

Options for Management of Diaprepes in Florida Citrus

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Before attempting to manage Diaprepes it is important to understand its life cycle.

Citrus is only one of a large number of host plants used by this beetle. Adults feed on young flush which is necessary for egg development. Eggs are laid in adjacent older flush, sandwiched between two leaves. Eggs generally hatch

within 2 weeks and “neonate” larvae drop to the ground where they attempt to dig in and find feeder roots to feed on. Larvae feed on successively larger roots as they develop over a period of from 4 months to a year or more. They pupate in the soil and may emerge in as little as 2 weeks when conditions are favorable, or linger in the soil when they are not.



Targets and Strategies

Control Adults

Broad Spectrum (Sevin, Lorsban)

Control Eggs

Micromite, parasitoids)

Barriers to Neonate Larvae

Brigade, Screen

Control Larvae

Nematodes

Control root rot

Resistant rootstocks, fungicides, water

Each life stage presents opportunities and constraints for control.

- The adult is the most accessible lifestage, and can be controlled with broad-spectrum insecticides.
- Certain growth regulators may sterilize the eggs, both through ingestion and direct contact with residues on leaf surfaces.
- Physical or chemical barriers can be placed on the ground to prevent penetration by neonate larvae.

Nematodes that attack insects can be applied to the soil.

- Finally, root rot that may be exacerbated by weevil feeding may be controlled with fungicides.
- When considering all these options, the ultimate question to ask is whether benefits (increased yield) will be sufficient to offset costs.

Control Strategies: Constraints

Adult Control

Disrupts Biological Control; Short Residual

Egg Control

Residual (Micromite) / Establishment (wasps)

Chemical Barrier to Neonate Larvae

Cost, Efficacy, Effect on Ants

Larval Control (Nematodes)

Efficacy? Rate? Cost

Root Rot Control

Cost, resistance (Fungicides) /
Pathovars (rootstocks)

- Adults usually only represent a small proportion of the total weevil population, so most weevils will escape control at any one time. Broad-spectrum insecticides can interfere with biological control of other pests, and may lose effect through selection for resistance.
- Growth regulators presently available as egg sterilants are expensive, may not have a long residual during rainy seasons, and could disrupt biological control
- Insecticidal barriers require bare ground for effective application and disrupt ant populations that prey upon neonate larvae.
- Nematode quality and effect are difficult to evaluate and not always satisfactory. Applications must be made with sufficient moisture.

Monitoring Devices



"Tedd's" trap

Attracts emerging adult weevil by simulating a



Cone or Emergence Trap

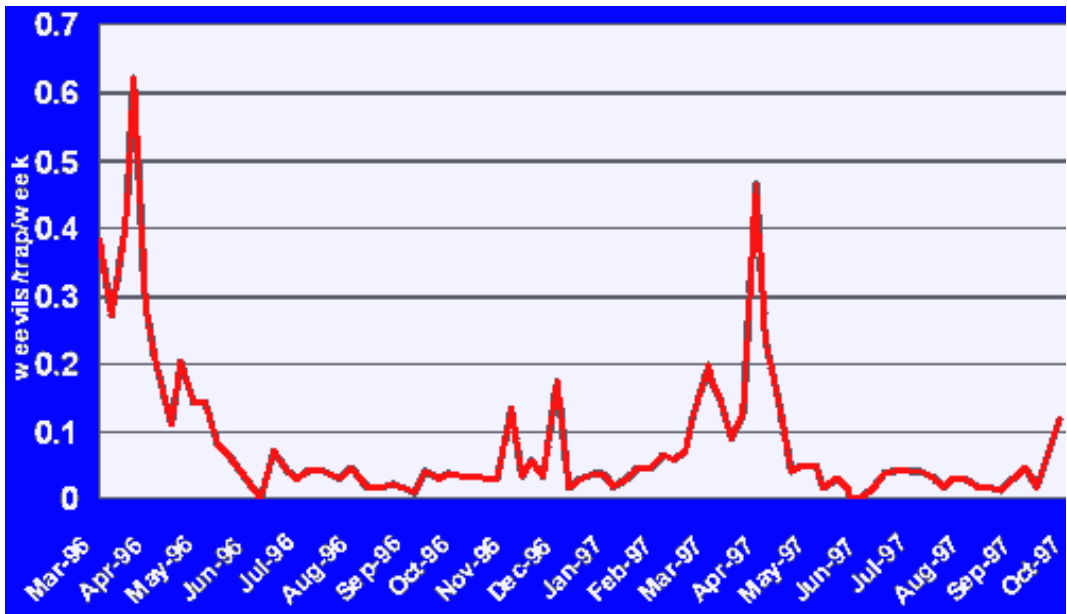
Captures all adult weevils emerging underneath.

