



Governor's Environmental and
Economic Leadership Award 2008



Investors' Circle Top 20



2008 Cleantech Innovator
Award



Biopesticides as Environmentally Friendly Alternatives

Pam Marrone, PhD
CEO and Founder



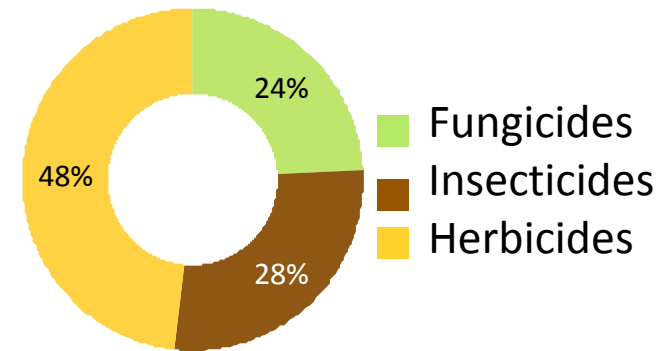
Global Chemical Pesticide Market

A \$34 bn market in 2008 – no real growth

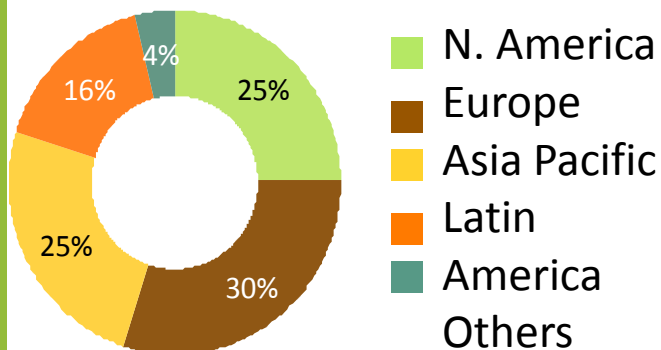
The global chemical pesticide market is mature

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

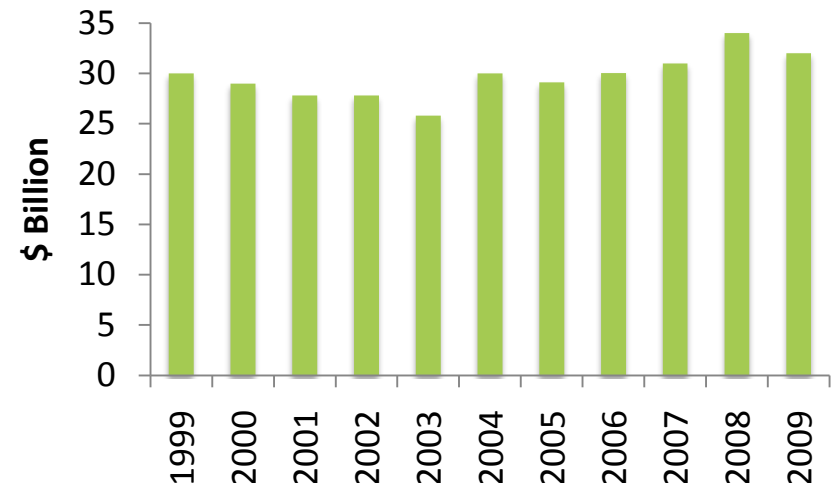
Product segmentation



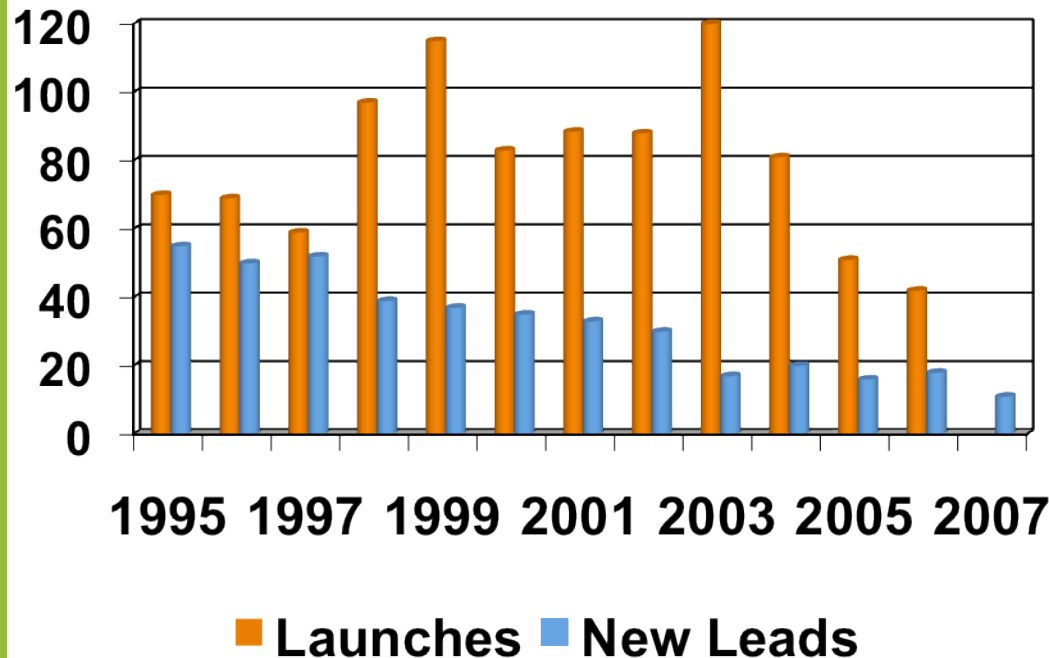
Geographical segmentation



Market growth inline with inflation

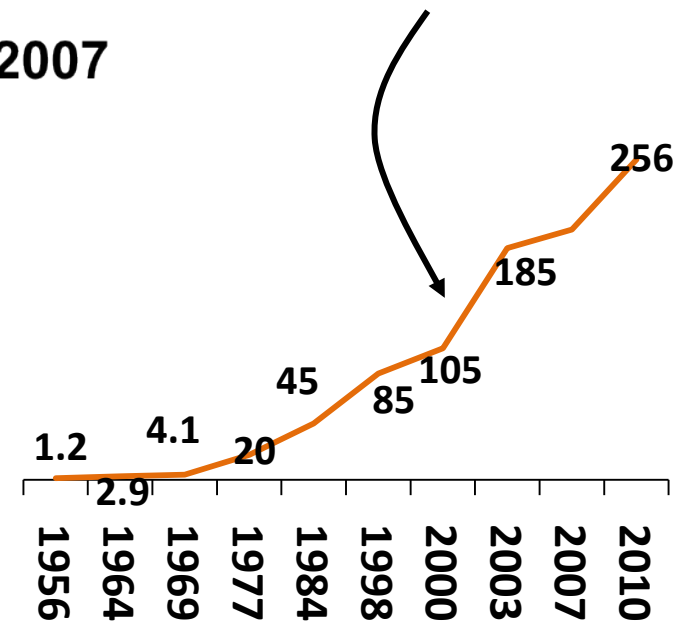


Fewer New Chemicals – Higher Cost



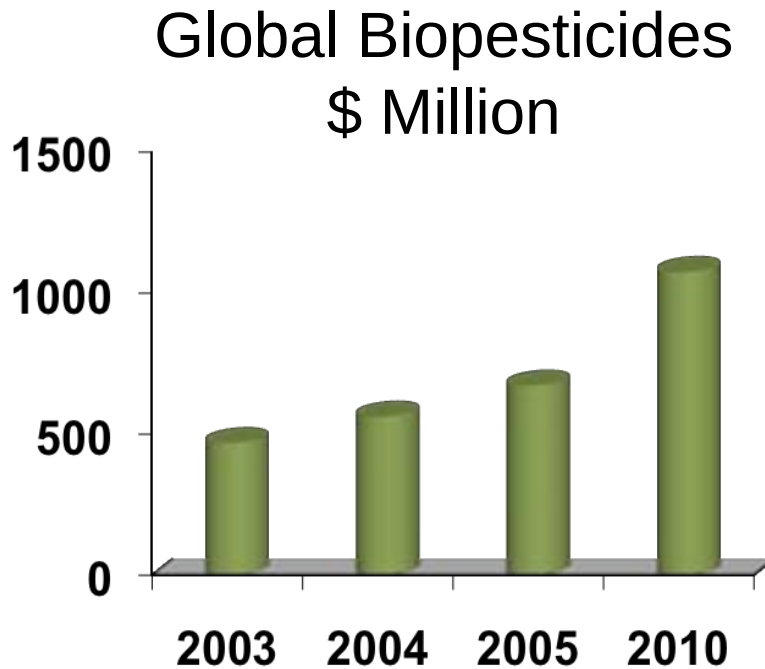
Only one new chemical active ingredient was registered by the EPA in 2009

