

Management of Selected Pests in Walnuts

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Focus on these pest species

Codling Moth



Pacific Flatheaded Borer



Direct Pests

Walnut Husk Fly



Indirect Pests

Tenlined June Beetle



Codling Moth

Cydia pomonella

- Major pest of walnuts
- Three generations per year
- Overwinters as mature larvae in cocoons
- Spring moth emergence coincides with leafing out of early walnut varieties
- Eggs laid on leaves, larvae bore through the blossom end into the nutlet
- Completion of one generation from egg to egg requires about 1,000 Degree-Days when temperatures are between 50 and 88°F.



Codling Moth

Cydia pomonella

- Newly hatched larvae of the second generation bore in anywhere on the husk surface
- They penetrate the shell to feed on the developing nutmeat
- Some of these larvae will not emerge with the remainder of the 2nd generation, but remain until the following spring
- The other larvae complete development and emerge as adults in late July and early August



Codling Moth

Cydia pomonella

- In most of the Central Valley, a 3rd generation will be produced
- Mature larvae of this generation leave the nuts and spin up cocoons on the trees or in debris to overwinter
- Damage from the larvae varies with the generation
- Nuts infested by the 1st generation typically drop off
- A second peak of moths from the overwintered generation could damage nuts that remain on the tree
- Nuts attacked by the 2nd and 3rd generation larvae are unmarketable due to damage to the kernel



Codling Moth

Management Options

- Biological control

Usually not effective

- Mating Disruption

Can be effective where CM populations are low and no uncontrolled CM populations are nearby

- Insecticidal Control

Monitor with pheromone traps to determine optimal timing for chemical treatments. Use DD estimates.



Codling Moth

Insecticidal Control

Various products examined



Warrior (Lambda-cyhalothrin)

Delegate 25WG (Spinetoram)

Altacor 35WG (Rynaxypyr™)

Belt 4SC (Flubendiamide)

Lorsban (Chlorpyrifos)

Leverage 2.7EC (Imidacloprid + Cyfluthrin)

Proclaim 5SG (Emamectin Benzoate [Avermectin BI])

Acetamiprid (Alpha Cypermethrin [Neonicotinoid])

Codling Moth

Insecticidal Control

Various products examined



Warrior (Lambda-cyhalothrin)

Delegate 25WG (Spinetoram)

Altacor 35WG (RynaxypyrTM)

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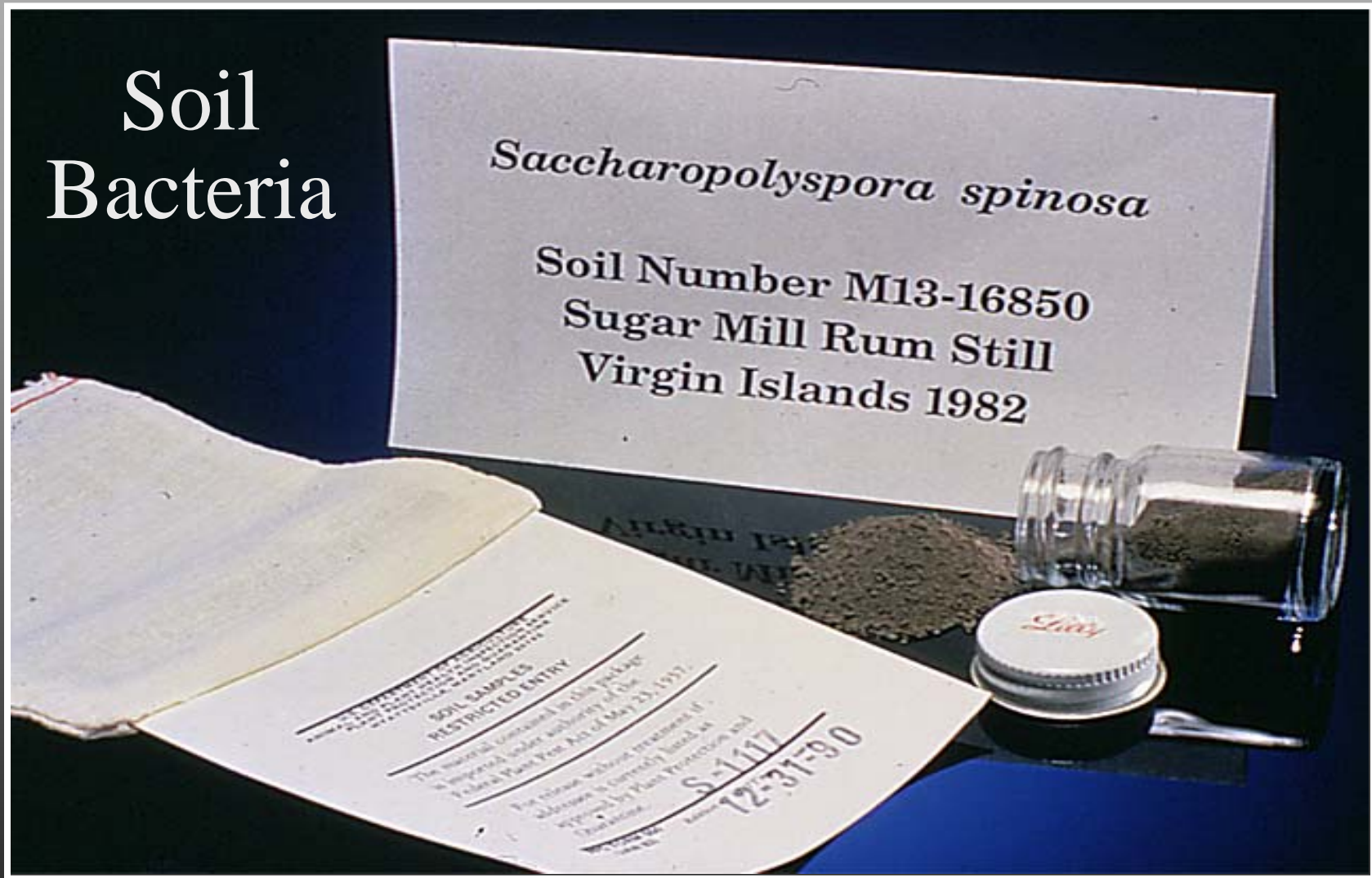
Acetamiprid (Alpha Cypermethrin [Neonicotinoid])

Origins of Spinosad



Origins of Spinosad

Soil
Bacteria



Delegate 25WG

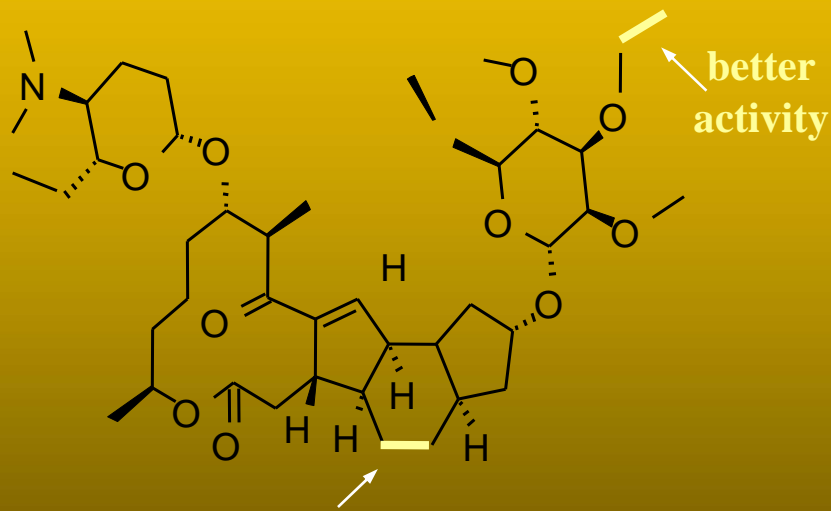
New mode of action

Spinetoram excites the insect's nervous system by altering the function (excitation) of the nicotinic ACh and GABA receptors. Spinetoram is not effected by modes of detoxification of other insecticides.