tree.

Monitoring populations trends is important to optimize application timing.

- The “Teddners” pyramidal trap consists of 2 interlocking triangular vanes topped with a screen cone “boll weevil” trap. Weevils emerging from the soil are looking for a dark silhouette indicating a tree trunk, and mistakenly climb up through a hole in the screen cone and are trapped. However, weevils fallen from trees can also climb into the Tedders trap.
- The emergence trap captures only weevils emerging from the area encompassed by its cone-shaped screen. It catches fewer weevils but the origin of these weevils is known with certainty. We are using it to check on the results from Tedders traps.

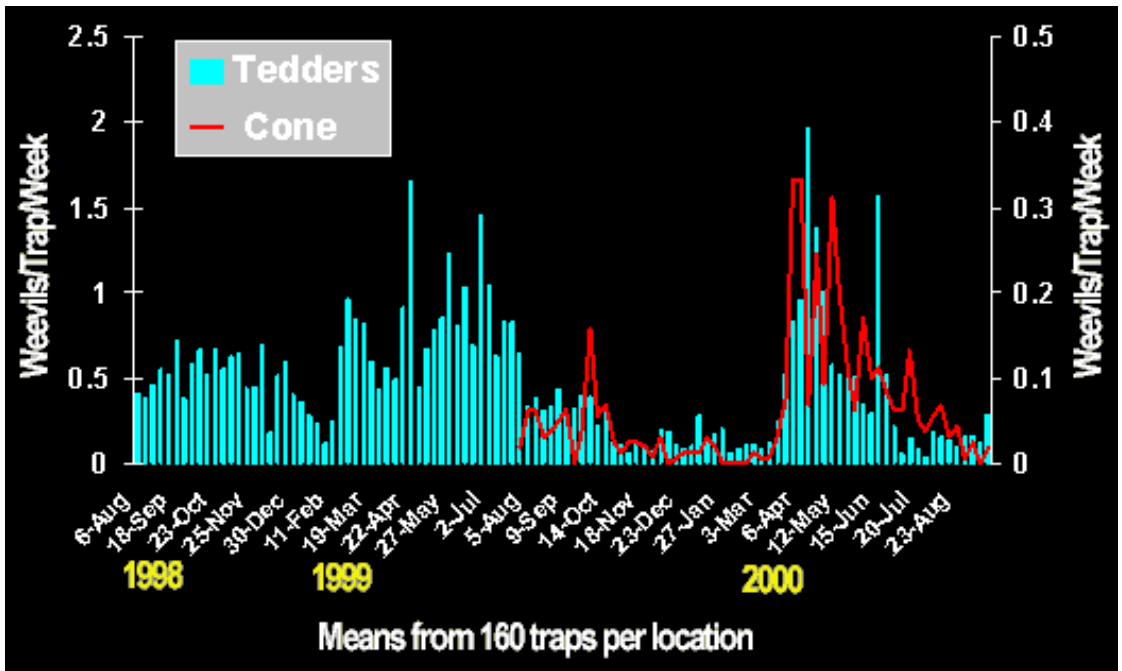
Diaprepes Emergence in Hendry County, Groves ONE and TWO Combined



Teddners trap data collected from northwestern Hendry county showed a one large emergence peak in springtime with a small, secondary peak in fall. This pattern indicated one generation primary per year and lent itself to planning applications for Diaprepes control.

