Plum Curculio: Challenges, Changes & Management Strategies

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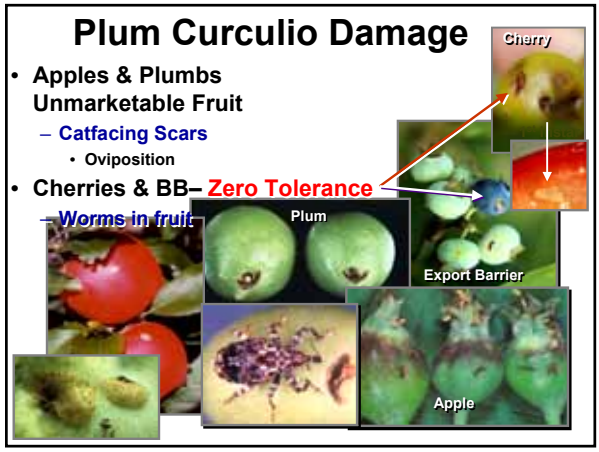
- PC Problem: Policy
- PC Monitoring
- Insecticide Trials
- USDA/RAMP Study
  - Things Growers should not do…
  - Emerging Insecticide Strategies
  - Problems with Neonicotinoids
  - Possible IGR Strategy
- Novel Organic Controls

Michigan's Agricultural & Natural Beauty

US Production Stats
#1 Cherry
#1 Blueberry
#1 Turf
#1 Christmas Trees
#1 Dry Beans
#2 Woody Ornamentals
#2 Flower Bulbs
#2 Asparagus
#2 Processed fruit & Vegs
#3 Seed Corn
#3 Apple
#3 Peaches
#3 Pickles
#3 Pumpkins / squash
#4 Staked Tomatoes
#4 Cut flowers
#4 Sugar beets
#4 Carrots
#5 Potatoes

Plum Curculio Damage

- Apples & Plumbs Unmarketable Fruit
  - Catfacing Scars
    - Oviposition
- Cherries & BB– Zero Tolerance
  - Worms in fruit



Apples, Sweet and Tart Cherries

Food Quality Protection Act 1996
AZM Rate Reduction & Cancellation

	2007-2009	2010-2012
Season Max	1.5 lbs	0.75
	ai/acre/year	ai/acre/year

- Aerial Applications Prohibited
- 60 ft Buffer Zone – Dwellings
- 60 ft Buffer – Water
- Pick Your Own – Prohibited

Increased Worms in Cherries

FDA Law – Zero Tolerance
USDA Inspection Standards
State of Michigan Law (1928)

- Impact on Growers ⇧ bankrupt
- Impact on Processors ⇩ contracts
- Impact on Industry ⇩ competitiveness

Difficult to Control a Pest Without Developing Monitoring Tools

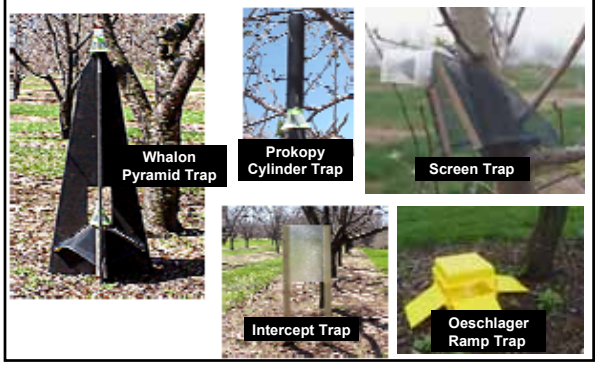
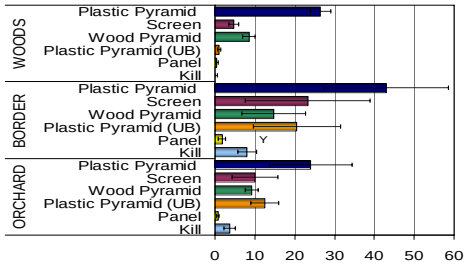
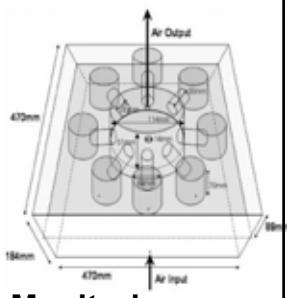