Cost to Develop
a New Synthetic
Chemical (\$Mil)

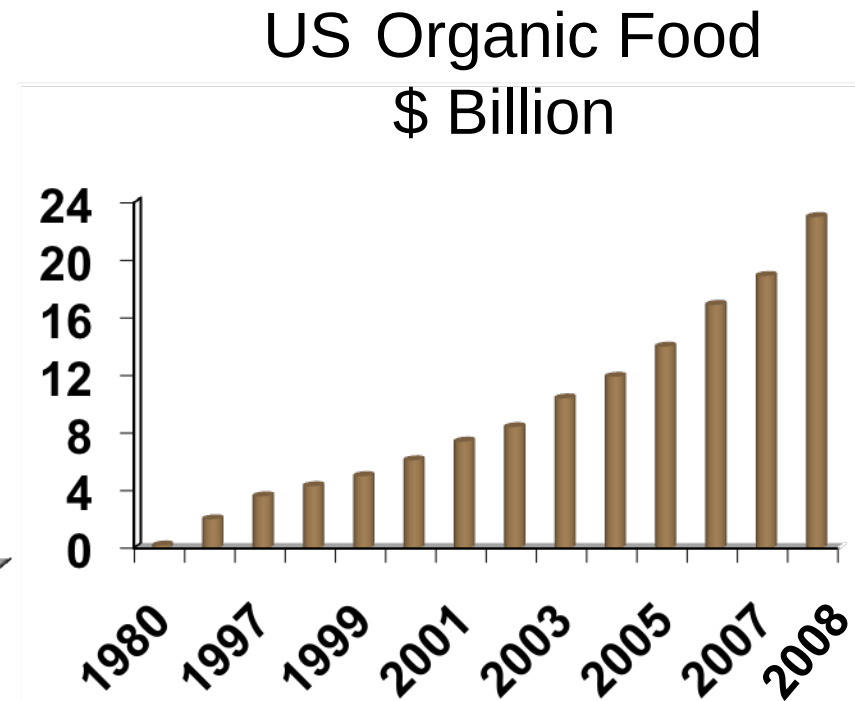


Biopesticides – Growing Rapidly

12 biopesticides EPA-registered in 2009



Source: BCC Research



Source: Organic Trade
Association

But most biopesticides are used in conventional ag!



Biopesticides are the Lowest Risk Category of Pest Management Products

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
- ❖ Non toxic mode of action; most are soft on beneficials
- ❖ 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
- ❖ Highly biodegradable - do not persist in the environment
- ❖ Use the safest (=food grade) inerts

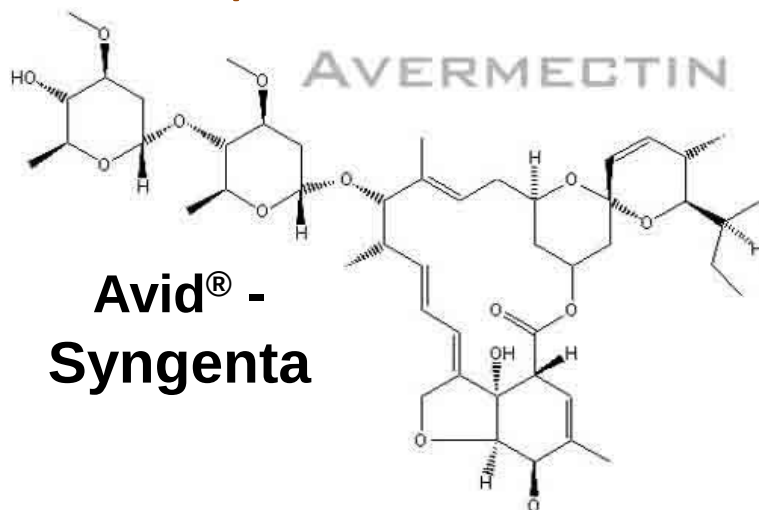


What are Biopesticides?

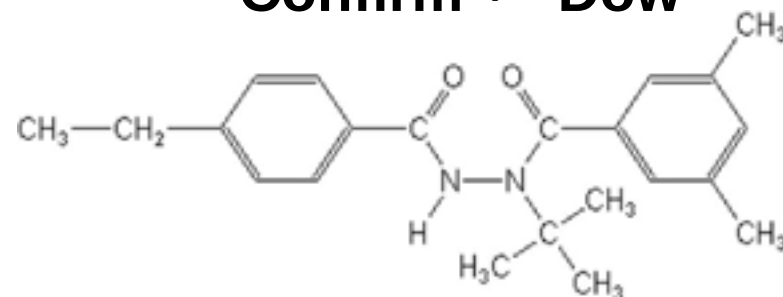
- ❖ **Microbials** (e.g., bacteria, virus, fungus)
- ❖ **Biochemicals** (e.g. plant extracts (some), pheromones, fatty acids) - *nontoxic mode of action* to the pest, plant pathogen, weed
- ❖ Spinosad (pure compound from the microbe *Saccharopolyspora spinosa*) and pyrethrum (plant extract) have organic formulations, but are registered as chemicals =(neuro)toxic mode of action to the pest)



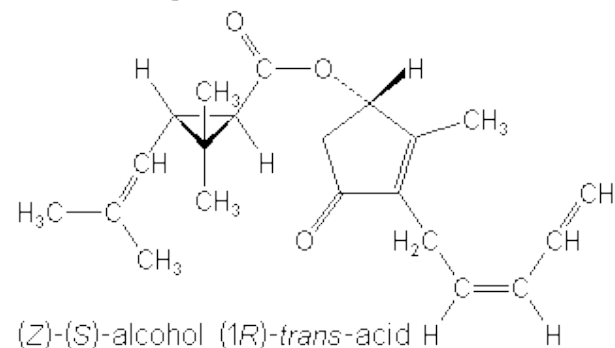
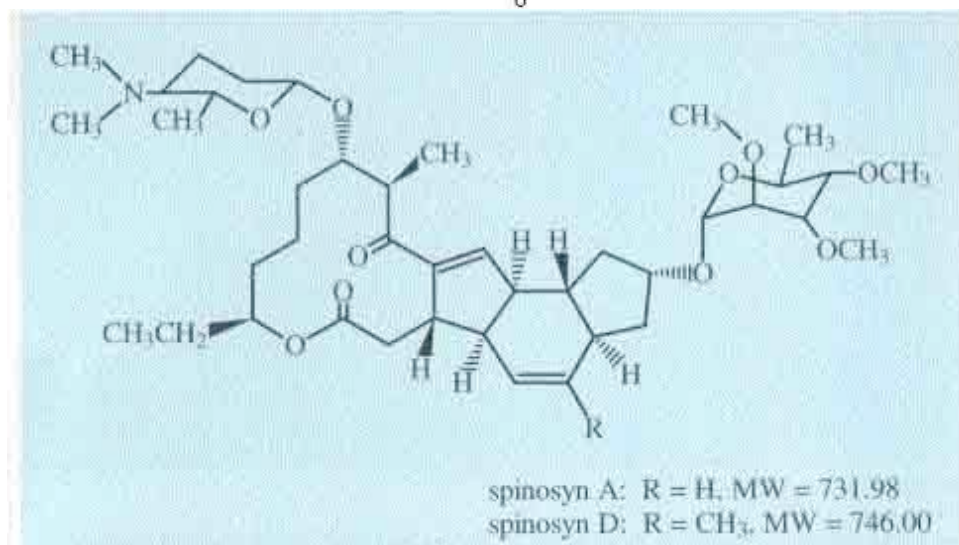
Successful Insecticides from Natural Products - NOT Biopesticides