“Avoid use of the same active ingredient or mode of action (same insecticide group) on consecutive generation of insects. However, multiple applications to reduce a single generation are acceptable.”

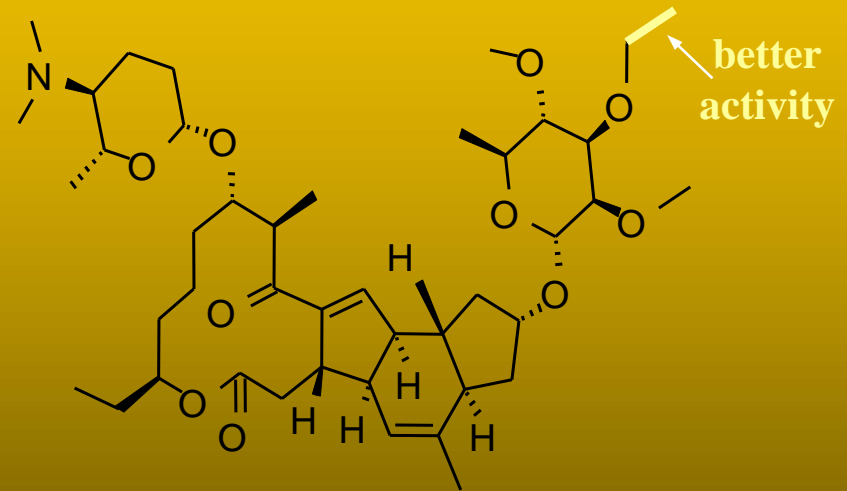
Spinetoram [Delegate 25WG]

Major component



more photostable

Minor component



Chemical **modification of spinosyn** that resulted in increased photostability and improved efficacy

Codling Moth

Insecticidal Control

Various products examined



Warrior (Lambda-cyhalothrin)

Delegate 25WG (Spinetoram)

Altacor 35WG (Rynaxypyr™)

Belt 4SC (Flubendiamide)

Lorsban (Chlorpyrifos)

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Acetamiprid (Alpha Cypermethrin [Neonicotinoid])

Altacor 35WG

New mode of action

Anthranilic Diamide is derived from *Ryania speciosa*, a native American tropical plant

Rynaxypyr™ = chlorantraniliprole

Rynaxypyr activates the insects ryanodine receptors causing a release of stored calcium in the muscle. Rynaxypyr has a greater affinity for insect receptors compared to mammalian receptors.

“Make no more than three successive applications per generation on the same insect species on a crop. The following application(s) to the target pest in the next generation must be with an effective product with a different mode of action.”

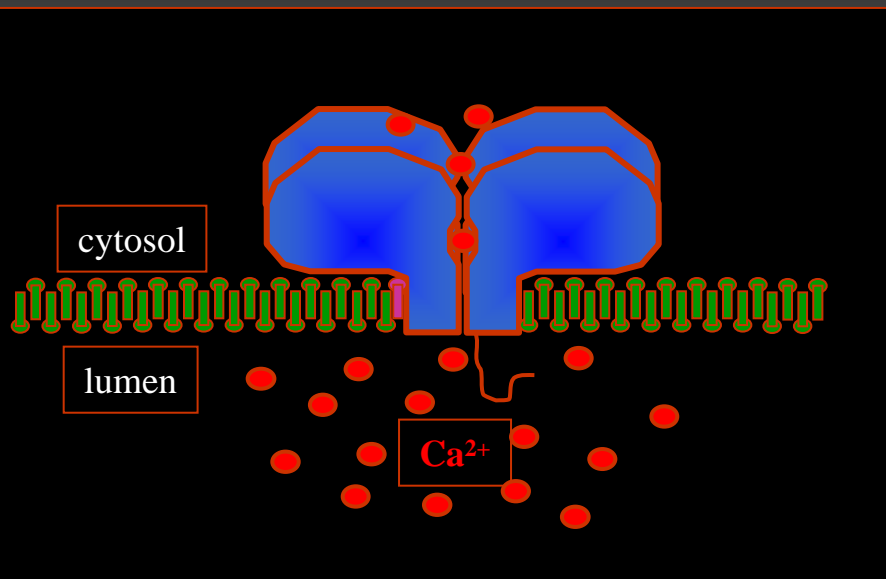
DuPont™ RynaXypyr™ Novel Mode of Action

Activates Insect Ryanodine Receptors

Ryanodine Receptor:



Plays a critical role in
muscle contraction



RynaXypyr™:

Rynaxypyr binds to this
receptor, causing uncontrolled
release of calcium,
to the point of depletion
Result: muscle paralysis

Codling Moth

Insecticidal Control

Various products examined



Warrior (Lambda-cyhalothrin)

Delegate 25WG (Spinetoram)

Altacor 35WG (Rynaxypyr™)

Belt 4SC (Flubendiamide)

Lorsban (Chlorpyrifos)

Leverage 2.7EC (Imidacloprid + Cyfluthrin)

Proclaim 5SG (Emamectin Benzoate [Avermectin BI])

Acetamiprid (Alpha Cypermethrin [Neonicotinoid])

Methods

CM Trials in Hollister and Tracy

- ❖ All treatments replicated 4 times
- ❖ Single tree applications
- ❖ Applied using hand-held orchard sprayer at 250 psi & 250 gal/ac
- ❖ Inspected 400-500 fruit per treatment

CM Efficacy in Walnuts 2005

Treatment	Rate/ac	No. Appl.	% Infestation
Delegate 25WG	4.5 oz	4	1.0 a
Delegate 25WG	6.0 oz	4	0.5 a
Altacor 35WG	2.0 oz	4	2.0 a
Altacor 35 WG	4.0 oz	4	0.5 a
Warrior	2.5 oz	4	0.0 a
Warrior	5.0 oz	4	0.0 a
Grower standard		4	0.8 a
Untreated check			22.5 b

CM Efficacy in Walnuts 2007

Treatment	Rate/ac	No. Appl.	% Total
Delegate 25WG	4.8 oz	2	0.2 a
Delegate 25WG	6.4 oz	2	0.2 a
Altacor 35WG*	3.0 oz	2	0.8 ab
Altacor 35WG	3.0 oz	2	0.2 a
Altacor 35WG	4.0 oz	2	0.2 a
Grower standard		2	2.4 b
Untreated check			6.2 c

*Treatment includes 0.25% PureSpray Green horticultural oil volume to volume.

CM Efficacy in Walnuts 2008

– Hollister –

Treatment	Rate/ac	No. Appl.	% Total
Delegate 25WG	3.2 oz	3	0.8 a
Delegate 25WG	4.8 oz	3	0.4 a
Delegate 25WG	6.4 oz	3	0.8 a
Altacor 35WDG*	3.0 oz	3	0.0 a
Altacor 35WDG*	4.0 oz	3	0.4 a
Belt 4SC	5.0 oz	3	0.5 a
Leverage 2.7SE	5.1 oz	3	0.3 a
Grower standard		3	0.0 a
Untreated check			2.6 b

*Treatment includes 0.5% PureSpray Green horticultural oil volume to volume.