Figure 3. Mean Total Number Plum Curculio Captured per Trap



Improving kairomone blends and repellents

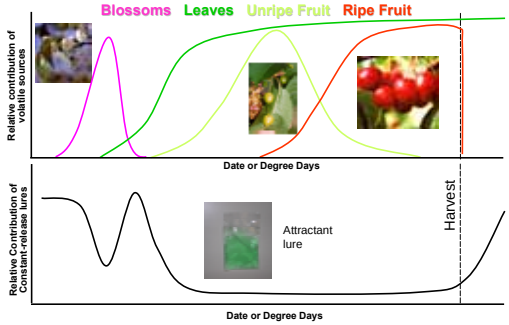
Objective: Test various attractants and repellants in the lab



Methods:

- **PC in Olfactometer**
- **Observe response to chemistry**

Plum Curculio Monitoring



Sources of plum curculio attractant odor throughout the growing season. (Top) Abundance profiles of attractive volatile components from plant structures. (Bottom) Comparative contribution of a single, constant-release lure.

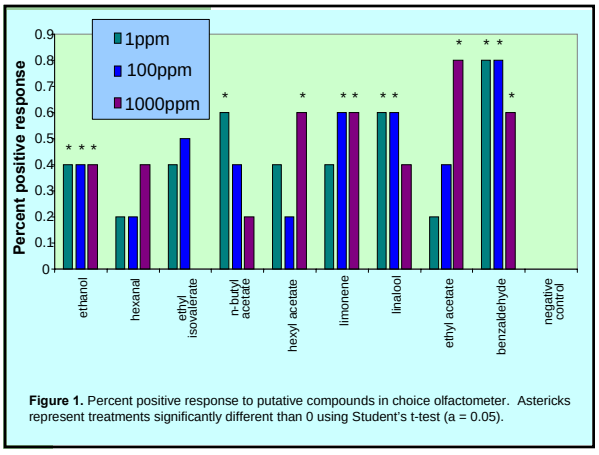
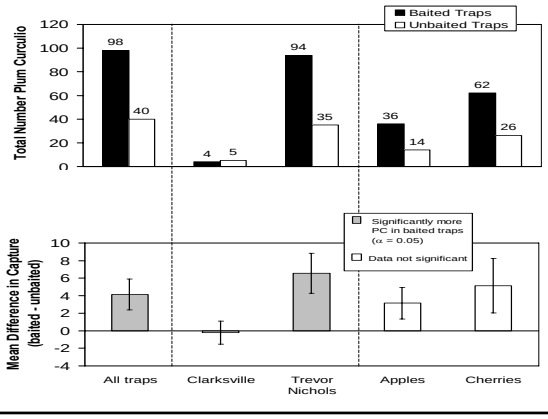
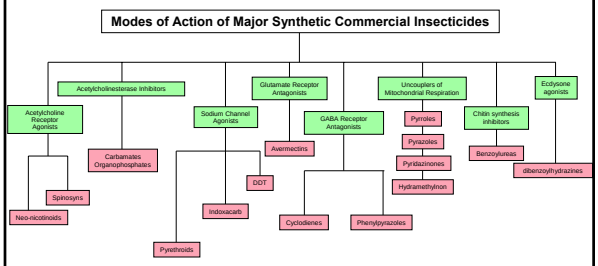


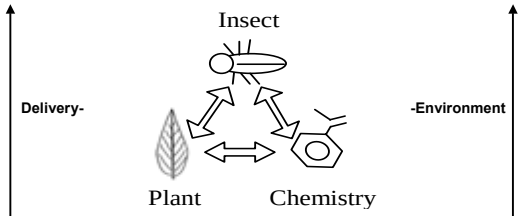
Figure 1. Percent positive response to putative compounds in choice olfactometer. Astericks represent treatments significantly different than 0 using Student's t-test (a = 0.05).