Tebufenozide (Mimic®, Confirm®) - Dow



Pyrethrins



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

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; some are effective

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



Organics Demystified



For
Organic Production

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



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



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

Biopesticide Advantages

- New modes of action - Prevent/delay pest resistance
- Significant yield/quality increases when used as part of an IPM program
- Can get back into the field with labor crews more quickly (short re-entry intervals)
- No pesticide residues
- Low/no mammalian toxicity; safer to non-target organisms
- No air, water pollution
- Can be approved for use in organic production/gardening
- 3 yrs and <\$3M to develop vs. 10 yrs & \$200M

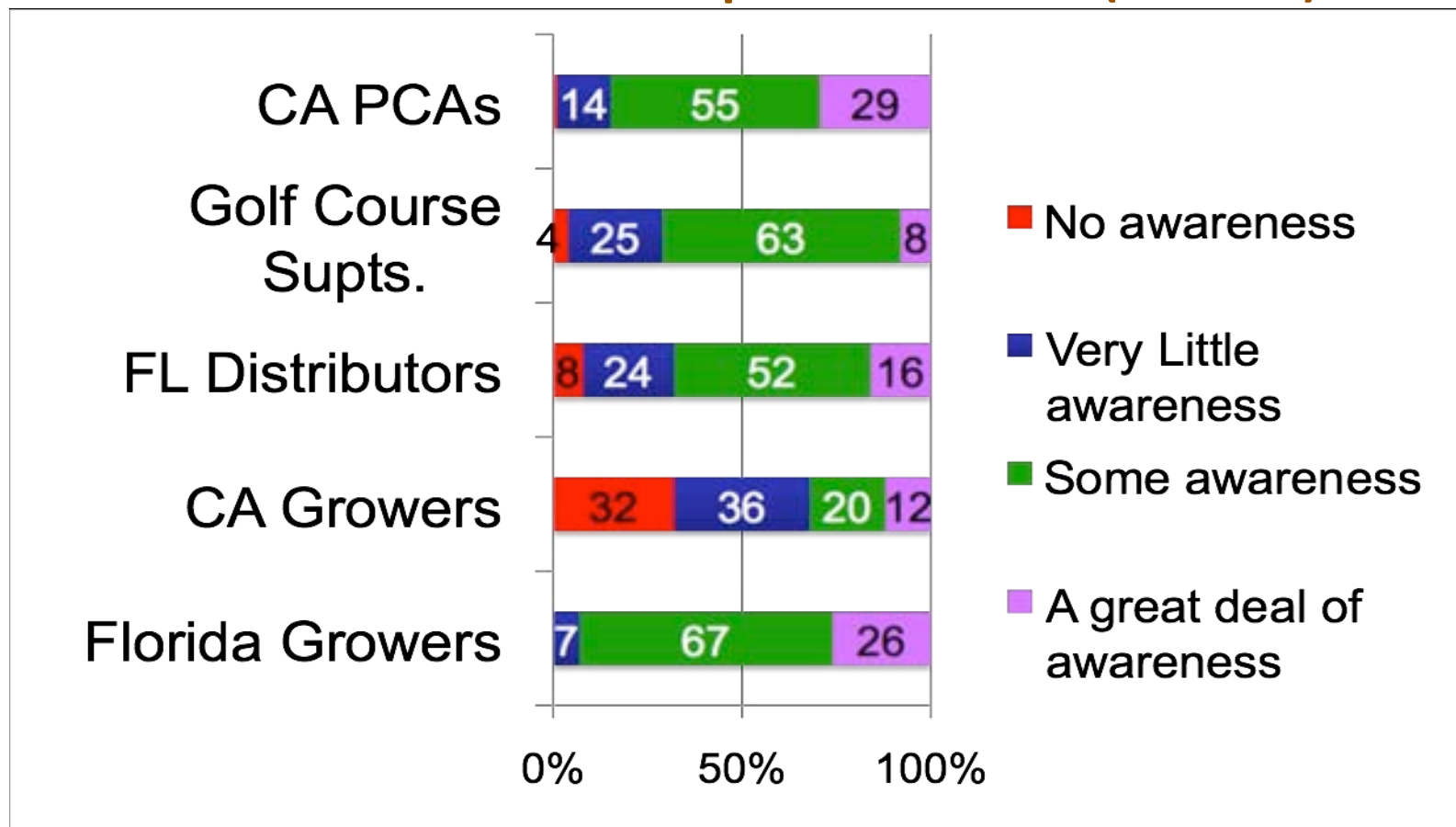


Factors Limiting Biopesticide Use

1. Price
2. Selection
3. Availability
4. Perception of low efficacy
5. Lack of awareness



Awareness of Biopesticides (2008)



Pesticides - Lawns and Landscapes Marrone[™] Bio Innovations

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



National Gardening Assoc. Survey

Natural and Organic 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.

National Gardening Assoc. Survey



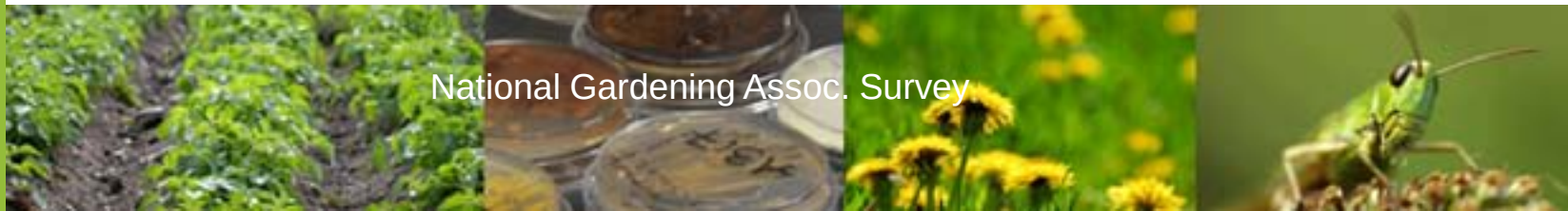
Why People Use or Don't Use All-natural/Organic Methods

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%)



What We Do

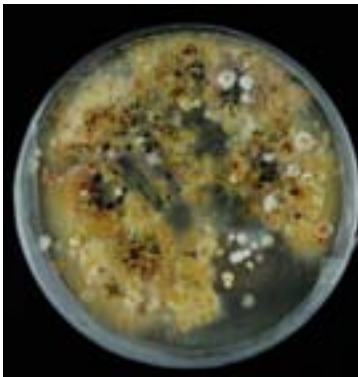
*We discover, develop, and market **effective** and **environmentally responsible** natural products (biopesticides) that fill unmet needs for weed, pest & plant disease management.*



Microorganisms Isolated From Unique Habitats and Geographies



Samples from around the world are cultured on specific media - Internal isolations and external collections



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



Purity is confirmed on separate plates

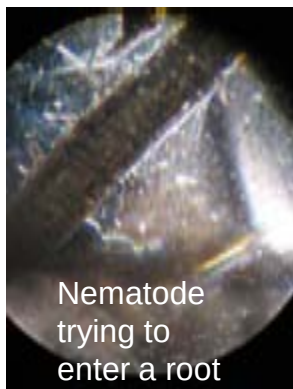
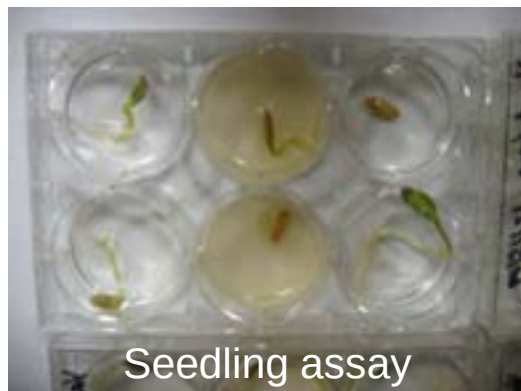