CM Efficacy in Walnuts 2008

– Tracy –

Treatment	Rate/ac	No. Appl.	% Total
Delegate 25WG	3.2 oz	3	0.2 a
Delegate 25WG	4.8 oz	3	0.4 a
Delegate 25WG	6.4 oz	3	0.6 a
Grower standard		2	0.0 a
Untreated check			4.6 b

CM Efficacy in Walnuts 2008

- Tracy -

Treatment	Rate/ac	No. Appl.	% Total
Proclaim 5SG*	3.2 oz	3	1.0 a
Proclaim 5SG*	4.0 oz	3	0.2 ab
Warrior II 2CS*	1.6 oz	3	0.2 ab
Warrior II 2CS* + Proclaim 5SG	1.6 oz 3.2 oz	3	0.0 a
Grower standard		2	0.0 a
Untreated			4.6 b

*Treatment includes 0.25% Dyne-Amic volume to volume.

Conclusions



- ❖ Delegate, Altacor, Belt, Warrior, and Proclaim all provided excellent control of Codling Moth
- ❖ A grower can now apply Delegate, Warrior, Proclaim or other effective insecticides for one Codling Moth generation and Altacor or Belt for the following generation

Acute Toxicity of Three Insecticides in Acidic Solution for Adult CM control

Codling Moth

Insecticidal Control

Various products examined



Warrior (Lambda-cyhalothrin)

Delegate 25WG (Spinetoram)

Altacor 35WG (Rynaxypyr™)

Belt 4SC (Flubendiamide)

Lorsban (Chlorpyrifos)

Leverage 2.7EC (Imidacloprid + Cyfluthrin)

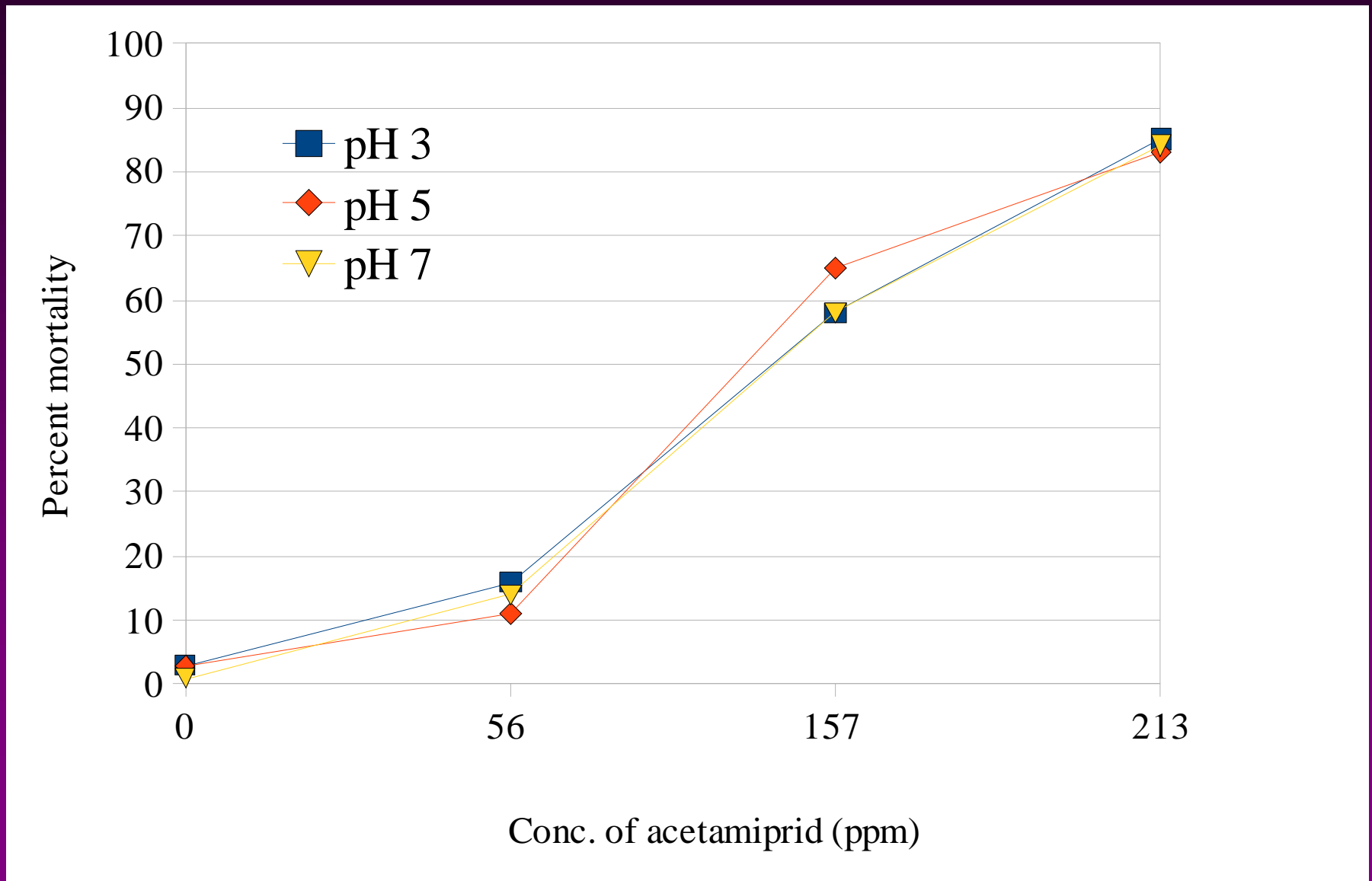
Proclaim 5SG (Emamectin Benzoate [Avermectin BI])

Acetamiprid (Alpha Cypermethrin [Neonicotinoid])