New Insecticides: Problem = Weevils



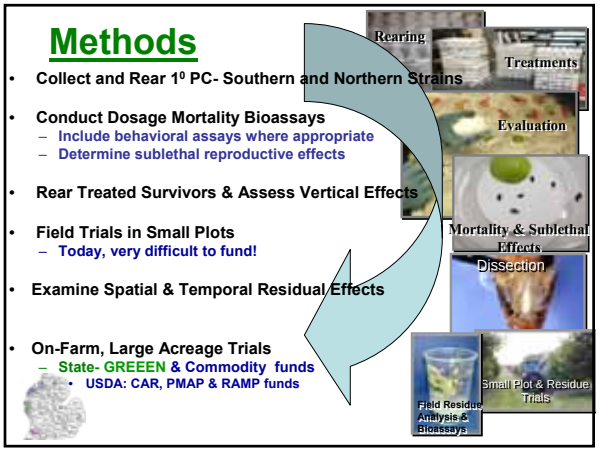
Insecticidal Activity: Plant, Insect, Chemical Interaction



PIC Triad

Methods

- Collect and Rear 1⁰ PC- Southern and Northern Strains
- Conduct Dosage Mortality Bioassays
  - Include behavioral assays where appropriate
  - Determine sublethal reproductive effects
- Rear Treated Survivors & Assess Vertical Effects
- Field Trials in Small Plots
  - Today, very difficult to fund!
- Examine Spatial & Temporal Residual Effects
- On-Farm, Large Acreage Trials
  - State- GREEEN & Commodity funds
    - USDA: CAR, PMAP & RAMP funds



Residues on/in Leaves and Fruit Coupled with Morbidity & Behavior Assays

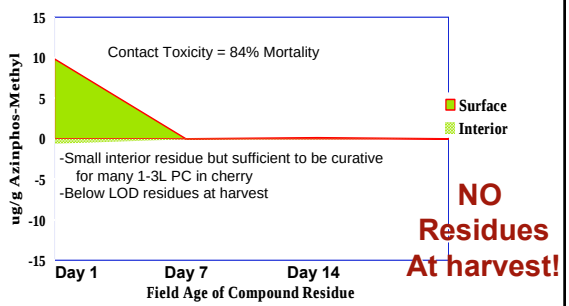
Apply Compound @ Recommended Rate

Harvest Infested Fruit Clusters
Observe Larval Emergence
Place Adults On leaves/Fruit

Analysis
MSU IR-4
Laboratory

Guthion Residue on/in Fruit

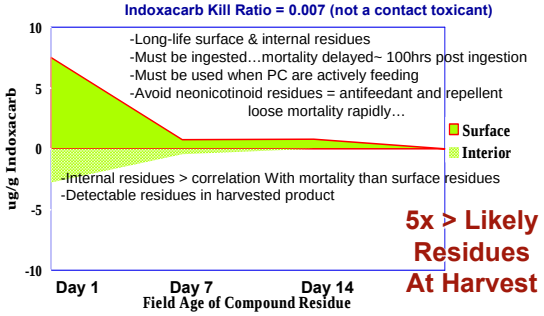
The "Standard" or a Kill Ratio = 1 (contact toxicant)



NO Residues At harvest!