Fermentation broths are used for bioassays



Testing Against Pests & Pathogens

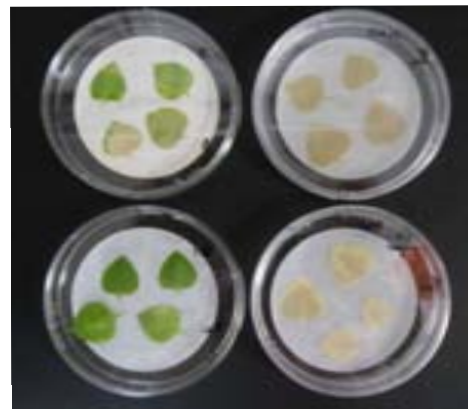
Nematode screening in vitro and in vivo



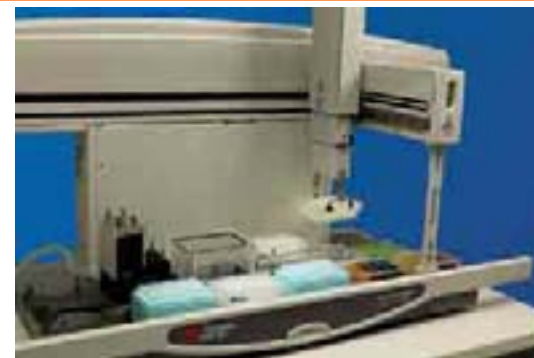
Plant Disease and **Insect testing** use miniaturized, automated assays against the pest or plant pathogen



Screening for an “organic Roundup®”

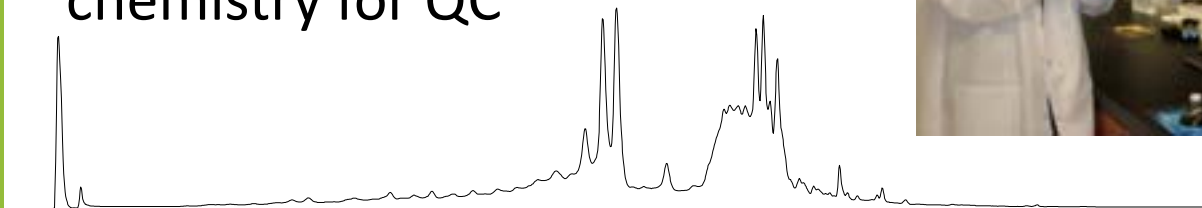


Weed screening includes high throughput enzyme assays looking for systemic mode of action needed to kill both shoots and roots



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
- ❖ Registration

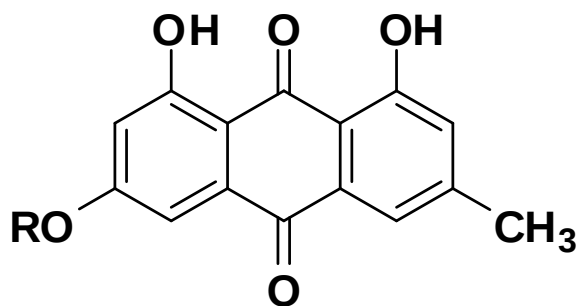
Develop user-friendly formulations (wettable powder, WDG, liquid suspension, RTUs) & packaging

NEW PRODUCTS





- ❖ 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.



R=H Emodin
R=CH₃O Physcion





ISR – Induced Systemic Resistance

A non-pathogenic inducer (REYSA) signals the plant to produce Phytoalexins, PR proteins, plant cell strengtheners, etc. that inhibit pathogens (different from SARs)

Regalia has multiple signaling pathways:

IMMUNE RESPONSE:

Induces Immune System to produce Phytoalexins, PR proteins, Phenolics, Antioxidants

STRENGTHENING the plant:

Induces production of ferulic acid for cell wall lignification & other phenolics

ATTACKING PATHOGEN (CONTACT):

Inhibits germination and induces production of glucanase enzymes that break down pathogen cell walls



- Berries
- Citrus
- Cucurbits
- Grapes
- Leafy greens
- Ornamentals
- Turf
- Peppers
- Pome fruit
- Stone fruit
- Strawberries
- Tomatoes
- Walnuts



Regalia® Diseases (Partial List)

- **Powdery Mildew**

(*Sphaerotheca* spp, *Erysiphe cichoracearum*)

- **Gray Mold**

(*Botrytis cinerea*)

- **Downy Mildew**

(*Bremia lactucae*, *Peronospora* spp.)

- **Bacterial Blight**

(*Xanthomonas* spp.)

- **Citrus Canker**

(*Xanthomonas* spp.)

- **Greasy Spot**

(*Mycosphaerella citri*)

- **Bacterial Leaf Spot**

(*Xanthomonas* spp.)

- **Target Spot**

(*Corynespora cassicola*)

- **Bacterial Speck**

(*Pseudomonas syringae*)

- **Tomato Late Blight**

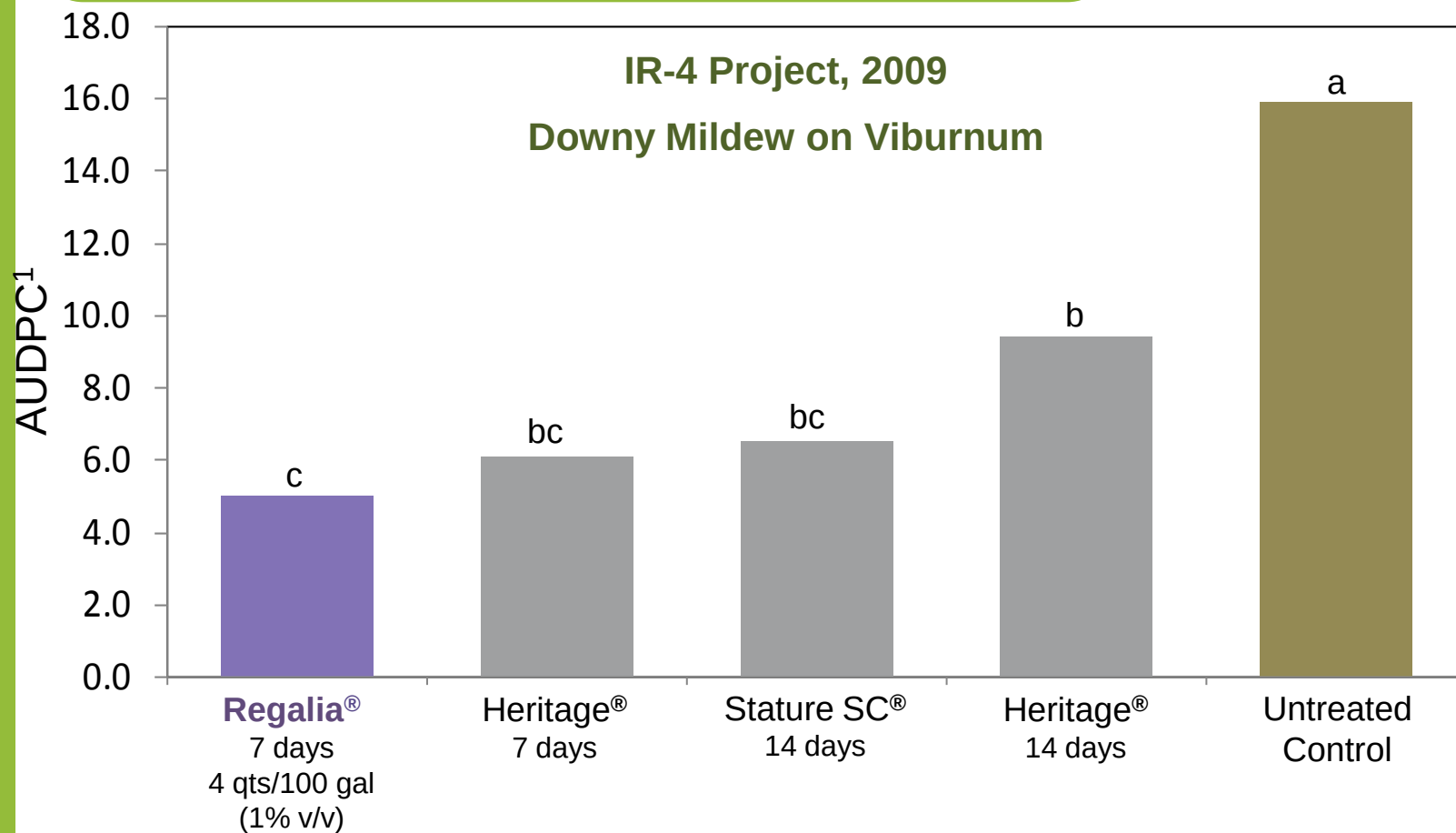
(*Phytophthora infestans*)

