Organic Methods for Control of Insect Pests and Diseases of Pecan and Peach

Dr. David Shapiro-Ilan and Dr. Clive H. Bock

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http://www.extension.org/organic_production

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USDA-ARS-SEFTNRL, 21 Dunbar Rd., Byron, GA 31008

Overview of presentation

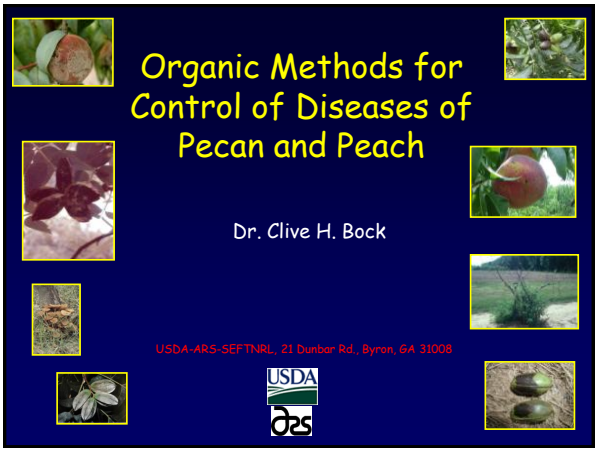
Presentation in two sections:

1) Organic methods for control of diseases of pecan and peach (Clive Bock)

2) Organic methods for insect pest control in pecan and peach (David Shapiro-Ilan)

About the crops:

- Both are perennial crops, and take several year to bear
- Limitations to organic production are due to both pests and diseases
- Peach suffers several postharvest issues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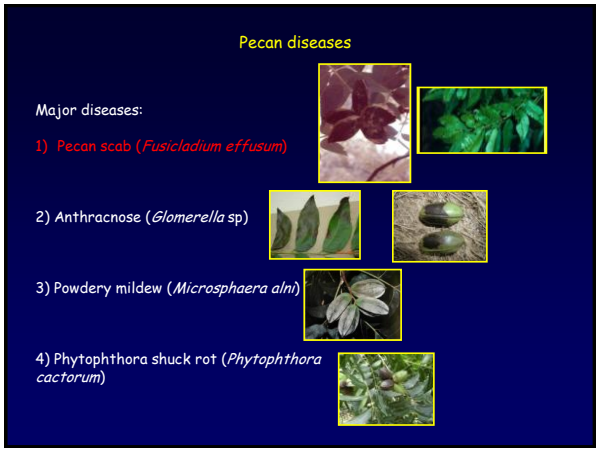
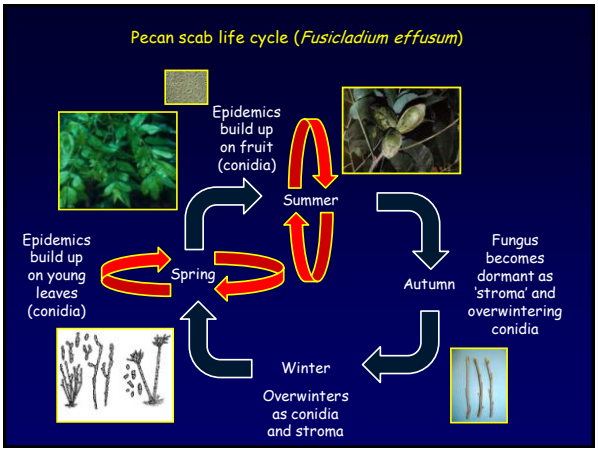
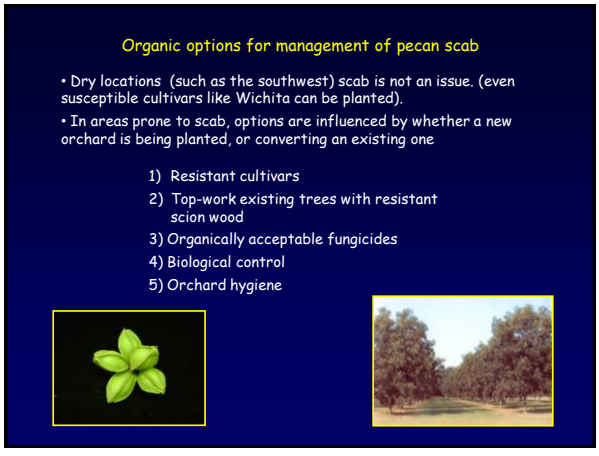