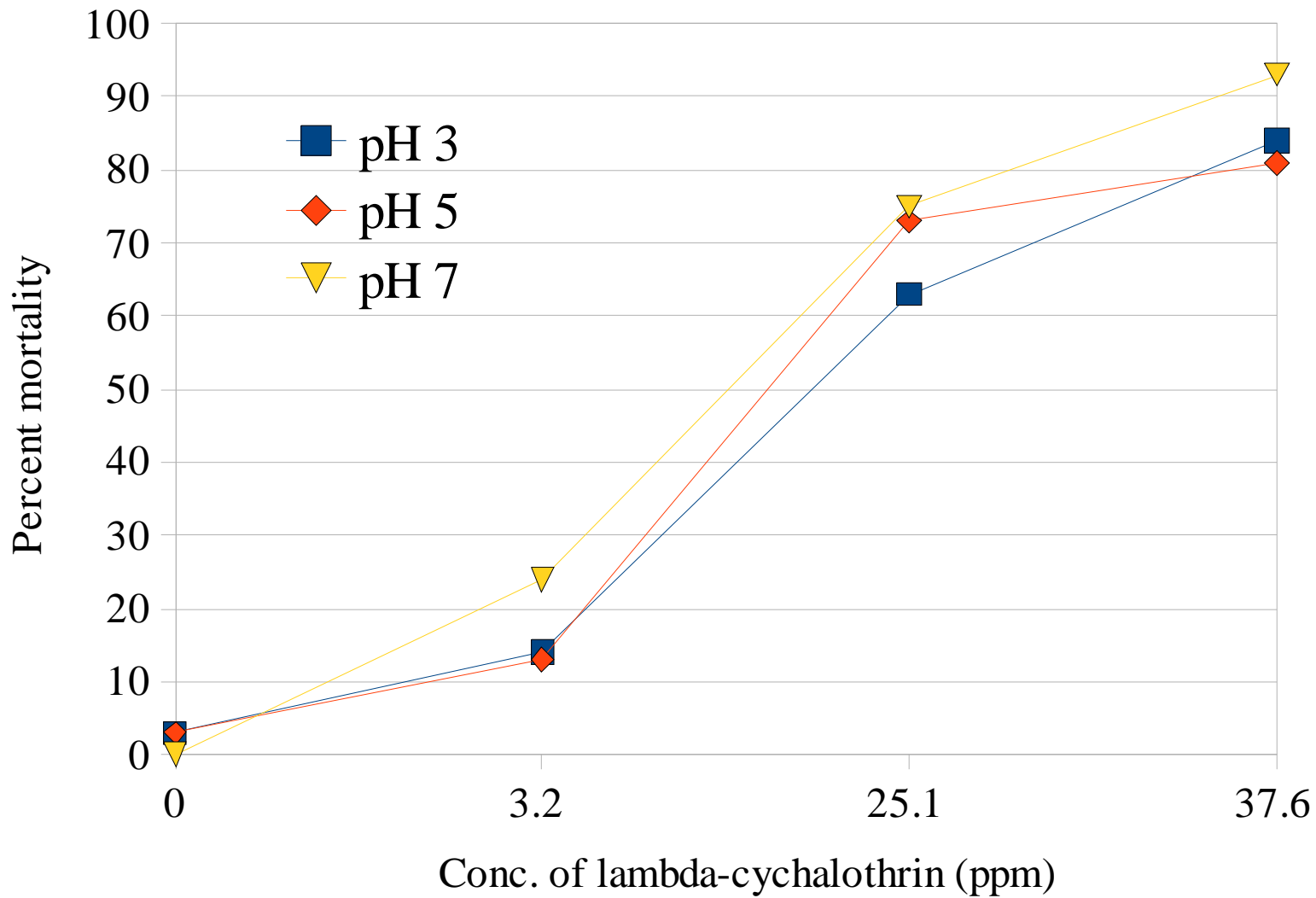
Methods - Adult Mortality

- ❖ Three rates of acetamiprid, chlorpyrifos, and lambda-cyhalothrin in solutions of pH 3, 5 and 7
- ❖ 2 μL /adult, 10 adults per rep, 8 reps per conc.
- ❖ Latron B-1956 at 0.25% v/v was used to break surface tension, allow penetration of CM scales

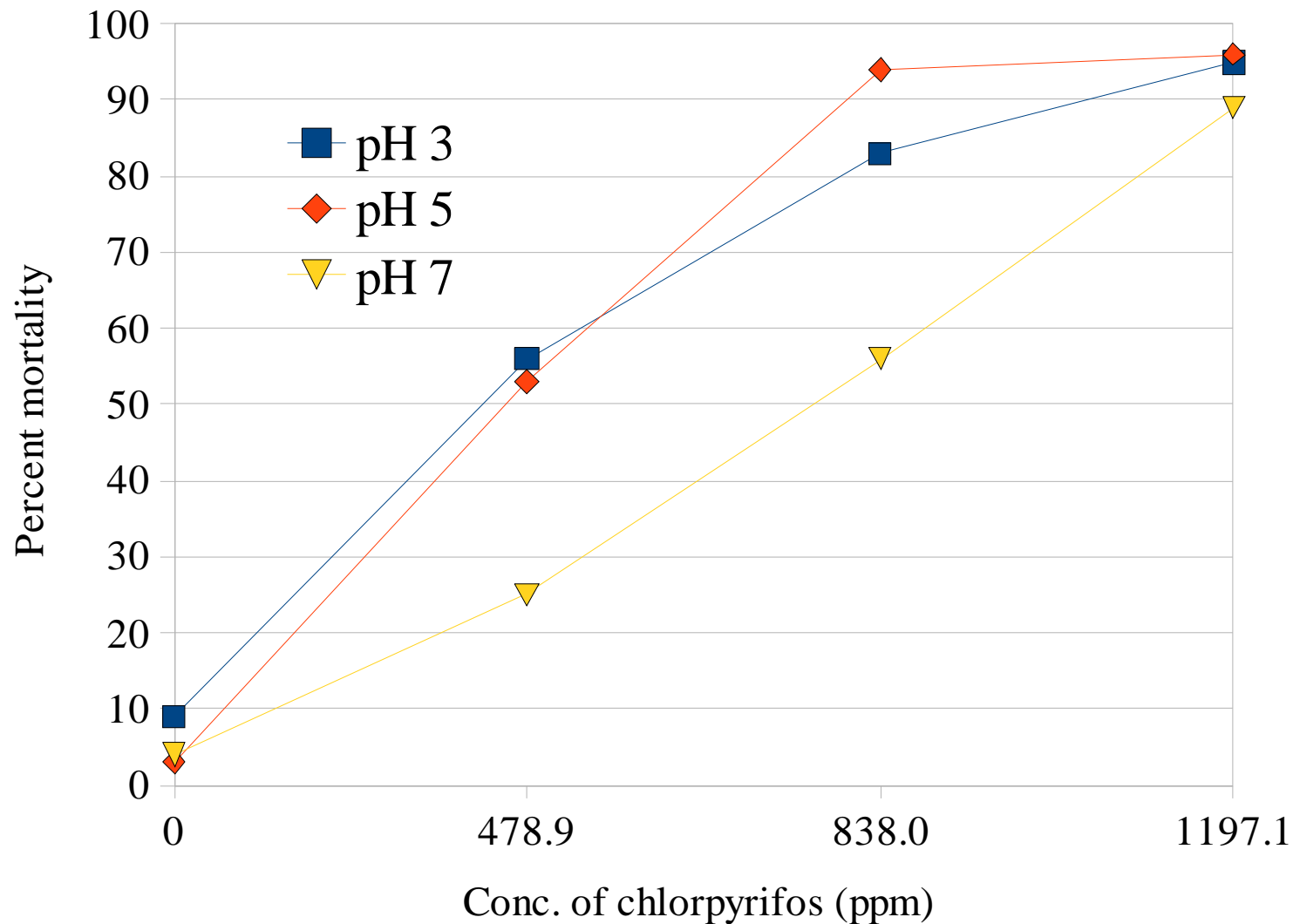
CM Adult Mortality: Acetamiprid @ pH 3, 5 & 7



CM Adult Mortality: Lambda-Cyhalothrin @ pH 3, 5 & 7



CM Adult Mortality: Chlorpyrifos @ pH 3, 5 & 7



Conclusions

- ❖ For chlorpyrifos, pH 3 and pH 5 levels resulted in significantly greater mortality than pH 7 at conc. of 479 and 838 ppm
- ❖ For both lambda-cyhalothrin and acetamiprid, no significant difference in mortality among any pH levels

Focus on these pest species

Codling Moth



Pacific Flatheaded Borer



Direct Pests

Walnut Husk Fly



Indirect Pests

Tenlined June Beetle



Walnut Husk Fly

- This fly is a member of the insect family Tephritidae
- One generation per year
- WHF overwinters as pupae in the soil
- Emergence is from June through September with a peak in numbers in July and August
- Adult females must feed on carbohydrate and nitrogen food sources before they can lay eggs
- An individual female will lay 10 to 20 eggs in the husk
- There are three larval instars (white to yellow in color)
- Mature larvae drop to the ground to pupate



Walnut Husk Fly

Summer



Early
Summer



Fall

Statewide IPM Project
2000 Regents, University of California

Walnut Husk Fly

Damage to Walnuts



Walnut Husk Fly

Monitoring Populations



Walnut Husk Fly

Insecticidal Control

Various products examined



Bait sprays vs. No bait

Assail 30SG (Acetamiprid)

Delegate 25WG (Spinetoram)

Altacor 35WGD (Rynaxypyr™)

Provado 1.6F (Imidacloprid)

HGW86 10SE (Cyantraniliprole = Cyazpyr™)

Methods - Field Efficacy

- ❖ Treatments applied with hand-gun orchard sprayer at about 250-300 gal/ac
- ❖ Three applications applied at three week intervals
- ❖ Evaluations of 100 nuts per replicate on two dates

WHF Efficacy in Walnuts 2008

Treatment	Rate/ac	No. Appl.	% Total
Assail 30SG ^a	8.0 oz	3	0.0 a
Delegate 25WG ^b	3.2 oz	3	8.0 ab
Provado 1.6F ^a	7.0 oz	3	12.0 b
Altacor 35WDG ^b	4.0 oz	3	29.0 c
Provado 1.6F ^{ab} + Delegate 25WG	7.0 oz 3.2 oz	3	4.0 ab
Assail 30SG + Delegate 25 WG	8.0 oz 3.2 oz	3	2.0 a
Untreated		3	24.0 c

^aTreatment includes 0.25% Dyne-Amic volume to volume.