- **Early Blight of Tomato**

(*Alternaria solani*)



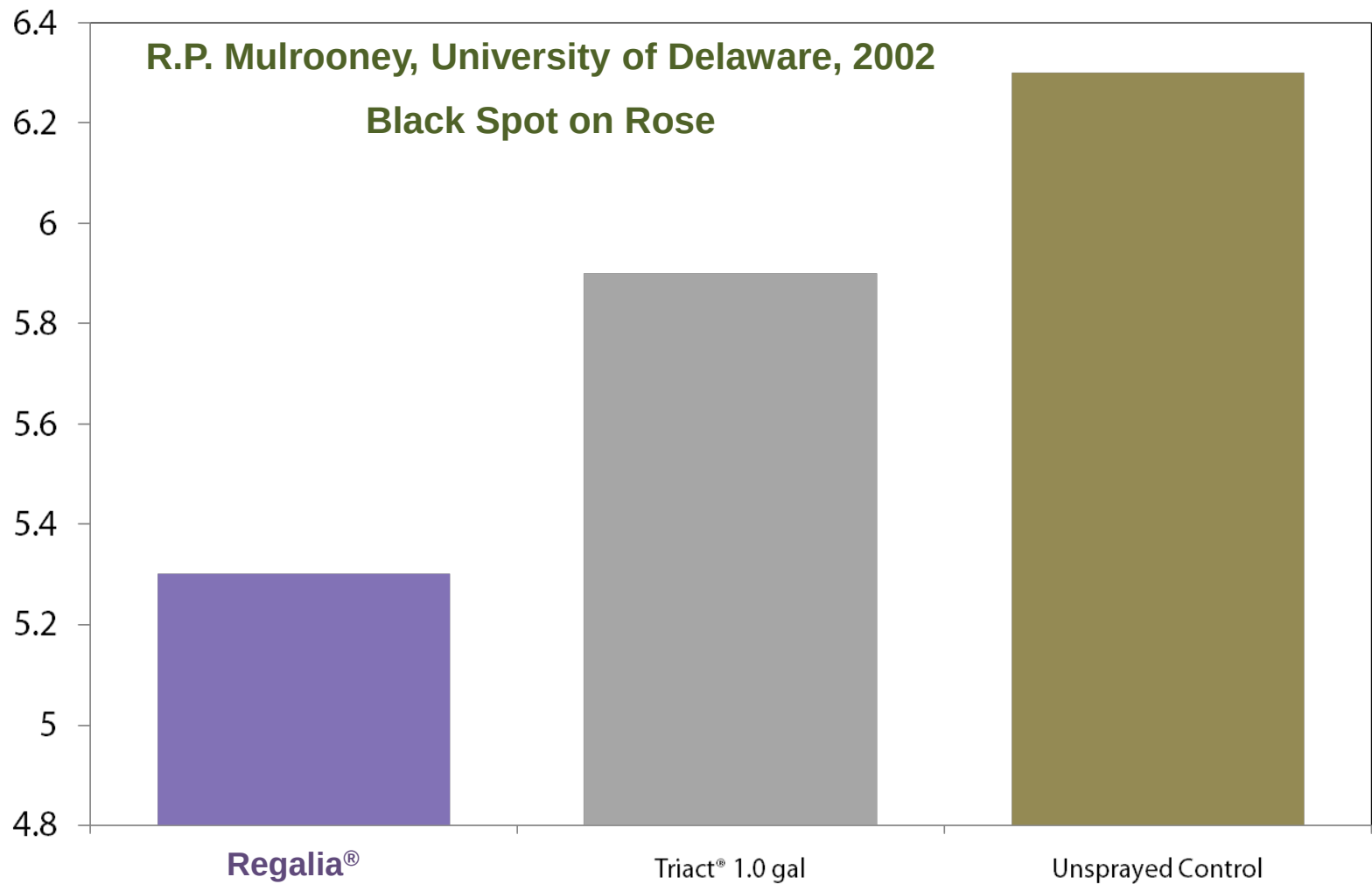
Regalia® performs equal to or better than Heritage® or Stature® at controlling Downy Mildew on *Viburnum*



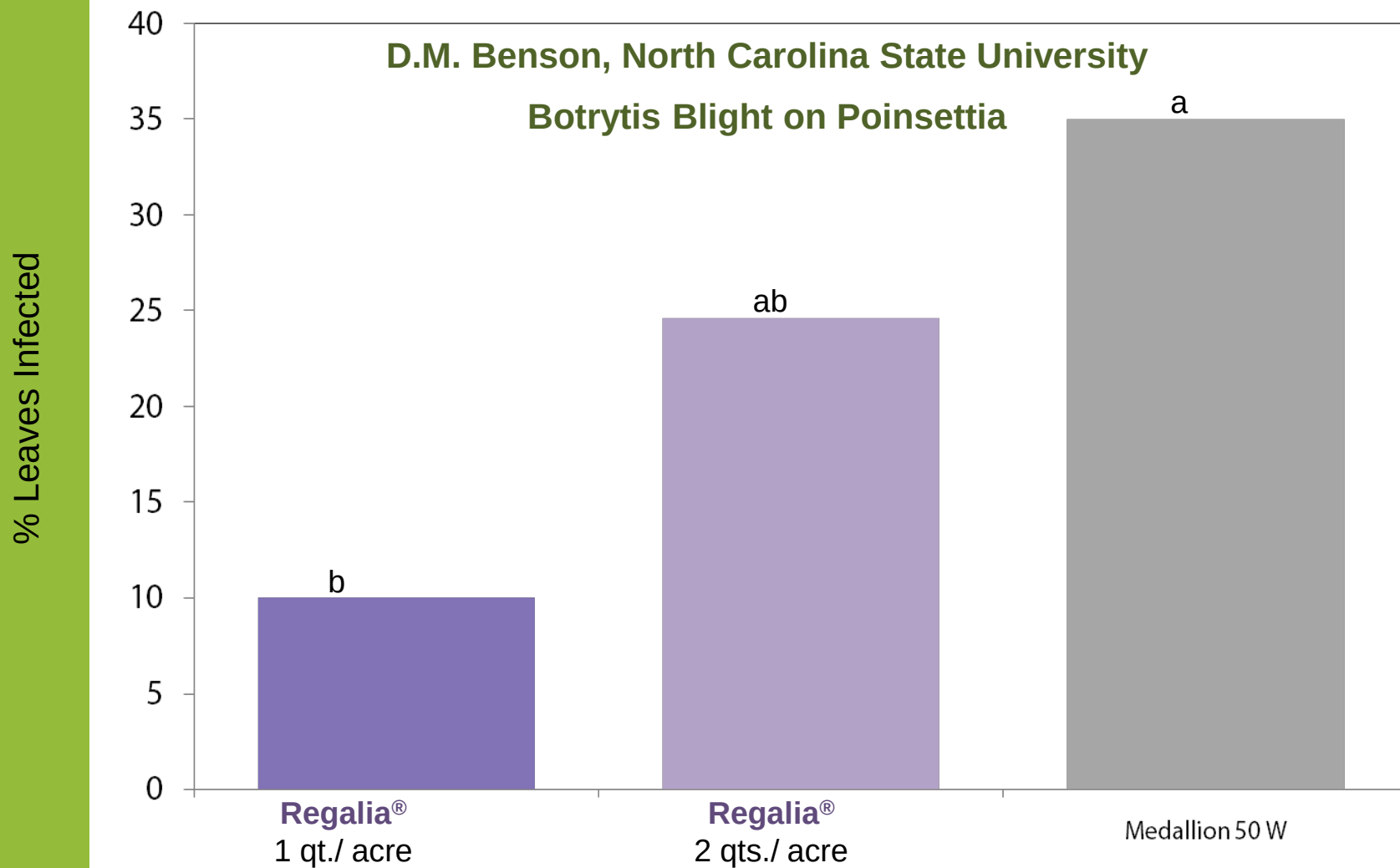
¹Area Under Disease Pressure Curve.