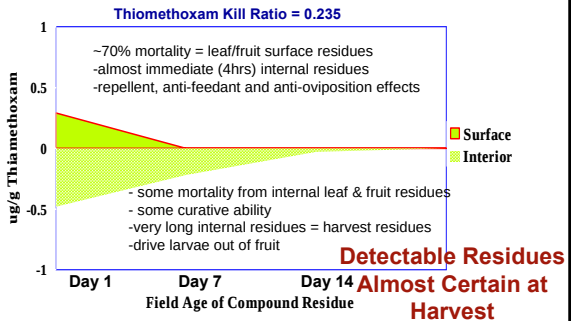
Avaunt Residue: Fruit

Indoxacarb Kill Ratio = 0.007 (not a contact toxicant)



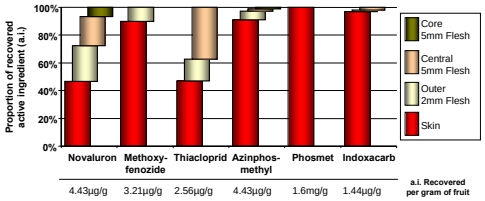
5x > Likely Residues At Harvest

Actara Residue: Fruit



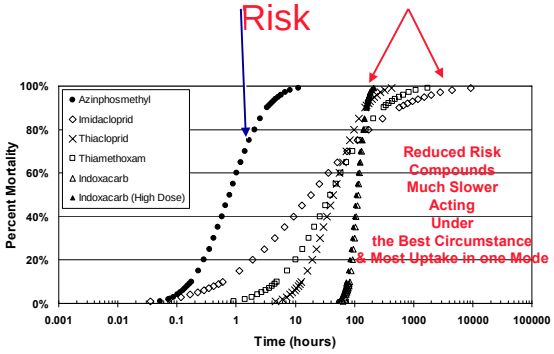
Detectable Residues Almost Certain at Harvest

Where the Compound IS & its CONCENTRATION in Relation to the TARGET & its BEHAVIOR; Determine Efficacy

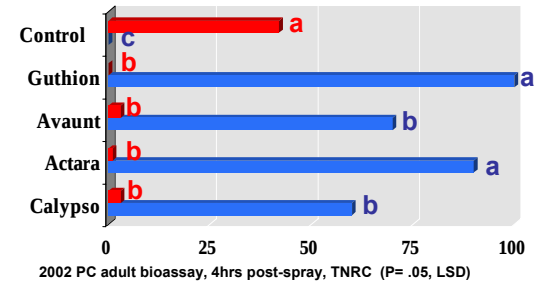


With RR Compounds: Pest Control Just Got Much, Much More Complex!

Lethal Time: AZM Vs. Reduced Risk



Residual Activity on Plum Curculio



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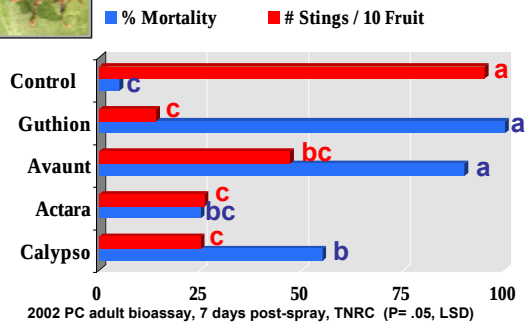
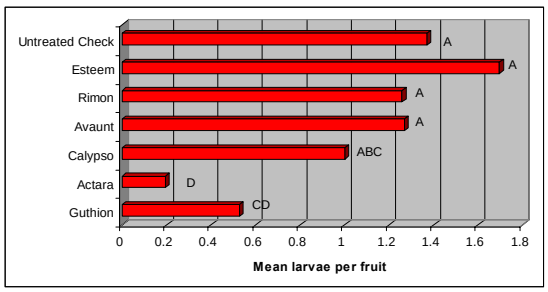
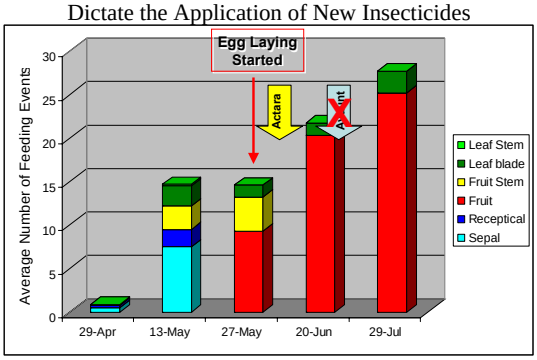