^bTreatment includes 3 pt NuLure

WHF Efficacy in Walnuts 2009

Treatment	Rate/ac	No. Appl.	% Total
Assail 30SG ^{ab}	8.0 oz	3	3.5 a
Assail 30SG ^b	6.4 oz	3	3.8 a
Assail 30SG ^a	6.4 oz	3	2.0 a
Assail 30SG ^{ab}	4.0 oz	3	3.2 a
Provado 1.6F ^{ab}	7.0 oz	3	3.5 a
Treated check ^{ab}		3	40.3 b

^aTreatment includes 0.5% Dyne-Amic volume to volume.

^bTreatment includes 3 pt NuLure

WHF Efficacy in Walnuts 2009

Treatment	Rate/ac	No. Appl.	% Total
HGW86 10SE	16.9 oz	3	17.5 ab
HGW86 10SE ^a	16.9 oz	3	17.3 ab
HGW86 10SE ^{ab}	16.9 oz	3	10.5 a
Altacor 35WDG ^a	4.0 oz	3	30.8 bc
Altacor 35WDG ^b	4.0 oz	3	16.3 ab
Delegate 25WG ^{ab}	6.4 oz	3	33.8 bc
Treated check ^{ab}		3	40.3 d

^aTreatment includes 0.5% Dyne-Amic volume to volume.

^bTreatment includes 3 pt NuLure

Conclusions

- ❖ Neonicotinoid insecticides (Assail and Provado) provided excellent control of WHF
- ❖ Inclusion of NuLure or Dyne-Amic did not improve efficacy
- ❖ Altacor, HGW86, and Delegate provide marginal or no control
- ❖ Inclusion of NuLure did improve efficacy with Altacor and HGW86

Focus on these pest species

Codling Moth



Pacific Flatheaded Borer



Direct Pests

Walnut Husk Fly



Indirect Pests

Tenlined June Beetle



Pacific Flatheaded Borer

- *Chrysobothris mali* is a beetle whose immature stages are found within the limbs, scaffolds, and trunks of trees
- This insect usually attacks weakened or stressed trees that have been injured by sunburn, frost, or plant diseases
- Females are attracted to injured wood and lay their eggs on bark, usually near pruning wounds or on weakened limbs exposed to the sun
- When the eggs hatch, the larvae bore through the bottom of the egg straight into the wood
- Larvae feed in the cambium layer, and when mature they bore into the wood to construct a pupal chamber or they pupate under the tree's bark



Pacific Flatheaded Borer

- Full grown larvae have characteristic large, flattened segments just behind the head
- There is only one generation per year
- Adults emerge over a prolonged period so larvae in an area may be many different sizes at any one time
- Water soaked areas develop on the bark at larval feeding sites, and eventually the bark splits revealing frass-filled galleries
- Newly planted trees are highly susceptible to serious damage and can be easily girdled by feeding larvae
- Larvae rarely kill large trees



Pacific Flatheaded Borer



Pacific Flatheaded Borer

Management Options



- Curative options are limited
- With this insect, an ounce of prevention is worth a pound of cure
- Early research did not support the use of insecticide applications for management of this pest
- Damage can be minimized by maintaining healthy trees and preventing sunburn
- For newly planted trees, use tree wraps or paint them with water-based white latex paints (1 part paint & 1 part water)
- Apply paint to the trunk and cover the area 1 inch below the soil line up to the scaffold crotch

Pacific Flatheaded Borer

Management Options



- Prune trees such that the scaffold remains shaded
- Apply paint mixture to older tree limbs to prevent sunburn
- Pruning, topping, or girdling trees in spring or summer can predispose them to flatheaded borer attack
- If borer injury is found, prune out and destroy affected branches or trees
- Remove or destroy pruned limbs & branches before bloom to help prevent re-infestation of the orchard
- Borer injury weakens trees and makes them attractive to other species of wood borers

Focus on these pest species

Codling Moth



Pacific Flatheaded Borer



Direct Pests

Walnut Husk Fly



Indirect Pests

Tenlined June Beetle



Tenlined June Beetle

- This species is native to the western USA
- It is typically found in dry, sandy soils
- Very little is known about this insect compared to most of the pest species attacking nut and orchard crops in California
- This pest only attacks the roots of its host plants
- Its host range includes walnuts, almonds, cherries, plums, and other trees
- It has a two-year developmental cycle in California
- Its presence is often detectable from the pencil diameter emergence holes at the base of its host trees
- Research is underway to refine methods for its control





Tenlined June Beetle Life Stages



Injury to roots can be serious. Third instar grubs can be found damaging large roots over 5 feet below the soil surface.