Pecan diseases
Major diseases:
1) Pecan scab (Fusicladium effusum)
2) Anthracnose (Glomerella sp)
3) Powdery mildew (Microsphaera alni)
4) Phytophthora shuck rot (Phytophthora cactorum)


Pecan scab life cycle (Fusicladium effusum)
Epidemics build up on fruit (conidia)
Summer
Epidemics build up on young leaves (conidia)
Spring
Autumn
Fungus becomes dormant as 'stroma' and overwintering conidia
Winter
Overwinters as conidia and stroma


Organic options for management of pecan scab
• Dry locations (such as the southwest) scab is not an issue. (even susceptible cultivars like Wichita can be planted).
• In areas prone to scab, options are influenced by whether a new orchard is being planted, or converting an existing one
1) Resistant cultivars
2) Top-work existing trees with resistant scion wood
3) Organically acceptable fungicides
4) Biological control
5) Orchard hygiene

Host resistance

Newer cultivars with high levels of resistance:

Excel
Mandan
Amling
Lakota
Zinner

Older resistant cultivars that are widely grown:

Elliot
Caddo
Kanza
McMillan
Sumner (some loss of resistance?)

Scab susceptible cultivars:
Wichita, Mahan, Apache, Burkett, Candy, Cherokee, Cheyenne, Delmas, Mohawk, Schley

Historically there is a risk of loss of resistance, so even with resistant cultivars, there is a risk of needing to resort to organically acceptable fungicides

http://www.ceasup.edu/commodities/fruits/pecanbreeding/cultivars/scab_resistant.html
http://aggie-horticulture.tamu.edu/orchard/pecans/controls.htm

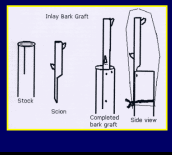
Top-working - host resistance

- Top-working existing, susceptible cultivars is possible
- Best done on young vigorous trees
- Practical if the acreage is not too great
- Use scab resistant scion wood

Excel
Mandan
Elliot
Caddo
Kanza
Amling
McMillan
Sumner (some loss of resistance?)

Highest rate of success with bark grafts (Goff et al., 1996):

- Trees 3-15+ y age
- 1 to 4" stock
- April-June



Organically acceptable fungicides

- There are several organically acceptable fungicides available to control various plant diseases
- Few of these have been thoroughly tested on pecan diseases
- Bordeaux mixture (hydrated lime + copper II sulfate, $Ca(OH)_2 + CuSO_4$)
- Scab is the disease that has received most attention

Management of scab with Bordeaux mixture

Based on early work by Demaree (1923, 1924), and Cole and Large (1939) a 4-spray program was recommended. Later, a six-spray program was recommended (Large, 1966, Osburn et al., 1966 (USDA))

Pros:

- Lots of data exists to confirm efficacy
- Even on susceptible cultivars can give some control in epidemic years
- Readily available

Cons:

- Risk of defoliation if dry - alleviated by use of low-lime mixtures (use weather-based scab advisory)
- Reputedly hard on equipment (corrosive)
- Copper build up in soil
- Black aphid

Recommended spray program :

- Pre-pollination application of a 4-1-100 mix (12 lbs copper sulfate, 3 lb hyrdrated lime in 100 gal water) when leaves ¼ to ½ grown
- A first cover application of a 6-2-100 mix (18 lbs copper sulfate, 6 lb hyrdrated lime in 100 gallons water) a few days after pollination
- Second application of a 6-2-100 mix 2-3 weeks after first
- Third application of a 6-2-100 mix 2-3 weeks after second
- Fourth application of a 6-2-100 mix 2-3 weeks after third
- Fifth application of a 6-2-100 mix 2-3 weeks after fourth