- Treatments directed against adults, eggs or neonate larvae should be applied soon after the spring peak to achieve maximum effect since the largest number of adults would be present and laying eggs at this time.
- Nematodes directed against larvae should be applied during the summer rainy season. This would assure that most of the weevil population would be in the larval state, and that soil moisture would be sufficient.

Weevil Captures: 1999- 2000



Unfortunately, the same, clear pattern is not always observed. This grove in the same general area had been infested more recently than the previous example and showed a somewhat different pattern, especially the first 2 years (1998-99). Although a spring peak was observed, considerable emergence occurred year-round and overall emergence levels were much higher. However, in 2000 we saw captures drop 50% overall, and even more in the summer and winter. The pattern of captures in cone (emergence) traps follows the general trend of the Tedders traps.

It appears that the emergence pattern in this grove may be settling down to one similar to the first grove. It is not clear what factors drive this process but we suspect that native nematode populations building up in the soil in response to Diaprepes may be at least partly responsible.

Insecticidal Control of Adults or Eggs: Recommended at Peak Emergence

- Carbaryl (Adults)
- Dead weevil lays no eggs
- Cheap
- Broad spectrum insecticides can flare scales, spider mites, etc.
- Resistance?

Micromite® (Eggs)

- Persistent in dry season
- Alternative to Sevin ®
- Difficult to evaluate
- Good miticide but timing may be wrong
- Esteem® an option?
- Oil alone may help

Killing adults and sterilizing eggs have the same objective of preventing the next generation from entering the soil. In addition, both are foliar sprays that would be applied within the same time frame. What are the pros and cons of each?

A spray directed against adults is easier to evaluate and the broad-spectrum insecticides used such as carbaryl are relatively cheap. On the other hand, these materials can flare scales, mites and other pests, either through suppression of natural enemies or by direct effects upon the pest. Persistence is low and pests can become resistant.

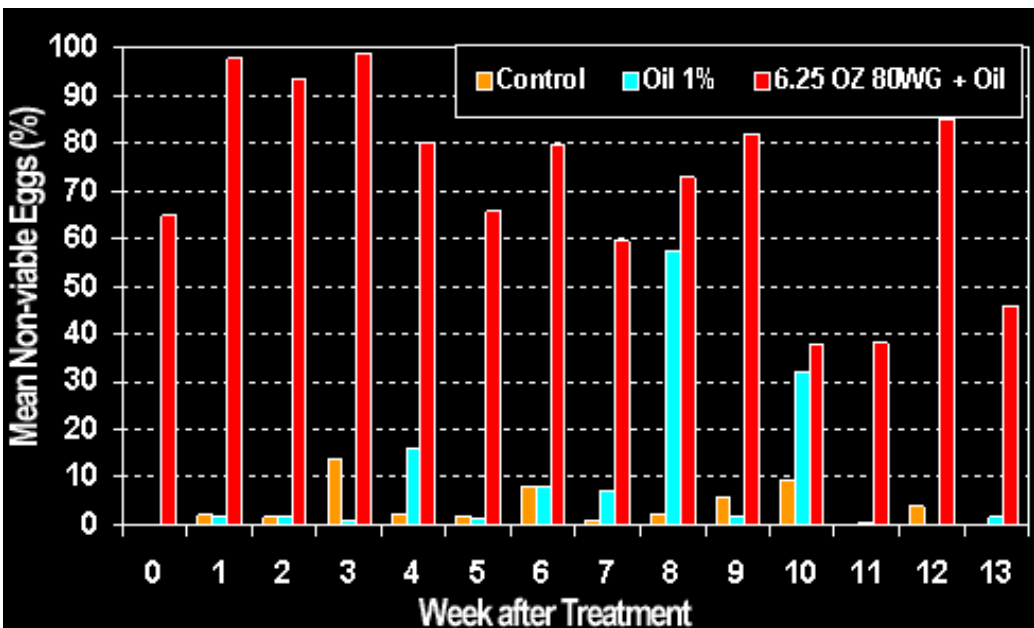
Micromite® (diflubenuron) used as an egg sterilant is more persistent, at least in dry season. It also controls rust mite and to some extent citrus leafminer, although the correct timing for Diaprepes would be too early for rust mite. On the other hand, its effectiveness for Diaprepes is difficult to evaluate. It is relatively expensive, and, like any other pesticide, could cause resistance if used excessively.