22 Dec 2004

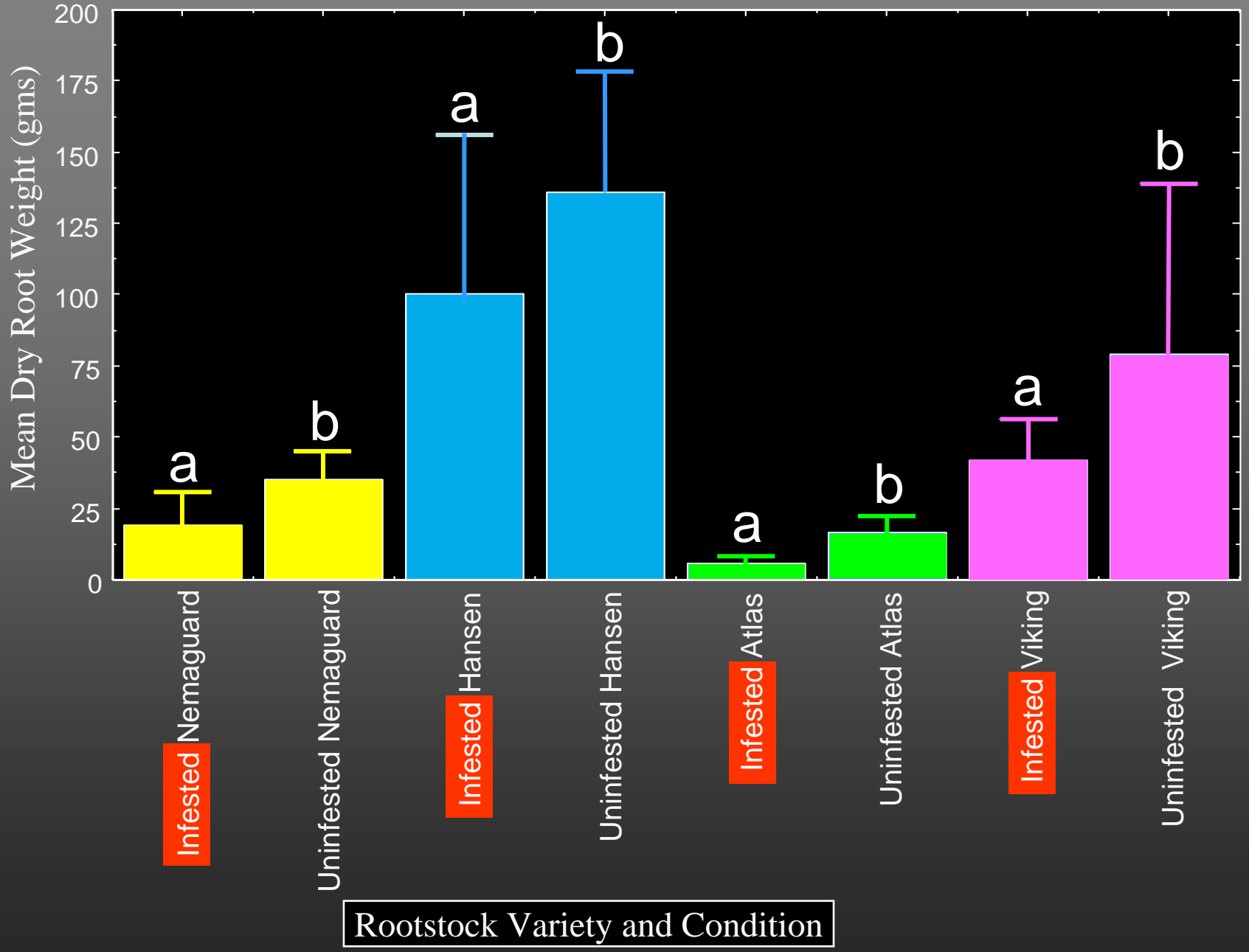


3rd instar TLJB grubs introduced to soil on 11 January 2005

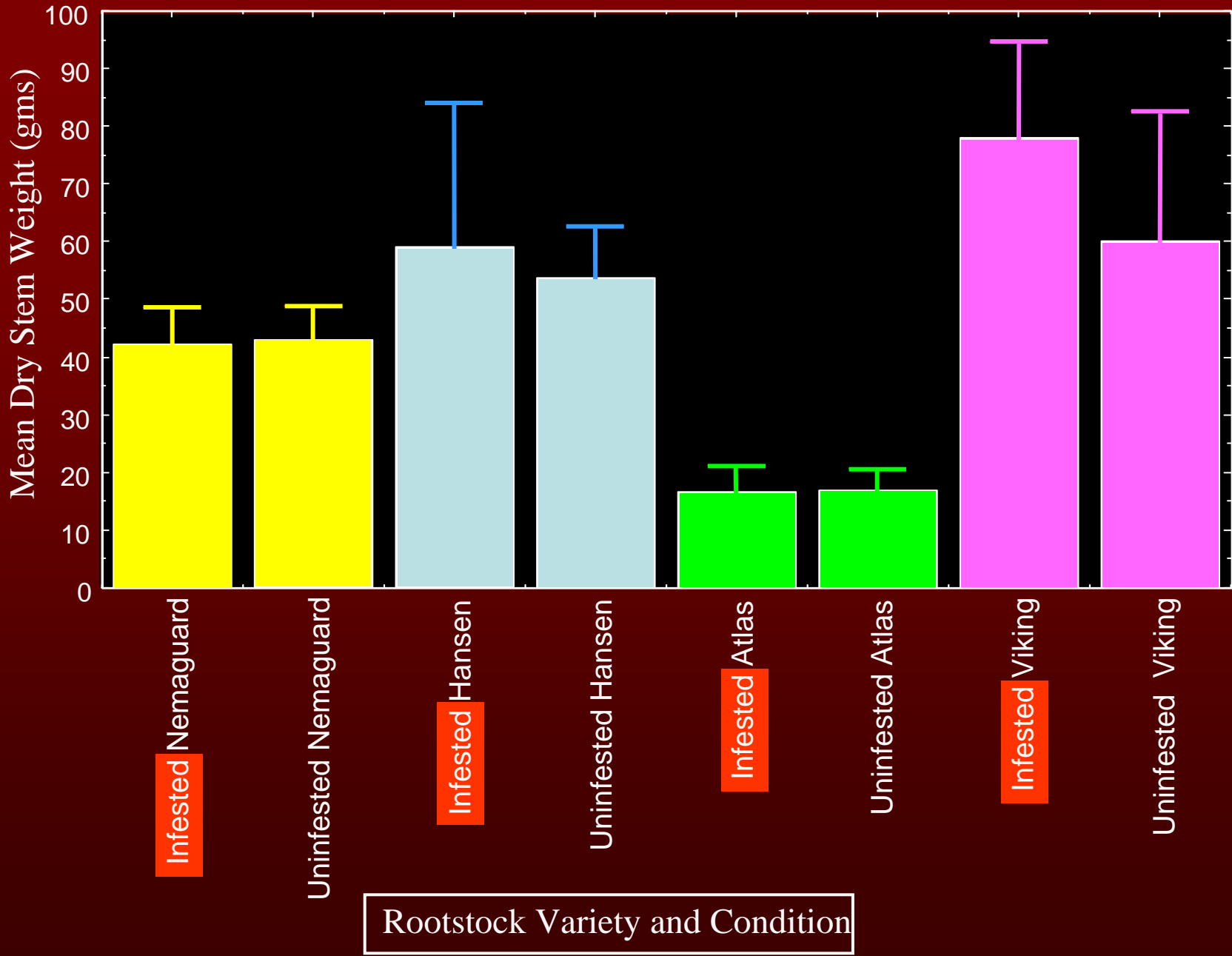
24 Mar 2005

Viking rootstock before and after 60 days of 20 TLJB grubs feeding

IMPACT ON ROOTS



IMPACT ON STEMS



Current UC Recommendations

- Remove infested trees and fumigate soil before replanting
- Inspect roots of infested trees for live larvae or larval feeding injury
- Remove all trees in the infested area plus one or two uninfested trees on all sides of the infested area
- Fumigate soil and replant

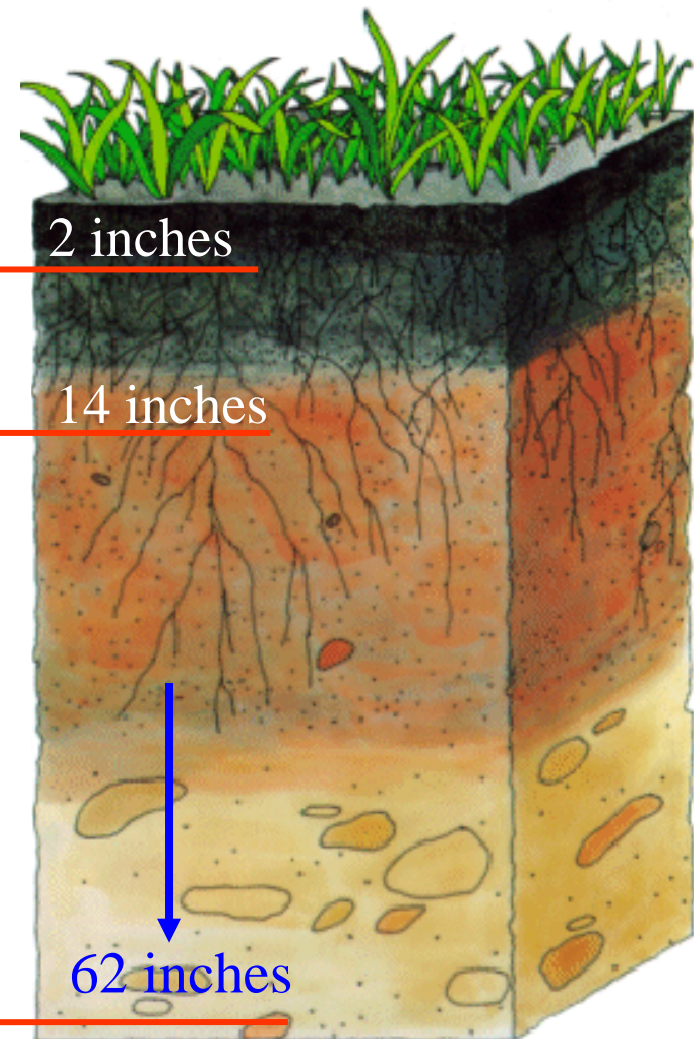


Challenges to Managing TLJB

Most TLJB grubs found within this level where the almond roots are

Toxic materials or pathogens must penetrate more than 14 inches or more to kill most TLJB grubs. **1 inch of water is needed to deliver toxins one foot deep.**