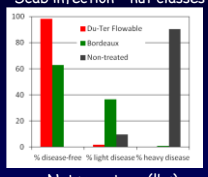
(if weather conditions conducive to scab, an early pre-pollination of 4-1-100 mix can be recommended when first leaves showing)

Bordeaux mixture – efficacy

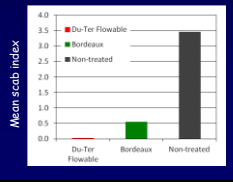
'Mahan' 1965 (very susceptible)

- Jefferson Co., FL, cv. Mahan
- Orchard received sprays 14 April, 14 May, 25 June, 9 and 29 July and 8 August) using a 35 gpm hydraulic sprayer @ 450 psi
- Assessments on 18 August. Scab index (0-4): 0 = no scab, 1=trace – 10%, 2=11-25%, 3=26-50% and 4=>50% shuck area diseased
- Rainfall in 1 Jan – 9 Sept 1965 was 54.05 inches, 10.57 above average (43.48)

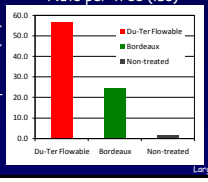
Scab infection – nut classes



Scab index – nuts



Nuts per tree (lbs)



Large (1966)

Preliminary work on biocontrol of pecan scab

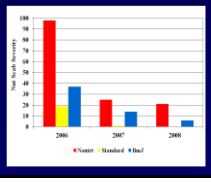
Bacillus mycoides isolate J

- Commercialized as "BmJ" (Montana Microbial Products)
- Induces resistance mechanisms in the plant (not directly toxic to the pathogen)
- Effective as a foliar spray, not via roots as are some other bacterial resistance inducers, so can be applied with conventional spray equipment

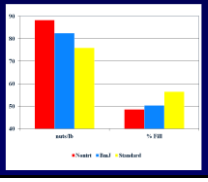
B. subtilis

- 'Serenade' (AgraQuest, Inc)
- Achieve disease suppression through nutrient competition, site exclusion, colonization, and attachment of the bacteria to the pathogen - might induce plants' natural defense mechanisms

Scab severity 2006-8



2006 – Yield on Wichita



- Efficacy of BmJ on Scab Severity on Wichita, Tifton, GA (10 sprays applied on a 2-week interval)
- 2006 a heavy scab year, 2007/8, relatively mild scab
- Severity (% area of nuts infected)
- Data courtesy of Dr. Tim Brenneman, University of GA

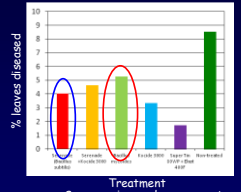
Orchard hygiene

- Removal of leaf trash and other pecan tree debris that can act as a source of inoculum in the spring
- Ensure old shucks are no longer hanging in the tree after harvest
- There are other important reasons to clean up debris, but it is of limited use for scab as the pathogen has a great capacity to multiply and cause an epidemic

Biocontrol of anthracnose

- UGA fungicide test, Ponder Farm, Tifton, 2010
- Cultivar Desirable, foliage assessed 20 July
- *Bmj* and *B. subtilis*
- Data courtesy of Dr Tim Brenneman , University of GA

Anthracnose – incidence on leaves



LSD = 1.5

Rates:
Serenade (Bacillus subtilis) [6 qt/A]
Serenade [6 qt/A] + Kocide 3000 [1.75 lb/A]
Bacillus mycoides J [4.2 oz]
Kocide 3000 [1.75 lb/A]
Super Tin 80WP [3.75 oz]+ Elast 400F [25 fl oz]
Non-treated

Spray regime and assessments:
10 sprays per season
Incidence is the % of leaflets on middle leaf on each terminal

Sulfur to control powdery mildew on pecan

- Sulfur has been shown to be effective against powdery mildew (Brenneman et al., 1988)
- Apply as needed at a rate of 4-6 lb acre
- Sulfur sprays virtually eliminate the fungus compared to non-untreated fruit which had 80% of fruit surface area diseased