Regalia vs. Black Spot on Rose

Black Spot Rating



Regalia vs. *Botrytis* Blight on Poinsettia





Untreated



4 wks.



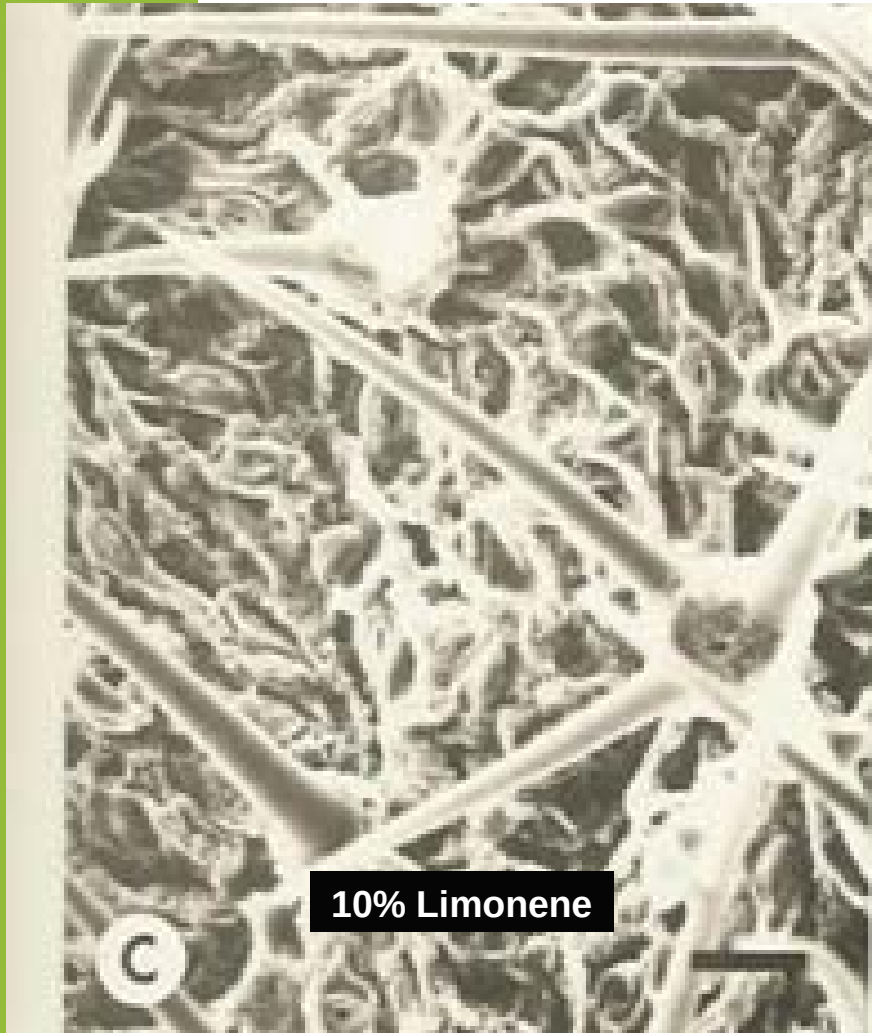
Untreated



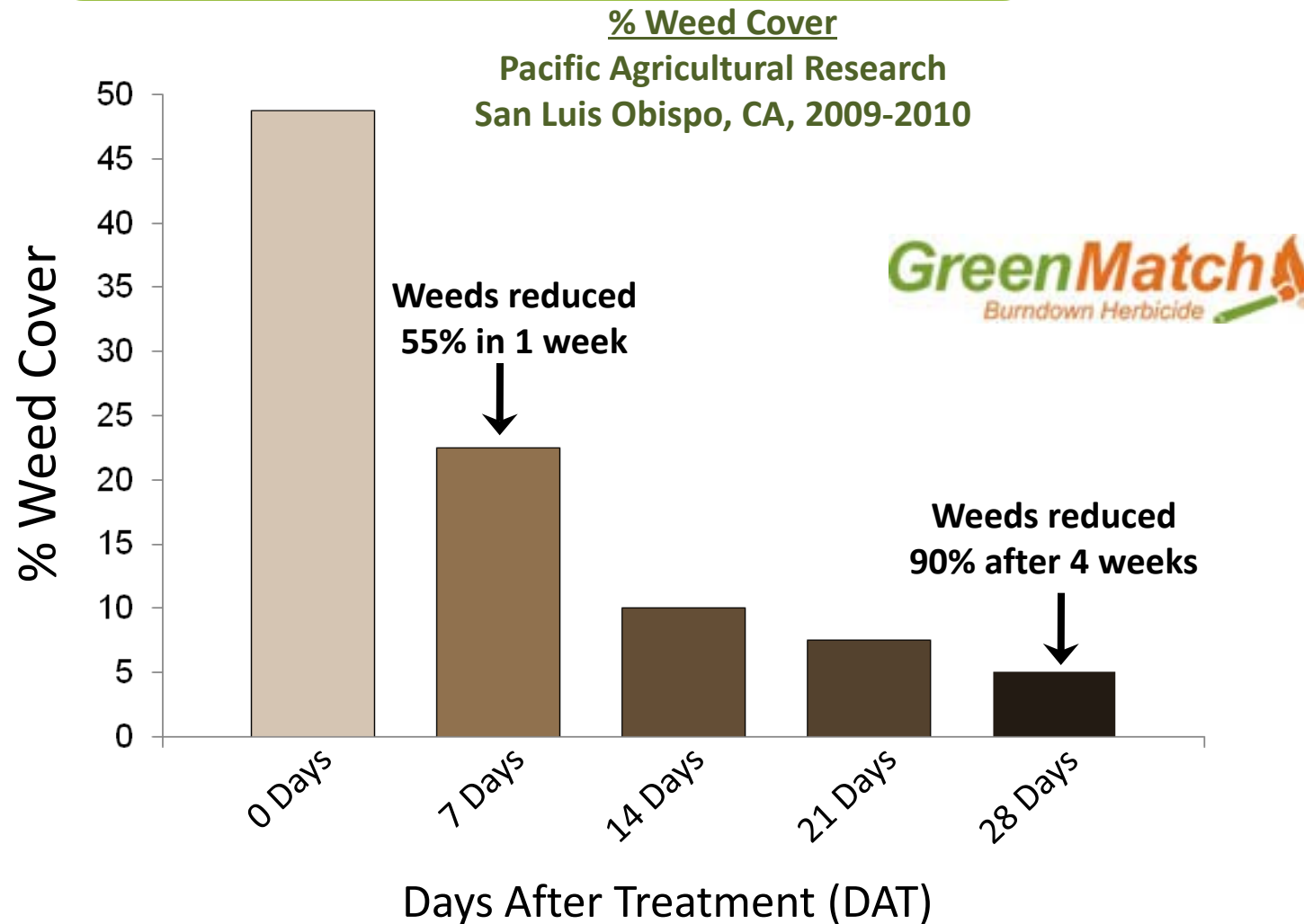
3 wks.