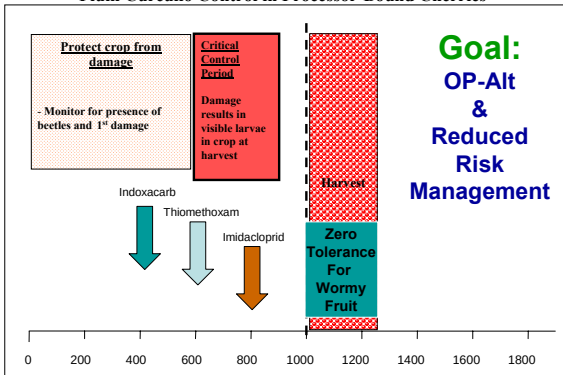
Curative Activity of Insecticides on Plum Curculio Larvae



PC adult feeding patterns during Production Season
Dictate the Application of New Insecticides



Plum Curculio Control in Processor-Bound Cherries

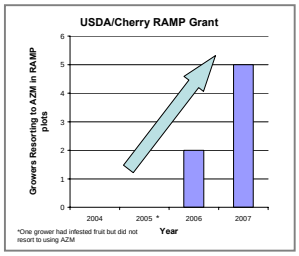


Goal:
OP-Alt
&
Reduced
Risk
Management

AZM Insecticide Alternative's in Cherry

- New Research
  - Finishing 1+ USDA RAMP GRANT (ohio state, osu, mark, mark)
  - INDUSTRY'S INVESTMENT
  - MSU'S INVESTMENT
- AZM
  - GFW, LR, PC, CFF
- New Tool's
  - Imidacloprid (2004)
    - GFW, LR, PC, CFF (7d)
  - Thiamethoxam (2006)
    - GFW, LR, PC, CFF (14d)
  - Acetamiprid (2008)
    - GFW, LR, PC, CFF (7d)
  - Spinosyn (2003)
    - GFW, LR, PC, CFF (7d)
  - Indoxacarb (2007*)
    - GFW, LR, PC, CFF (14d)
- MRL's
- Economically Sustainable?
- Time to Adapt.....

9 Paired Orchards: AZM : Nicotinoids



PC Populations Increased in Nicotinoid Orchards over 4 years

FQPA Ushered Changes Yields New Insight!

Acute vs Chronic Effects of Various RR Insecticides

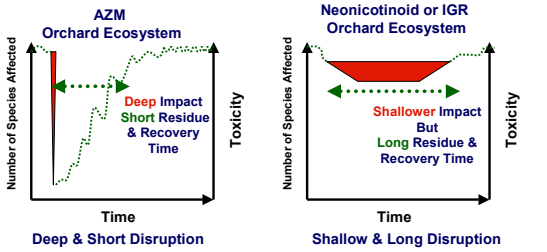


Figure 1. An illustration of the chronic ecological effects of different insecticides upon an orchard ecosystem.