Summary – organic control of pecan scab and other diseases of pecan

- Resistant cultivars are the best solution to scab
- Avoid very susceptible cultivars in scab-prone areas
- Use the full range of available management practices including:
  - Top working trees with resistant scion wood
  - Use of organically acceptable fungicides (particularly Bordeaux mixture, sulfur, others?)
  - Biological control (*B. subtilis*?)?
  - Orchard hygiene (minor effect for scab)

Peach diseases

Organic production of Peach

Major diseases:

1) Brown rot (*Monilinia fructicola*)

2) Scab (*Fusicladosporium carpophilum*)

3) Bacterial spot (*Xanthomonas pruni*)

4) Armillaria spp. root rot

5) Peach tree short life (*Mesocriconema xenoplax*/cold + *Pseudomonas syringae pv. syringae*)/nematodes

Organic production of Peach

- From a disease perspective, organic production of peach is challenging, especially in wet environments
- An integrated approach is needed to manage these diseases including:
  1) Resistant cultivars/rootstock (only available for certain diseases)
  2) Applying organically acceptable fungicides
  3) Orchard hygiene
  4) Use of wind breaks



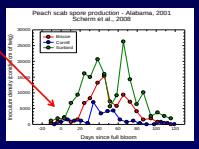


http://www.ipm.ucdavis.edu/PMG/selectnewpest.peach.html
http://www.clemson.edu/extension/horticulture/fruit_vegetable/peach/diseases/diseases.html
http://extension.psu.edu/fruit-diseases/stone-fruit
http://extension.uga.edu/agriculture/ag-fruits-vegetables/peaches/

Peach scab

- Current USDA grading system: peach fruit is downgraded from #1 to #2 if there is scab damage ("…cracked, or when aggregating more than 3/8 inch in diameter…" ~4-6 well-developed lesions on a fruit)
- If 10% or more of the fruit in a shipment has scab damage, the whole shipment can be downgraded
- Spores are produced from overwintered stem lesions
- Conidial production starts about two weeks before shuck split, and peaks for 3-4 weeks after shuck split
- The time of onset, peak, and tapering-off of spore production is critical for management decisions





1) Apply organically acceptable fungicides (sulfur)
There are no scab resistant cultivars
There are no proven effective cultural approaches to manage scab

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2011 Peach Scab data

- USDA, Byron, GA, 2011 (data courtesy of Dr. Phil Brennan, University of GA)
- Control as effective with sulfur as conventional fungicides
- Disease incidence and severity still exceeds that stated for grade #1 fruit

Treatment and rate/A	Application timing [z]	Scab incidence [y]	Scab severity [x]
1. Untreated Control	---	96.9 a	130.8 a
2. Bravo Weather Stik 6F 4.125 pt	PF	96.9 a	98.7 ab
3. Bravo Weather Stik 6F 4.125 pt	SS	88.8 ab	91.1 bc
4. Bravo Weather Stik 6F 4.125 pt	PF, SS	70.6 b	62.4 cd
5. Abound 15 fl oz	PF	81.3 ab	33.5 de
6. Abound 15 fl oz	SS	45.0 c	28.4 e
7. Abound 15 fl oz	PF, SS	20.6 d	3.2 e
8. Bravo Weather Stik 6F 4.125 pt Yellow Jacket Sulfur 90W 9 lb	PF, SS 1-10 C	34.4 cd	8.3 e
9. Abound 15 fl oz Yellow Jacket Sulfur 90W 9 lb	PF, SS 1-10 C	18.8 d	4.2 e
10. Yellow Jacket Sulfur 90W 9 lb	PF, SS, 1-10C	31.9 cd	8.4 e
LSD (P = 0.05)		20.0	33.6

[z] PF = petal fall to 1% shuck split application, SS = shuck split to 10% shuck off application, and C = cover spray application.
[y] Scab incidence (percent infected fruit) was recorded for 40 randomly selected mature fruit from each plot. Means followed by the same letter are not significantly different when using Fisher's protected LSD test.
[x] Scab severity was determined by counting the number of scab lesions observed on each of 40 fruit. Means followed by the same letter are not significantly different when using Fisher's protected LSD test.