Non-Target Effects of Adulticides



Chaff and Purple Scale on Murcotts

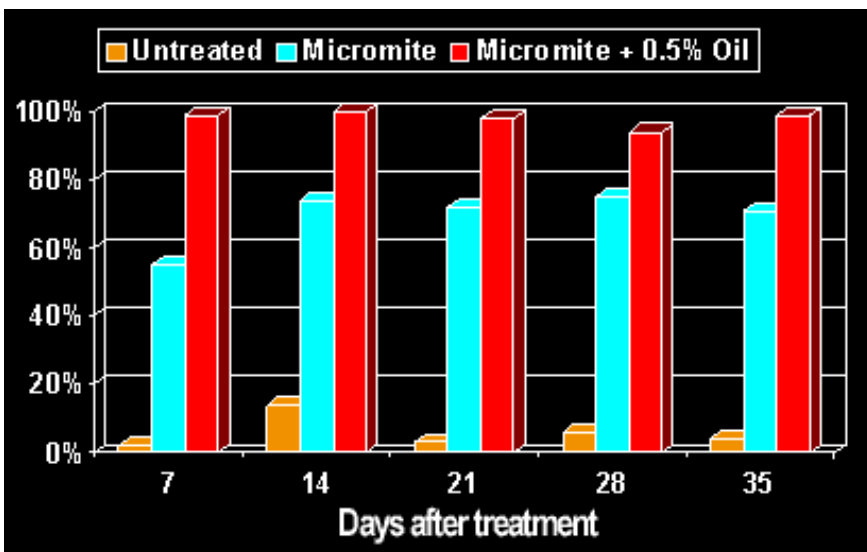
These Murcotts tangerines were brought in by a consultant for a grove that had treated numerous times with Sevin® to control Diaprepes. Apparently, these sprays suppressed parasitic wasps that control armored scales, in particular chaff scale. Scales built up and may now cause a severe impact on packout.



This field test of the persistence of Micromite® 80 WG was carried out at the Kerr Center for Sustainable Agriculture near Ft. Pierce FL on small but mature grapefruit trees. Micromite at 6.25 oz with 1.0% oil, and oil was applied on 15 Feb 2000 to runoff with a handgun, so coverage was excellent. Five leaf pairs per treatment were removed weekly and caged with egg-laying adults. Eggs were held for a maximum of 33 days to observe hatch rate. Between 4,000 and 5,000 eggs were tested for each treatment.

Hatch from untreated leaves was 96% compared to 88% for trees treated with oil only and 28% for trees treated with Micromite. Significant suppression of egg hatch was observed through 13 weeks after the application. Many eggs hatched after the normal 15-day incubation period, producing larvae weak-looking larvae, so mortality estimates are thought to be conservative. Rainfall during the entire trial was 5.23 inches. Bullock's (next slide) data looks equally encouraging although for only 35 days with a total of 3.8 inches of rainfall.

Reduction in hatching of eggs laid by weevils caged at start of each period on foliage sprayed to runoff. Rainfall 3.8 inches in 4 events first week of trial, 30 May-5 June. Bullock, 1996.