Emerging Neonicotinoid (RR) Issue…

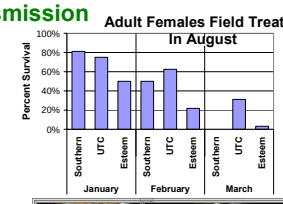
- Premature emergence
  - larvae exit post treatment
- New Damage:
  - Larvae exiting can penetrate a 2nd or 3rd cherry; eventually escape control…

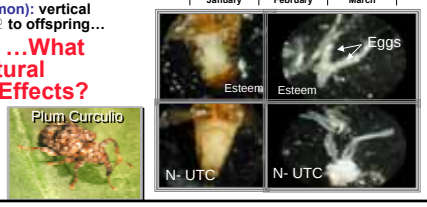
Anti-feedant Results in More Injury At Harvest

IGR's Present a New Set of Ecological Challenges
Subtle Endocrine-Like Effects & Vertical Transmission

- Esteem (pyriproxifen): will brake diapause
- Esteem treated females produced eggs = create a two generation pest in apples & mortality in cherries …>>> complexity!
- Esteem treatment caused reduced fat reserves = winter mortality…
- Novaluron (Rimon): vertical transmission ♀ to offspring…
- If they do …What about Natural Enemies Effects?

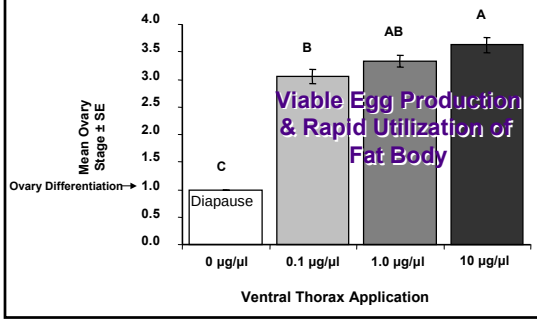
Adult Females Field Treated In August





PC Ovary Development with Esteem™

Obligate Diapause Broken



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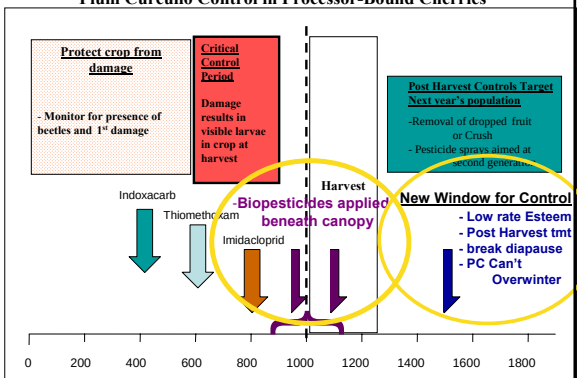
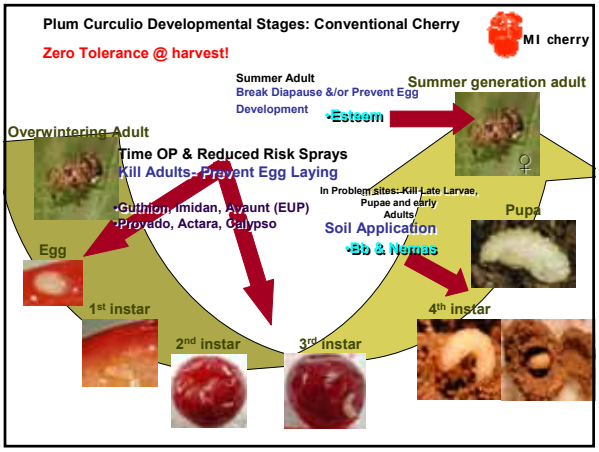


Plum Curculio Developmental Stages: Conventional Cherry

Zero Tolerance @ harvest!

MI cherry



Organic Production

Phenology & Emerging Control of Plum Curculio?