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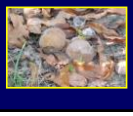
Brown rot of peach

1) Apply organically acceptable fungicides (sulfur)
Commence spray when buds are pink (6 lb/100 gal)

Pink	Full bloom	Petal fall	Shuck -split	1st cover	2nd cover	3rd cover	4th cover	5th cover	6th cover	7th cover
X	X	X	X	X	X	X	X	X	X	X

2) Orchard hygiene
Prune infected wood
Remove mummies in tree and on ground

No host resistance available, although some cultivars are more susceptible than others

Photos courtesy of P. Brannen, University of GA, GA

Bacterial spot of peach
Xanthomonas arboricola pv. pruni

1) Some resistance like cvs. Sentinel and Clayton. Many others are very susceptible eg: O'Henry and Ryan Sun

2) Wind breaks to reduce damage: bacteria spread in wind and rain

3) Copper / oxytetracycline spray focused early in the growing season, from dormant through early shuck split and during fruit maturation

If regular rain then more frequent sprays (watch for Cu toxicity)


General program for in-season use of copper for bacterial spot suppression on peaches and nectarines (modified from David Ritchie, North Carolina State University)

Stage	Formulated 53%copper (lb/acre)*	Metallic copper (lb/acre)
Delayed dormant	4 to 5	2
7 to 10 day interval	2	1
1 to 5 to bloom	1	0.5
Petal fall	0.5	0.25
Shuck split	0.25	0.125

After shuck split switch to Mycoshield (oxytetracycline) at 8 oz. Mycoshield per 50-100 gals water per acre (every 7-10 days if wet)

Photos courtesy of D. Ritchie, North Carolina State University, NC

Armillaria spp. root rot/PTSL/nematodes






1) Resistant rootstocks
2) Orchard hygiene (remove old stumps and roots, rip land prior to planting)
3) Remove infected trees
4) Avoid pruning late in season (PTSL)

Photos courtesy of T. Beckman, USDA-ARS, Byron, GA

Armillaria spp root rot/PTSL/nematodes

MP-29 (USDA) Dr. Tom Beckman

- Clonal semi-dwarf plum-peach hybrid
- Resistant to Peach tree short life (PTSL)
- Resistant to Armillaria
- Resistant to most Root-knot nematodes
- Excellent productivity and fruit size

Rootstock influence on cumulative mortality due to *Armillaria* (ARR), peach tree short life (PTSL) and other causes on an *Armillaria* infested site in central Georgia[z] (Fort Valley, 2007-2011, Data courtesy of Dr. Tom Beckman)

Rootstock	Cause of Death (%)			
	Alive	ARR	PTSL	Other
MP-29	92 a	0 c	0 b	8 a
Guardian[y]	42 b	48 a	0 b	10 a
Sharpe	40 b	18 b	30 a	13 a

[z] Est. Spring, 2007 with 5 tree plots in a RCB design w/ 10 reps, budded with Majestic' peach.

[y] Guardian peach seedling rootstock was collected from a single seed line, SC3-17-7, now the dominant component of the bulk seed mix sold commercially.

Photos courtesy of T. Beckman, USDA-ARS, Byron, GA

Organic production of Peach

Organic production of peach is challenging, but…an integrated approach to help manage diseases can work and should include:

1) Planting resistant rootstocks/cultivars
2) Applying organically acceptable fungicides
3) Orchard hygiene
4) Wind breaks

Acknowledgements and research needs

For some of the presented data:
Dr. Tom Beckman (USDA-ARS-SEFTNRL)
Dr. Tim Brenneman (UGA, Tifton)
Dr. Phil Brennan (UGA, Athens)

Future research needs for organic control of pecan and peach diseases include:

- Establishing efficacy of compost teas on scab and anthracnose of pecan, and various diseases of peach
- Testing and optimizing the use of biocontrol agents on major pathogens of pecan and peach
- Test bicarbonates and other organically acceptable agents on the major pathogens of both crops
- Breeding resistant cultivars ….