- ❖ Made from citrus oils and lemongrass oil (EX) + organic surfactants (patent pending)
- ❖ Proven 4 wk performance on broad spectrum of weeds
- ❖ Great for small weeds less than 6 inches; needs 60 gpa

Scanning Electron Micrograph 8-wk old
velvetleaf - Demonstrates “degreasing”
properties on plant cuticle (Michigan State
University)

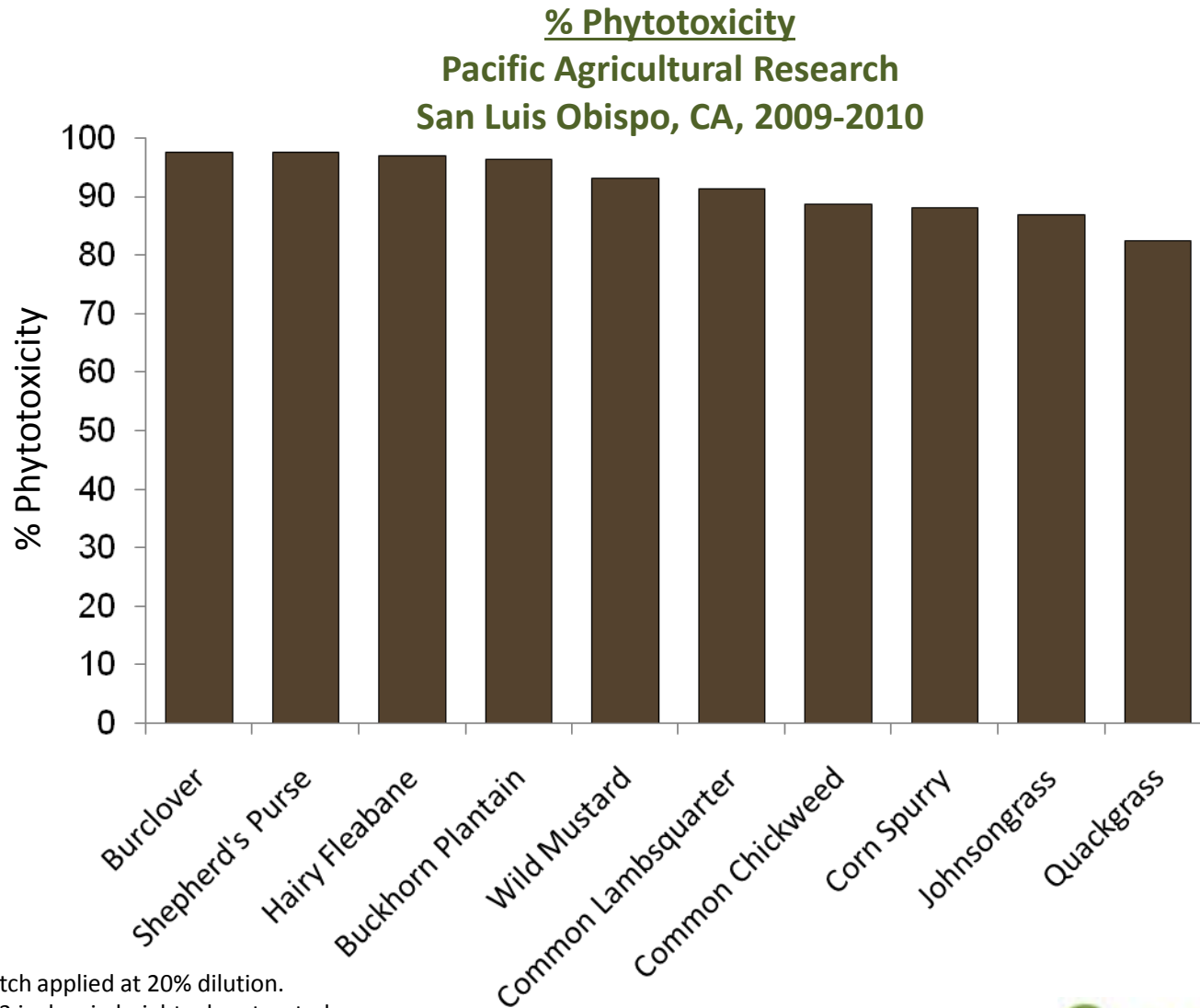


GreenMatch® Provides Fast and Lasting Weed Control



- GreenMatch applied at 20% dilution.
- Weeds 2-3 inches in height when treated.
- Weeds Evaluated: Buckhorn Plantain, California Burclover, Common Chickweed, Hairy Fleabane, Corn Spurry, Shepherd's Purse, Wild Mustard, Common Lambsquarter, Johnsongrass, Quackgrass.

GreenMatch® Kills Broadleaf and Grass Weeds, both Annuals and Perennials.



- GreenMatch applied at 20% dilution.
- Weeds 2-3 inches in height when treated.
- % Phytotoxicity = Average % phytotoxicity at 7, 14, 21 and 28 days after treatment for each species.



GreenMatch® Keeps Fields Clean



- GreenMatch applied at 20% dilution.
- Weeds 2-3 inches in height when treated.

GreenMatch[®] is Phytotoxic to Weed Seed.



- Treatments applied at 20% dilution.
- Weed height= 5-6 inches when treated.

MBI 005 – Selective Bioherbicide

- ❖ **Use:** Broad spectrum control of broadleaf weeds and aquatic sedges
- ❖ **Crops:** Rice, corn, wheat, sugarcane, sorghum, turf
- ❖ **Active ingredient:** *Streptomyces* compound produced by fermentation
- ❖ **Regulatory status:** Pending at the EPA; approval for turf ~Feb 2011; for food crops mid 2011



MBI 005 – Selective Bioherbicide



10DAT

UTC

MBI-005
1.0 mg/mL

MBI-005
0.5 mg/mL

Roundup
1 fl oz/gal

Dandelion
Test



24DAT

Lambsquarter – 7DAT



Dandelion – 7DAT



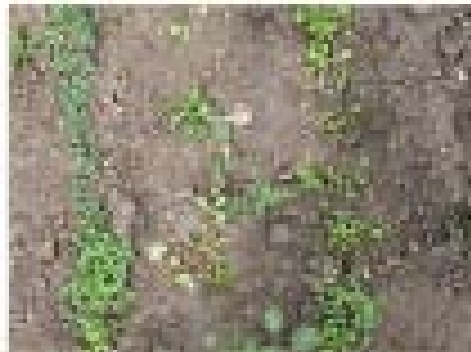
Velvetleaf – 14DAT



Sunflower – 7DAT

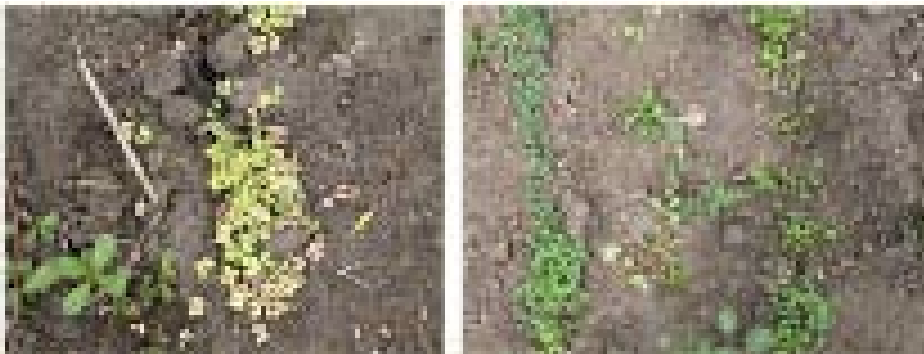
Phoma macrostoma Bioherbicide

- Karen L. Bailey, Agriculture and Agri-Food Canada
- Discovered from diseased sow thistle
- Licensed to Scott's for turf
- Control of: dandelion (68%), field bindweed (60%), annual sow thistle (97%), and wild mustard (82%).
- Some reduction in perennial sow thistle, smart weed, Canada thistle, false cleavers, hemp nettle, and Brassica (25-50%).
- No effect on stinkweed, lambs quarters, and wild oat.