Insecticidal Barrier for Control of Neonate (Hatching) Larvae:

Pro

- Worked with Dieldrin and Aldrin

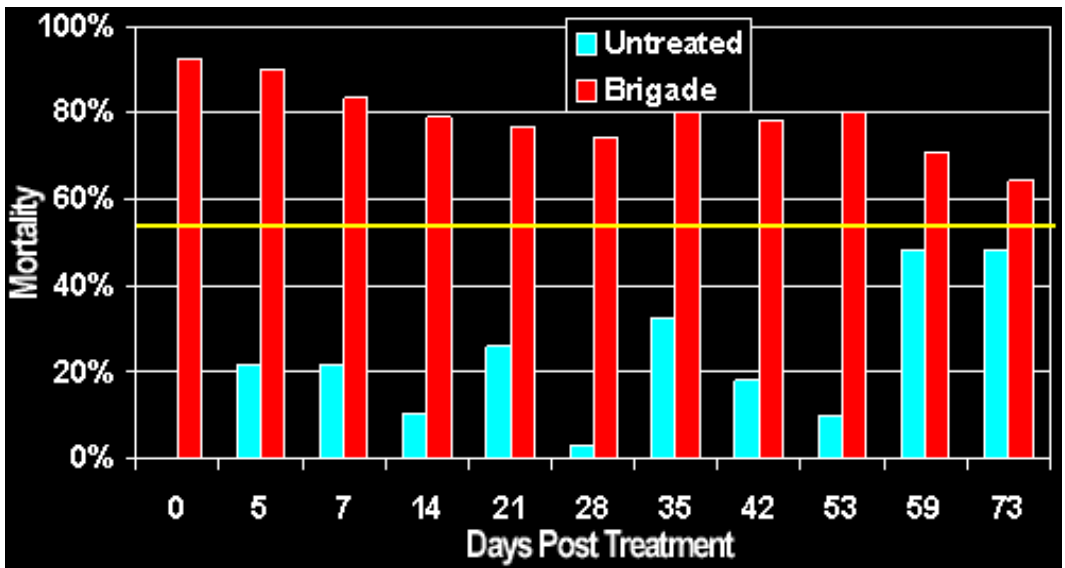
- Potentially long residual
- Avoids foliar applications

Con

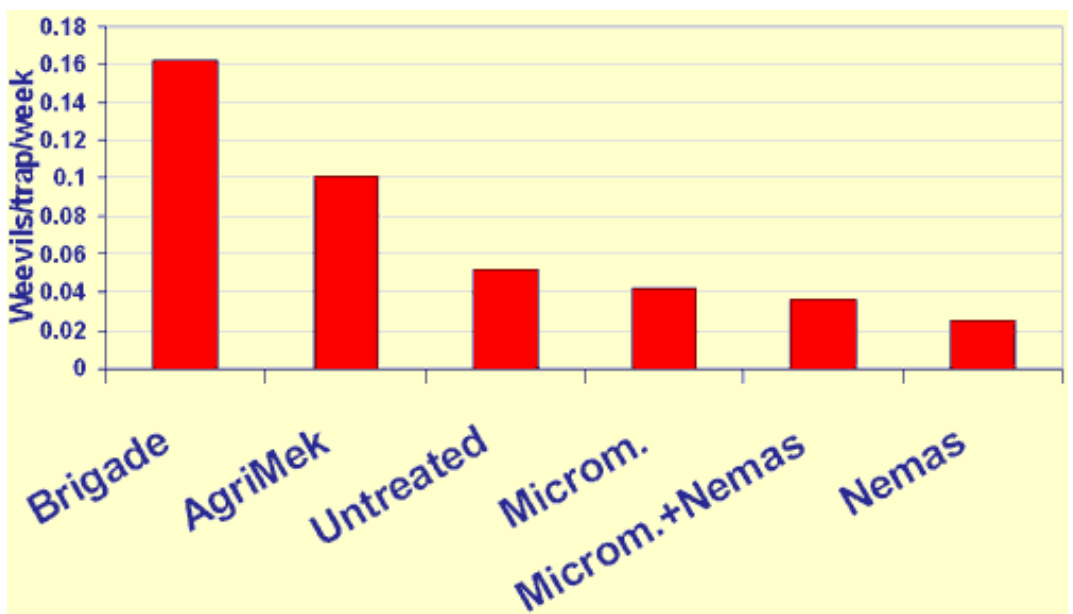
- Capture® only product presently available
- Interference from litter and weeds
- Kills or repels ants that prey on neonates
- Efficacy? Persistence?
- Cost