Organic Methods for Insect Pest Control in Pecans and Peaches

David Shapiro-Ilan
USDA-ARS, SE Fruit and Tree Nut Research Laboratory, Byron, GA USA


Agricultural Research Service
the in-house research arm of the U.S. Department of Agriculture

Outline

Pecan

- Pecan weevil
- Aphids
- Lepidoptera
- Stink bugs


Peach

- Plum curculio
- Peachtree borer


The Good Guys







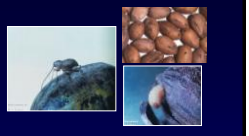
- Preserve the good guys!
- When needed use them as curative agents!

Pecan Weevil, *Curculio caryae*

- Key pest of pecan,
- Life-cycle 2-3 yrs
- Adults emerge July-October

(but mostly mid-Aug to mid-Sept)

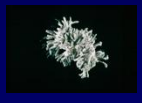
- Most crawl or fly to the trunk
- Larvae drop to soil (late Sept to Dec), & form a soil cell at 3" to 10" depth
- About 90% of the larvae pupate after 1 yr in soil & emerge as adults the next yr
- The other 10% remain as larvae an extra yr (3 yr life-cycle)



Traps used for monitoring

One Potential Microbial Agent for Pecan Weevil Control: Entomopathogenic Fungi

- Focus on Hypocreales: includes *Beauveria bassiana, Metarhizium* spp., *Isaria fumosorosea*
- Grow on artificial media, commercially available
- Can control various white grubs, black vine weevil, Lepidoptera, grasshoppers, aphids, white flies, etc

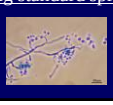


Fungus Vs. Pecan Weevil

Endemic (native) Fungus in the Orchard: 30% to 50% pecan weevil mortality from endemic fungi, e.g., *B. bassiana* (Shapiro-Ilan et al., 2003)

Applied/Introduced Fungi:

- 80% mortality or more over a two week period of during peak weevil emergence
- Best treatments application of *B. bassiana* to trunk or to the ground with a cover crop - Sudan grass (Shapiro-Ilan et al., 2008; Hudson et al., 2010)
- Apply using standard spray equipment (>10^{13} conidia/ha)



Clover Can Enhance Beneficial Endemic Fungi

Persistence of *Beauveria bassiana*

- Endemic + clover

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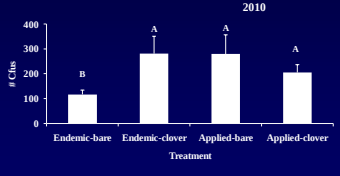
Endemic w/o clover

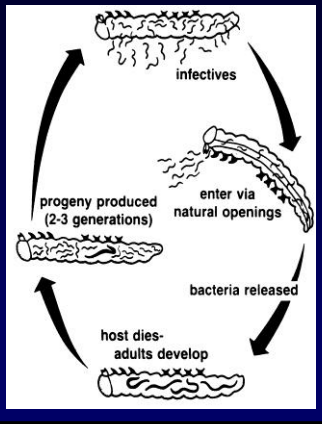


Shapiro-Ilan et al., 2012. Environmental Entomology

Entomopathogenic Nematodes
Steinernematidae & Heterorhabditidae

Entomopathogenic Nematodes (aka "Beneficial" Nematodes") are Safe Bio-insecticides

- Unlike plant parasitic nematodes, entomopathogenic nematodes only attack insects (but they can sometimes suppress plant nematodes indirectly)
- Entomopathogenic nematodes generally do not harm beneficial insects; phoretic relationships have been documented (e.g., Shapiro et al 1993 J. Nematol.)



Some Current Commercial Targets:

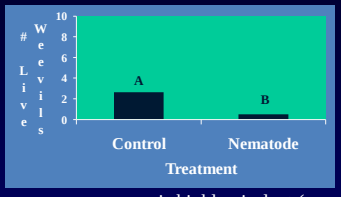
- Citrus root weevils, e.g., *D. abbreviatus*
- Black vine weevil *Otiorhynchus sulcatus*
- Fungus gnats (Sciaridae)
  - Mole crickets, *Scapteriscus* spp.
- White grubs (Scarabaeidae)
- Small hive beetle, *Aethina tumida*

  WFT, *Frankliniella occidentalis*
- Codling moth, *Cydia pomonella*
- Cranberry girdler, *Chrysoteuchia topiaria*
- Also, billbugs, cutworms, fleas , shore flies, etc.