Phoma macrostoma Bioherbicide (2)

- Soil moisture is a key requirement for efficacy
- Best on emerging seedlings; less effective on well established weeds using a single application.
- Post-emergent application of the bioherbicide granules was more difficult when the crop was established.
- Waiting US EPA approval
- Registered by PMRA (Canada's EPA)



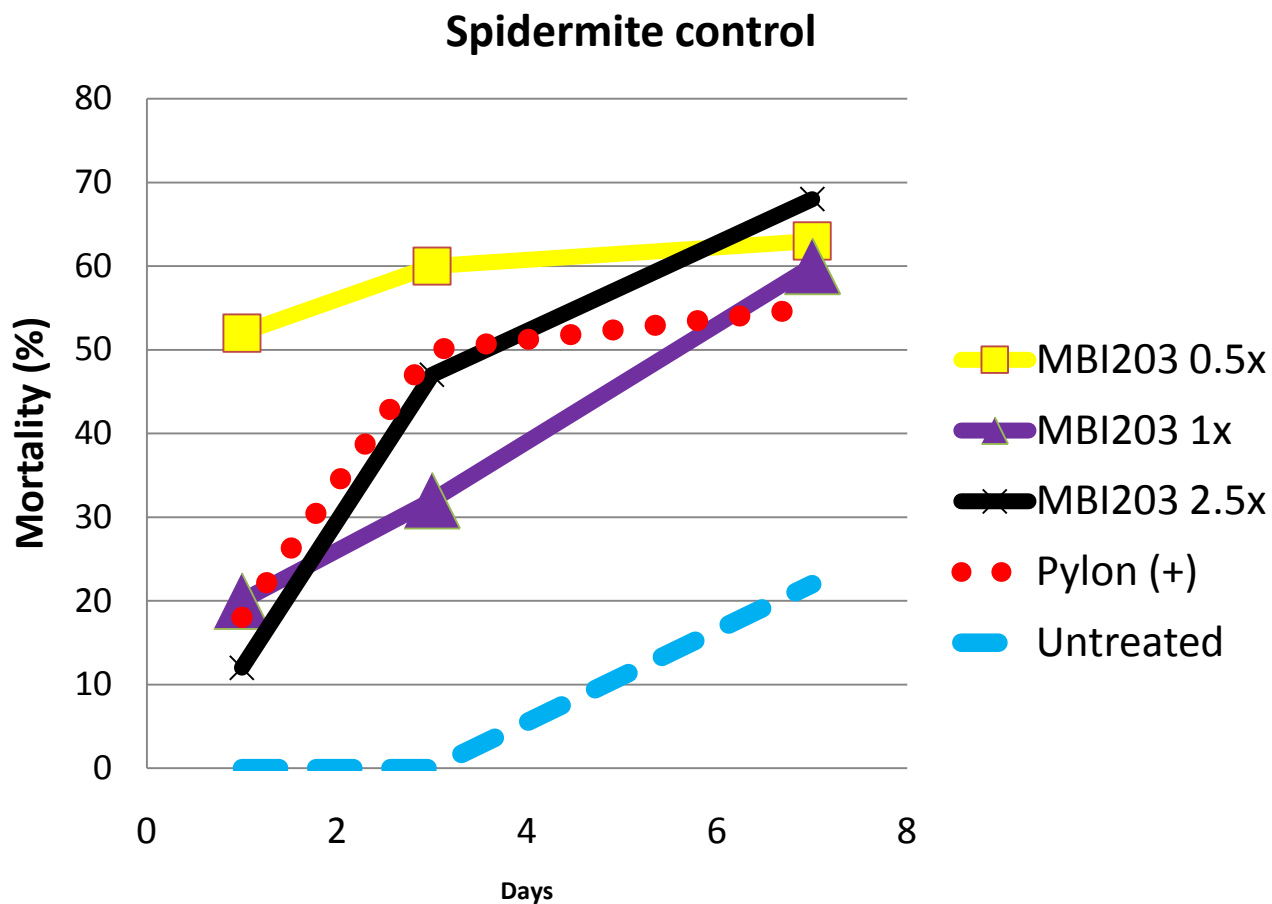
New Microbial Insecticide (MBI 203)

- ❖ **Source:** USDA-ARS's discovery – found under hemlock tree in MD (new species)
- ❖ **Use:** Broad spectrum sucking and chewing insect & mite control
- ❖ **Active ingredient:** *Chromobacterium substugae*
- ❖ **Regulatory:** Waiting approval at the EPA; Market launch mid 2011
- ❖ **Mode of action:** strong anti-feedant
- ❖ **Non-targets:** Non toxic to rats, birds, fish; good safety on *Daphnia* and beneficial insects





MBI 203 - Two-spotted Spider Mite



New Microbial Insecticide (MBI 206)

- ❖ **Source:** Early lab discovery (herbicide) redirected as highly active insecticide
- ❖ **Uses:** Broad spectrum – sucking and chewing insects
- ❖ **Active ingredients:** New bacterial species
- ❖ **Regulatory:** Submission to the EPA 1st Q 10; market launch 2011
- ❖ **Safety:** non toxic to all non-target organisms thus far
- ❖ **Mode of action:** Kills through contact and feeding
- ❖ **Spectrum:** Still being determined, stronger on armyworm than MBI 203



Sunburn, Drought Protection (MBI 501)



untreated



Treated



untreated



Treated –
Increased flowering

- ❖ Mixture of natural products (proprietary mix of fatty alcohols + plant based oil)
- ❖ Reflects heat energy on leaf thereby reduces the internal leaf temperature leading to reduction of transpiration
- ❖ Citrus, apples, nuts, berries, turf, vegetables, leafy greens, olives, ornamentals

3rd Commercial Product – Market entry, emergency use 2009
Mussels = \$ billions in economic & environmental damage



Zebra

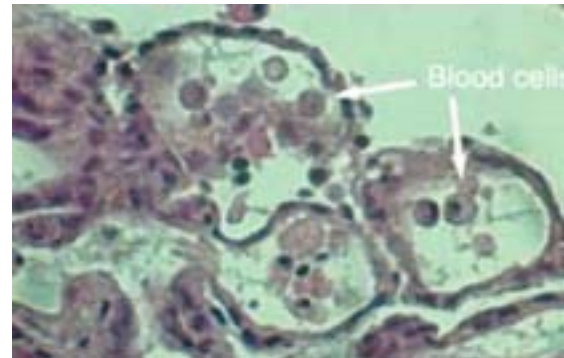
Quagga



Mussels
clog
pipes
in plants



Pseudomonas fluorescens
(dead) bacteria kill mussels when
they feed



Ruptured gut cells



Discovered by NYSM; patented – MBI is exclusive partner



REQUIEM™ from *Chenopodium ambrosioides* var *ambrosioides* = Food plant: Epazote



- A proprietary mix of terpenoid compounds extracted by steam distillation from a Central American herbaceous plant

Soft-bodied Insects and Mites:

- Thrips
- Whiteflies
- Aphids
- Mites
- Leaf hoppers
- Leafminers
- Psyllids



- EPA/DPR registered

Products Approved - 2009

- ❖ Fox urine - Animal repellent (Shake Away)
- ❖ Sodium perborate tetrahydrate - Herbicide (algae) - Lakes, ponds, lagoons, ornamental ponds, irrigation systems, reservoirs (Coeur d'Alene Fiber Fuels)
- ❖ Activated sewage sludge - Deer Repellent; around gardens (Milwaukee Metropolitan Sewage District)
- ❖ Iron HEDTA – Herbicide -Broadleaf weeds, moss, algae on lawns (Neudorff)



Other Products Coming - 2010

- ❖ Oregano oil – Herbicide for outdoor structures to control moss (Mossbuster)
- ❖ Calcium acetate - Insect attractant - Yellow Jackets (Bull Run)
- ❖ 2-Methyl-1-butanol -Insect attractant - Yellow Jackets (Bull run)



Biopesticides – Stay Tuned!

- ❖ Biopesticides are becoming mainstream – most are used in conventional systems
- ❖ But perceptions persist about efficacy/cost, although there are effective products
- ❖ There is still a large need for end-user education on biopesticides – what they are, how they work, when best to use them
- ❖ There will be more biopesticides than new chemicals registered in the coming years





Pam Marrone, Founder/CEO

pmarrone@marronebio.com

1-530-750-2800 (office)

www.marronebioinnovations.com