Insecticidal barriers sprayed on the soil surface to prevent penetration by neonate larvae was very effective. Worked with the chlorinated hydrocarbons Dieldrin and Aldrin which are very persistent in the soil. One advantage of this treatment is that it avoids foliar sprays that can impact beneficial insects in the canopy. However, these materials are no longer available. Instead we have the pyrethroid bifenthrin (Capture®) which is not nearly as persistent. As a result, Capture must be sprayed on bare ground to be effective which means litter and weeds must be removed. In addition it kills or repels ants that prey on neonates, so overall mortality could actually be lower. Finally, the 0.5 lb ai/acre rate is fairly expensive and lower rates are less effective.

Soil column bioassay using neonate larvae to test residual effects of bifenthrin. Soil surface under 5 year-old 'Hamlin' orange trees was cleaned of leaf litter and treated on 17 Sep. (McCoy et al. 2000)



This experiment portrayed in the proceeding slide was conducted in fall by Dr. McCoy at Lake Alfred and is included in a manuscript intended for submission to the Journal of Economic Entomology. Larval mortality on treated soil was significantly below the untreated check through 59 days post-treatment and averaged 75% exclusive of the first week. However, when mortality in untreated soil is subtracted we're left with only a 54% difference. The question now become whether mortality in the field due to ant predation might be greater than 54% and whether bifenthrin would protect weevil neonates from ants.



4 reps/treatment , 8 traps/plot, monitored weekly

The proceeding slide represents 2 years of Tedders trap data from replicated, single-row plots of mature 'Hamlin' oranges in Hendry County. Bifenthrin (Brigade 10 WSB) at 0.5 lb (ai) per acre was applied to weeded soil blown free of litter in spring and fall. BioVector® (Steinernema riobravae) was applied at 200 million/acre in summer and Micromite 25 WP at 0.1 oz/tree in spring and fall with a handgun when applied alone or only in spring when combined with BioVector. More weevils were trapped in plots treated with Brigade than in control plots. This result indicated that, in spite of insecticidal effects of Brigade on neonate larvae, interference with ant predation may reduce overall mortality of the pest.

Treatment of Larvae with Nematodes

Pro

- Only option for control of feeding larvae
- Selective/ Non-toxic
- Can be applied with irrigation

Con

- Difficult to evaluate quality, effect
- Requires adequate moisture
- Labeled rates may not be adequate
- Persistence?
- May not work in heavy soils

Insect feeding nematodes are presently the only option the grower has to intervene in the control Diaprepes larvae. The nematodes have no known effect on any beneficial organism or man. They can be applied conveniently through micro-sprinkler irrigation systems.