General Considerations for Applying Beneficial Nematodes

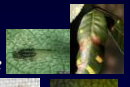
- Nematodes can be stored but generally under refrigeration (40-50 F/4-10C), depends on species
- Shelf-life generally several weeks to few months, depend on nematode species & formulation type
- Just strain or mix with water & go!
- Apply using standard spray equipment or via irrigation
- Remove filters & fine screens if possible
- Desiccation sensitive, so irrigate before and after!
- Avoid UV light and oxygen deprivation
- Optimum temperatures 68-84 F (but some are more flexible)

Suppression of Pecan Weevil Prior to Emergence



- *Steinernema carpocapsae* is highly virulent (especially to adult weevils)
  - Applied *S. carpocapsae* 3X per yr (25 per cm^2 minimum)
    - Less than 1% weevil survival in treated pots after 2 yrs
  - Lots of natural mortality (as expected); nematode provide 81% additional control (Shapiro-Ilan & Gardner, 2012)

Pecan Aphids

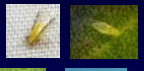


- 3 Species:

black pecan aphid, *Melanocallis caryaefoliae*

blackmargined aphid, *Monellia caryella*

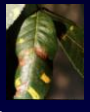
yellow pecan aphid, *Monelliopsis pecanis*

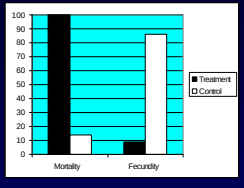


- Conserve natural enemies!

- Cover crops (e.g., clover, sesbania), molasses sprays can enhance natural enemies (Bugg & Dutcher 1993, Dutcher et al. 1999).

Pecan Aphids: Curative Controls





- Fungus, e.g., *Isaria fumosorosea* shows promise (Shapiro-Ilan et al., 2008)
- Showed virulence to all 3 pecan aphids species:

- Soaps, oil, neem products may have some efficacy

- See: http://web.pppmb.cals.cornell.edu/resourceguide/ (a good overall guide)

- Plant growth regulators, i.e., gibberellins, reduce development of black pecan aphids (Cottrell et al., 2009; 2010)

Lepidoptera Pests

- Pecan nut casebearer, *Acrobasis nuxvorella*
  - young larvae tunnel into young shoots & feed on nutlets; monitor with pheromones (by mid-April)
  - visit Pecan IPMPIPE
  - Apply control if 3% of nut clusters damaged

- Hickory shuckworm, *Cydia caryana*
- Feed on nut beginning early June, overwinters in shuck
- Check dropped nuts June & July; apply control if needed
- Destroy old shucks

Control of Lepidopteran Pests

- Bt (*Bacillus thuringiensis*) products have been registered/recommended for control of pecan nut casebearer, fall webworm, and walnut caterpillar, *Datana integerrima* (von Broembsen & Mulder, 2004; Knutson and Ree, 2004)

- However, Bt products tend to have relatively short residual times, and therefore careful timing of sprays is necessary

- Spinosad based products (e.g., Entrust®) derived from the naturally occurring soil bacterium, *Saccharopolyspora spinosa*
- Is effective in controlling pecan nut casebearer and hickory shuckworm, e.g. 100% suppression of PNC & 60-80% suppression of shuckworm (Dutcher and Hudson, 2003)

- Also registered for use against the fall webworm and walnut caterpillar

Stink bugs

- Brown stink bug, *Euschistus servus*
- The green stink bug, *Acrosternum hilare*
- Southern green stink bug, *Nezara viridula*

- Trap crops can reduce stink bugs in the orchard
  - http://nfrec.ifas.ufl.edu/MizellRF/stink_bugs/bug_trap_crops.htm
  - Russ Mizell webinar on eOrganic
  - Tillman et al. 2009, Environmental Entomology
  - Mixed host species, e. g, crimson clover and vetch, sorghum, millet, buckwheat, and sunflower (Mizell, eOrganic)