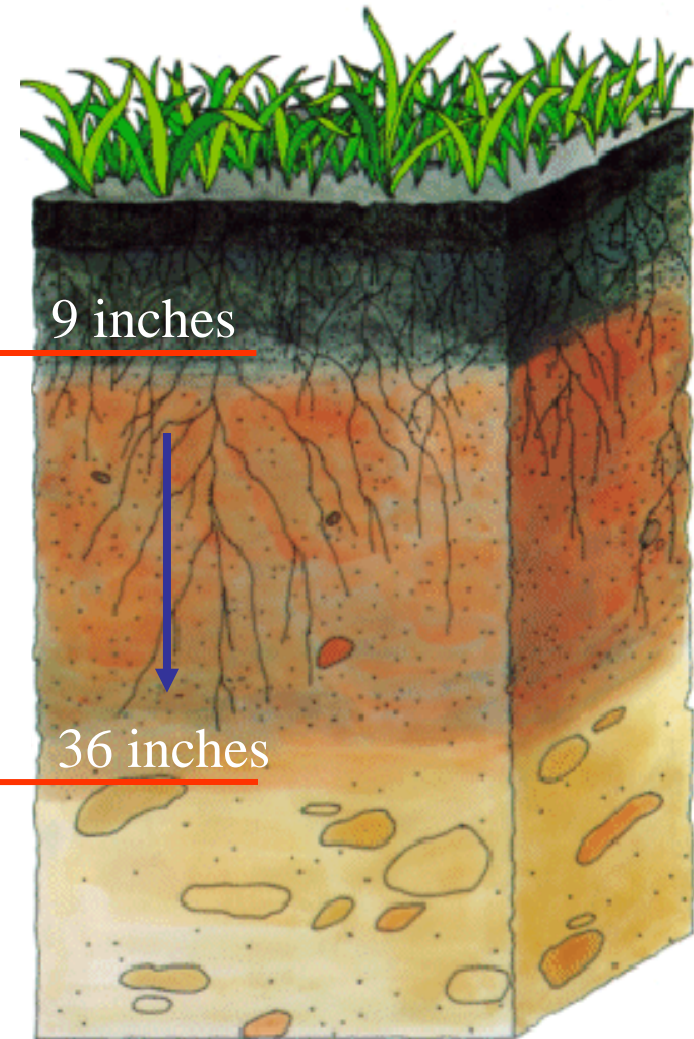
Large grubs may be this far down



Challenges to Managing TLJB

In the lab, we have killed TLJB grubs to this depth in soil columns

We are targeting suppression at 36 inches below the soil surface. This will require additional irrigation to move the insecticide down.



Soil Column

Because of the difficulty in locating grubs in the soil and the number of tests needed to determine effective insecticidal compounds as well as methods to facilitate penetration of the soil strata, laboratory methods were developed as an initial step in TLJB investigations instead of going straight to the field.

We continue to refine our soil column techniques for ease and repeatability. Our initial columns were about 10 inches in depth and divided into sections of about 3 inches each. We have now designed a column that will be 36 inches in depth.



Moving Imidacloprid through the soil / Methods

- Previously imidacloprid (Admire® 2, 21% a.i.) was tested at a concentration of 0.5 ml Admire in 1000 ml water. Two amounts of imidacloprid solution were used: 250 ml and 500 ml in the column
- Four soil depths were tested: 0 – 2 inches; 2 – 4 inches; 4 – 6 inches; and 8 – 10 inches
- Soil columns were made of 15 cm diameter PVC irrigation pipes that were cut into various lengths (7.5, 12.5, and 22.5 cm = ca. 3 inches; 5 inches; and 9 inches)
- Sandy soil (ca. 90% sand) was used
- Prior to treatment, the water in the soil was brought to field saturation capacity
- The insecticide was added very slowly to the column to ensure that the solution penetrated the soil rather than ran down the interior wall of the column
- The insecticide was allowed to penetrate the soil column for 24 hours, and was then disassembled to allow collection of samples of ca. 1 lb of treated soil from different column depths
- With respect to each soil depth, the collected soil was mixed and then set up in a test container to which a 3rd instar TLJB grub was added with a carrot piece
- Grub mortality was checked starting at 2 days post treatment and at 5 day intervals afterwards.

Percentage mortality of TLJB grubs exposed to treated soil with Imidacloprid in soil column tests

Solution (ml)	Soil depth (inches)	N	% Mortality of grubs post-treatment (weeks)							
			1	2	3	4	5	6	>10	
0 (CK)		10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	0-2	6	33.3	50.0	66.7	100.0	100.0	100.0	100.0	100.0
250	2-4	12	25.0	25.0	41.7	41.7	41.7	41.7	41.7	83.3
250	4-6	12	0.0	0.0	0.0	0.0	0.0	0.0	8.3	91.7
250	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3
500	0-2	6	16.7	50.0	66.7	100.0	100.0	100.0	100.0	100.0
500	2-4	12	8.3	75.0	91.7	100.0	100.0	100.0	100.0	100.0
500	4-6	12	0.0	41.7	100.0	100.0	100.0	100.0	100.0	100.0
500	6-10	12	0.0	16.7	16.7	16.7	16.7	16.7	33.3	91.7

Percentage mortality of TLJB grubs exposed to treated soil with Imidacloprid in soil column tests

Solution (ml)	Soil depth (inches)	N	% Mortality of grubs post-treatment (weeks)							
			1	2	3	4	5	6	>10	
0 (CK)		10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	0-2	6	33.3	50.0	66.7	100.0	100.0	100.0	100.0	100.0
250	2-4	12	25.0	25.0	41.7	41.7	41.7	41.7	41.7	83.3
250	4-6	12	0.0	0.0	0.0	0.0	0.0	0.0	8.3	91.7
250	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3
500	0-2	6	16.7	50.0	66.7	100.0	100.0	100.0	100.0	100.0
500	2-4	12	8.3	75.0	91.7	100.0	100.0	100.0	100.0	100.0
500	4-6	12	0.0	41.7	100.0	100.0	100.0	100.0	100.0	100.0
500	6-10	12	0.0	16.7	16.7	16.7	16.7	16.7	33.3	91.7