Plum Curculio Activity Window

Trap Out & Push / Pull

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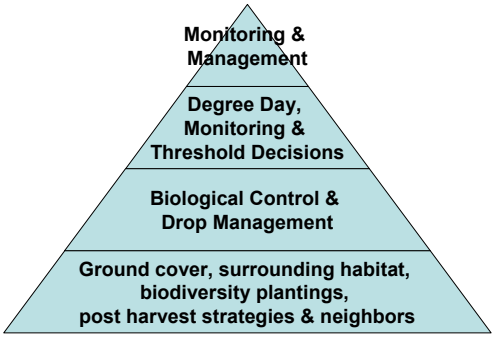
Plum Curculio Management



Apple Organic Pest Management & Spray Program

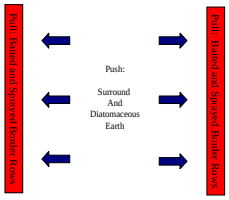
MI apple

- Surround (Kaolin Clay)
- Pyganic for PC & LFRL
- Oil
- Neem (azadirachtin)
- Monitoring, Timing, Thresholds
- Attract & Kill (Push/Pull)
- Predator Prey Ratios
- Biopesticides

9- Applications of Surround

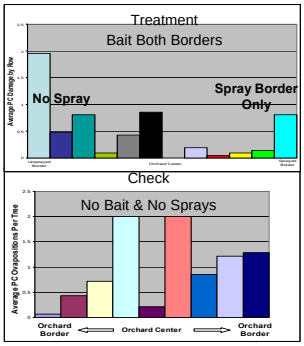
Push/Pull Strategy

- Pull PC to the Orchard Borders
- Kill PC by Trap Out and Border prays
- Push PC out of the Interior Rows



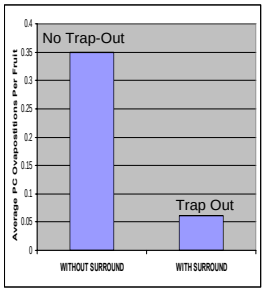
Clarksville 'O' Orchard: PC Distribution

- PC Damage much higher in check
- Border trapping pulled PC out of interior
- Spraying border reduced damage



Surround & Trap Out: Reduces Larval Damage & Oviposition Scars

- Reduces Oviposition Scars
- 2004, 05 & 06 Difference in PC Damage at Harvest

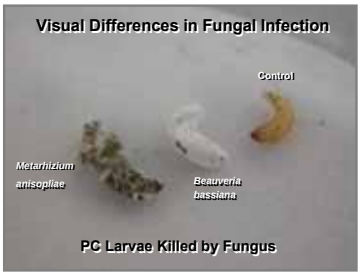


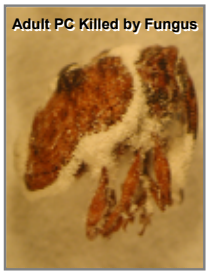
Beauveria bassiana (Bb)

- Insect pathogenic fungus
- Registered on over 100 crops
  - Sensitive to UV light, low rH, temperature extremes
- Strain variance: adapted to different hosts

Microscopic Image Courtesy of R. Humber

Important Fungal Pathogens of plum curculio





Novel Population Suppression Strategies

- Trap Out, Attractants & Border Sprays
- Phenology Models To Time Activity
- Kaolin Clay (Push)
- Drop Control
- Summer Generation Control Nemas

Strategy: Colonizing grain with fungus (build over time)

- Seed Bb, Ma &/or Nemas into drip line of trees
- Grow on cheap grain castings in the barn or surrogate hosts
- Colonized grain is dried and stored
- Application methods-
  - Disc fertilizer spreader (2007)
  - No-till drill
  - Hand Gun or Spray By hand applicator
- Irrigation helps activity and longevity

Experimental Methods

- Large Treatments:
  - Replicated 3x in 4 orchards
  - 2 cherry & 2 apple blocks
- Micro-plots within blocks
  - Replicated 4x per block
  - 5 treatments per micro-plot
    - Control
    - Spray (weed sprayer)
    - Low, med & hi rates

Methods: Plot Setup

Five treatments:

- Untreated Control (Water)
- Boom Sprayer
  - 3 applications at high rate
- Low density rice
  - $2*10^5$ spores/cm^2
- Medium density rice
  - $2*10^6$ spores/cm^2
- High density rice
  - $2*10^7$ spores/cm^2

Seeded

10 PC larvae per cup