Note – some stink bugs are good guys

Suppression of Key Peach Pests with Organic Approaches

D. Shapiro-Ilan[1], T. Cottrell[1],
R. Mizell[2], Tracy Leskey[3], & D. Horton[4]
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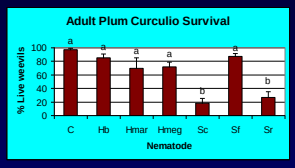
[2]University of FL
[3]USDA-ARS: Kearneysville, WV
[4]University of GA

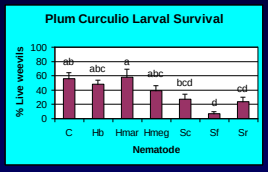
Plum Curculio, *Conotrachelus nenuphar*

- Key pest in stone fruits (e.g., peach, plum, cherries)
- Also a major pest in pome fruits (e.g., applies, pears)
- Adult = damaging stage
- Fruit drop => larvae develop in soil
- Adults overwinter in and around orchard
- Potential options: Surround®, Pyganic®, hogs (Grieshop et al. http://www.treefruit.msu.edu/extension/CAT/25_4.pdf
- Nematodes (Shapiro-Ilan et al. 2002, 2004, 2008; Alston et al. 2005; Pereault et al. 2009)

Plum Curculio – Initial Screening (lab)

Shapiro-Ilan, Mizell & Campbell 2002 J. Nematol.





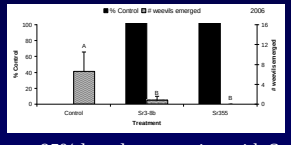
Critical to choose the best nematode for each pest!
For plum curculio we found most promise in Sc & Sr Vs. adults;
And Sf & Sr Vs. larvae

Plum Curculio, *Conotrachelus nenuphar*

- Larval control with Sr is highly efficacious!
- Problem? = adult is the damaging stage and large numbers can potentially enter from external overwintering sites (Jenkins et al. 2006 Env. Ent)
- Solution =

Set up trap crops/sentinel trees

And develop integrated program targeting each stage (Leskey et al)



>95% larval suppression with Sr (Shapiro-Ilan et al. 2004, 2008) (81-88%, Pereault et al. 2009)

Integrated Program for Control of Plum Curculio

Leskey, Shapiro-Ilan, Zhang, Wright et al

- Attract insects to trap trees on the border of orchards (trap trees in red)
- Apply curatives if possible…
- Some fruit drop is anticipated…so then apply EPNs to the soil to kill larvae and protect the crop
- Optimize nematode for soil and temperature (Shapiro-Ilan et al., 2012 J. Nematol.)

Borers Attacking Peach

Peachtree Borer (PTB)

Synanthedon exitiosa (Lepidoptera: Sesiidae)

- Larval feeding occurs at or below soil level on the trunk and roots
- Highly damaging pest, especially to young trees

Control of Peachtree Borer with Entomopathogenic Nematodes

- **High levels of control** with *S. carpocapsae* Vs. young and mature larvae (88-100%), can be preventative or curative!
- Curative: apply to soil at base of tree in spring (300,000 nematodes per tree) (Cottrell and Shapiro-Ilan, 2006)
- Preventative: Apply 3X during egg-laying period (Shapiro-Ilan et al. 2009)
- **Promises to be very economical** (relative to other nematode applications) – 0.075 to 0.15 billion IJs per ha per application! (many commodities require >10x that amount)
- Some adoption initiated.
- Future research: Larger scale field tests, varying times, type, & rates of application

Summary/Research Needs

Pecan

Pecan weevil: Beneficial nematodes & fungi (& use clover)
Aphids: Conserve natural enemies, some curatives if needed
Lepidoptera: monitor and use spinosad-based products (or Bt)
Stink bugs: trap crops

Peach

Plum curculio: beneficial nematodes, *S. riobrave* is best
Peachtree borer: beneficial nematodes, *S. carpocapsae* is best

Research Needs: Optimize existing tactics, find new biological approaches that work, improve conservation!

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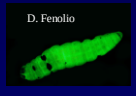

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