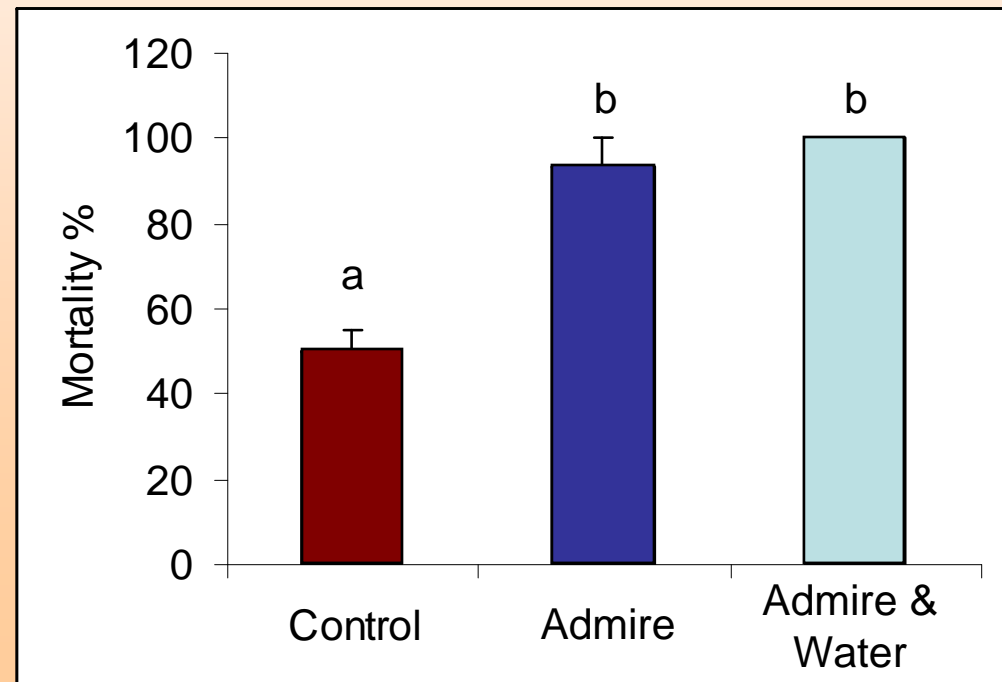
Diazinon treated

Untreated

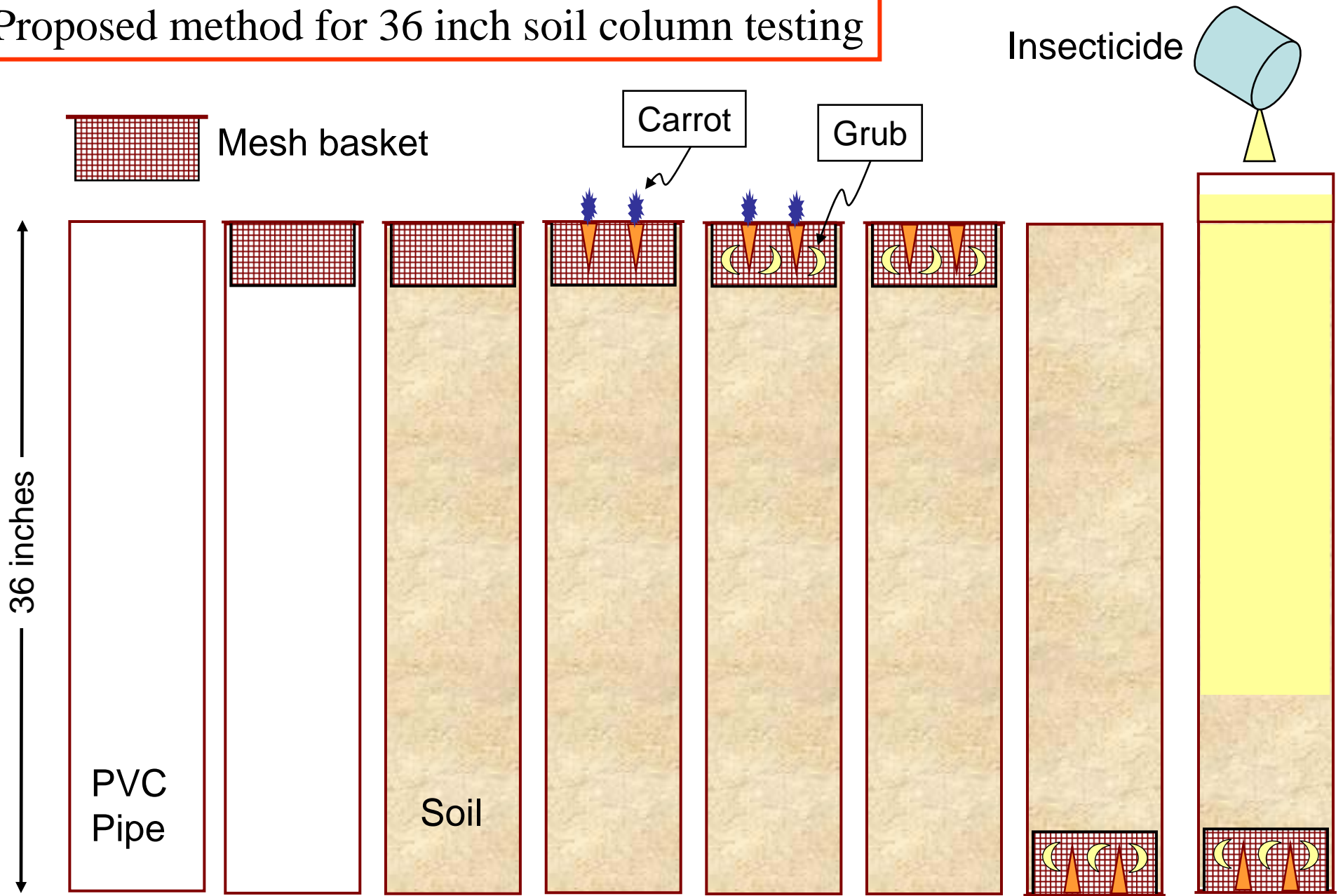


More on Imidacloprid / Methods & Results

- Another test using imidacloprid (Admire® 2, 21% a.i.) was conducted to determine if adding additional water following the initial imidacloprid treatment would be beneficial.
- Two treatments were established using peach plants in pots (9.8 inch diam. X 11.8 inch height) with infestations of 2nd and 3rd instar TLJB grubs.. A concentration 0.65 ml imidacloprid in 1000 ml water was applied at 100 ml of solution per potted plant. One group of plants was only treated with the imidacloprid solution. Another group received the same amount of imidacloprid, but that was followed with one-half inch of water after 24 hours. A check consisted of potted plants with TLJB grubs and 100 ml of water.
- Mortality was checked after 6 weeks.
- Treatments of the soil with imidacloprid caused significantly higher mortality of the grubs ($F = 24.3$, $P < 0.001$). However, the second treatment with one half inch of water being added after the imidacloprid treatment was not significantly different. HOWEVER, in the treatment receiving the post treatment water, all grubs died as compared to the first treatment where only a mean of about 95% of the grubs died.



Proposed method for 36 inch soil column testing



Summary

- In areas where codling moth populations are high, insecticides are commonly needed to produce profitable walnut yields
- Several low-risk insecticides are available currently, but precautions should be taken to reduce the development of insecticide resistance in treated codling moth populations
- Walnut hush fly is a constant problem that must be managed. Assail and Provado provided the best management solution
- Pacific flatheaded borer is best managed via preventative actions aimed at maintaining healthy stress-free and uninjured trees
- Tenlined June beetle continues to plague some areas, but research is underway to develop effective insecticide delivery methods for suppression of underground grub populations

A detailed caricature of an elderly man with a full, grey beard and mustache. He has large, round, round-rimmed glasses and is holding a thin string or cord with his right hand, which is raised towards his face. He is wearing a dark suit jacket, a white collared shirt, and a patterned bow tie. The background is a dark, textured brown. At the bottom of the image, the text "QUESTIONS ANYONE?" is written in a bright green, bold, sans-serif font.

QUESTIONS ANYONE?