On the other hand, the irrigation system system has to be operating optimally to produce satisfactory results. Soil moisture levels, especially at the surface, may not be adequate to ensure survival and movement of nematodes with other application methods. Nematode quality requires a microscope and experience to evaluate. Evaluation of efficacy requires use of traps or other monitoring methods, and ultimately yield estimates over at least 2 years. Nematodes may not function well in

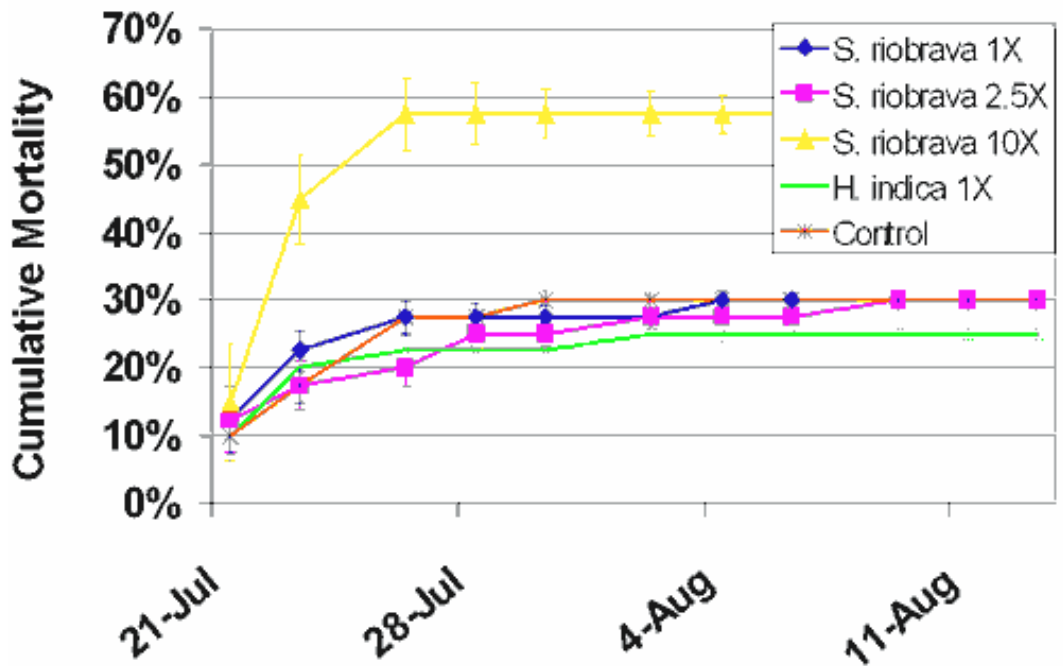
heavy soils. Labeled rates may not be adequate to produce measurable effects, especially in mature blocks. Persistence of nematodes in the soil is probably limited.



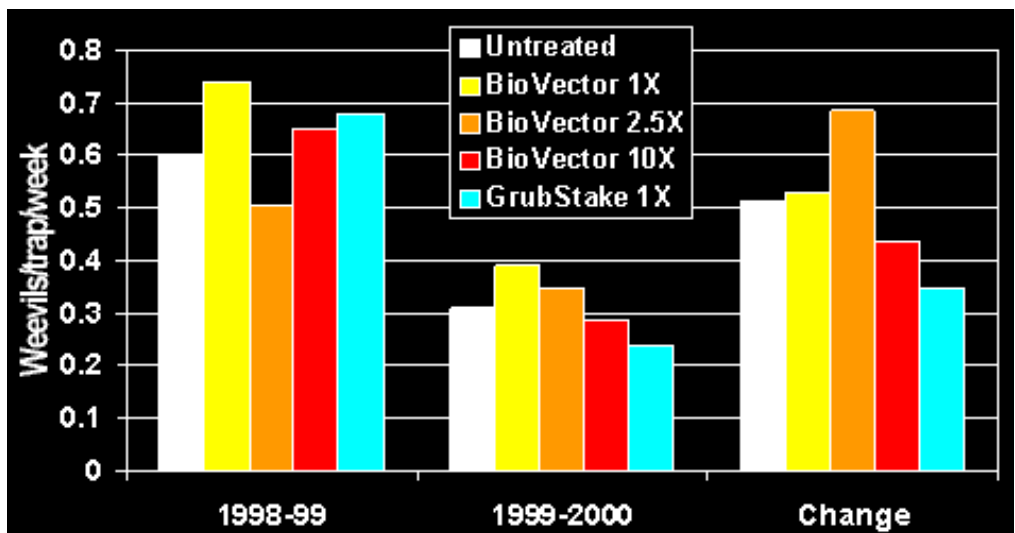
We developed a bioassay method to evaluate nematode persistence following a field application, using diet-fed weevil larvae. Soil was brought to the laboratory 12 hours, 5 and 12 days after application and placed in plastic cups with a weevil larva. Larvae were observed weekly and scored for condition and cause of mortality. Mortality in untreated plots was high, ranging from 30 to 50%. Mortality in soil from plots treated with 1 X Biovector or Grubstake never exceeded that observed that from untreated soil. By 5 days only the 10 X rate of BioVector was distinguishable; by 12 days none were.

