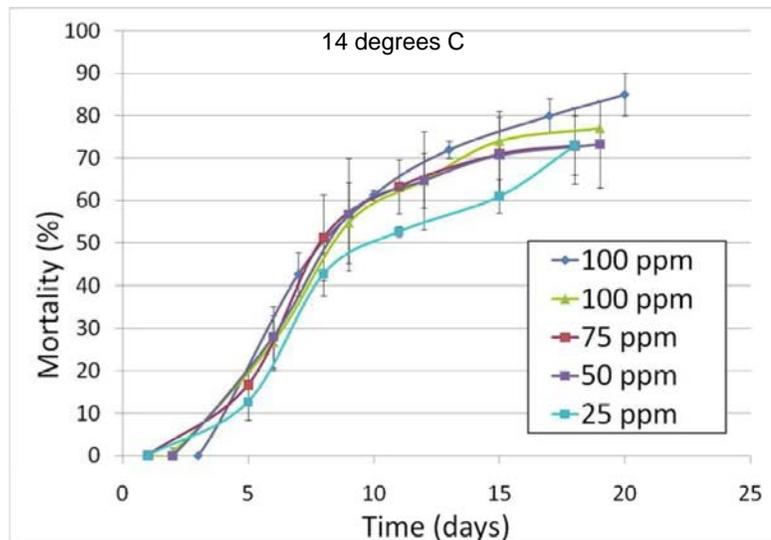
Quagga Mussels

- ✓ Biobox trials (Now)
- ✓ Domestic Water Pipe (Summer)
10 inches diameter x 100 ft
(ca. 415 gal)
- ✓ Spill Gate Enclosure (Future)
50 x 50 x 1 foot with barrier
(20,000 gal)



Davis Dam Biobox Rate Tests

New Formulation/Application – one 6 hr treatment



Biopesticides – Summary Comments

- ✓ Biopesticides are becoming mainstream - most are used in conventional systems
- ✓ But perceptions persist about efficacy/cost
- ✓ Integrate Biopesticides AND Conventionals
- ✓ It's **NOT** Biopesticides **vs.** Conventionals
- ✓ There is still a large need for end-user education on biopesticides – what they are, how they work, when best to use them



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