Much of the mortality observed in untreated plots was caused by species of insect-feeding nematodes that were different from those applied. These are apparently native nematodes that had built up in response to Diaprepes and cause considerable mortality to larvae.

Soil Bioassay 5 Days After 2nd Application



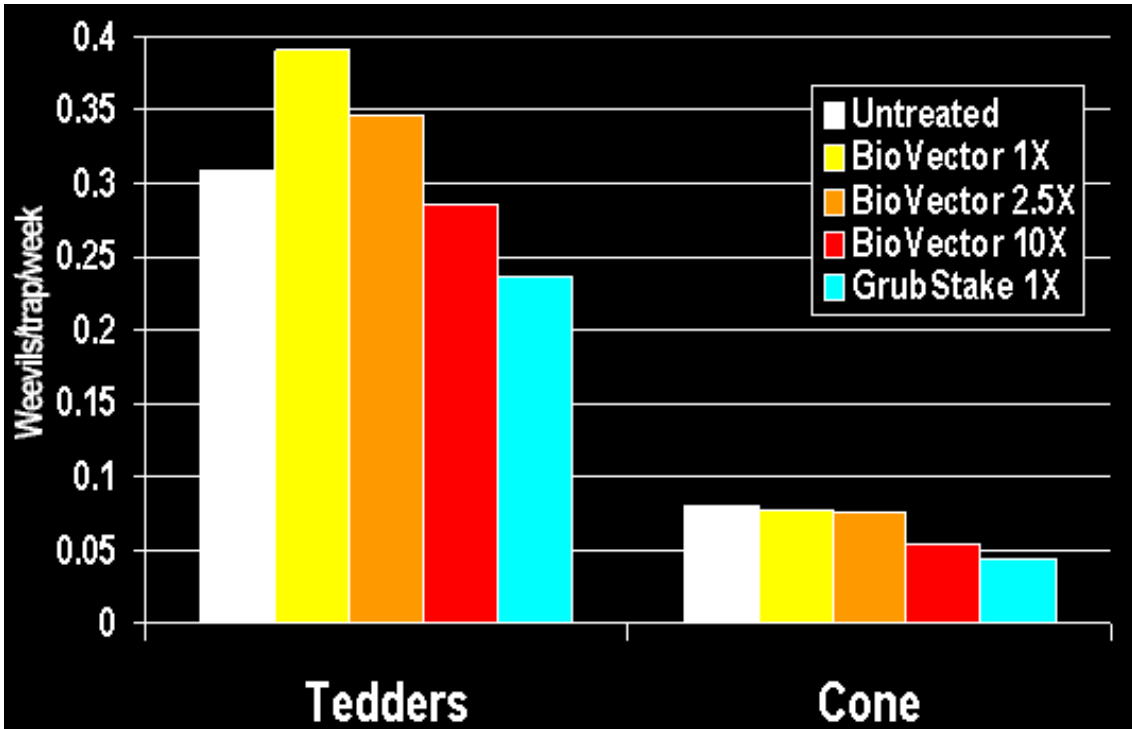
Tedders Trap Captures



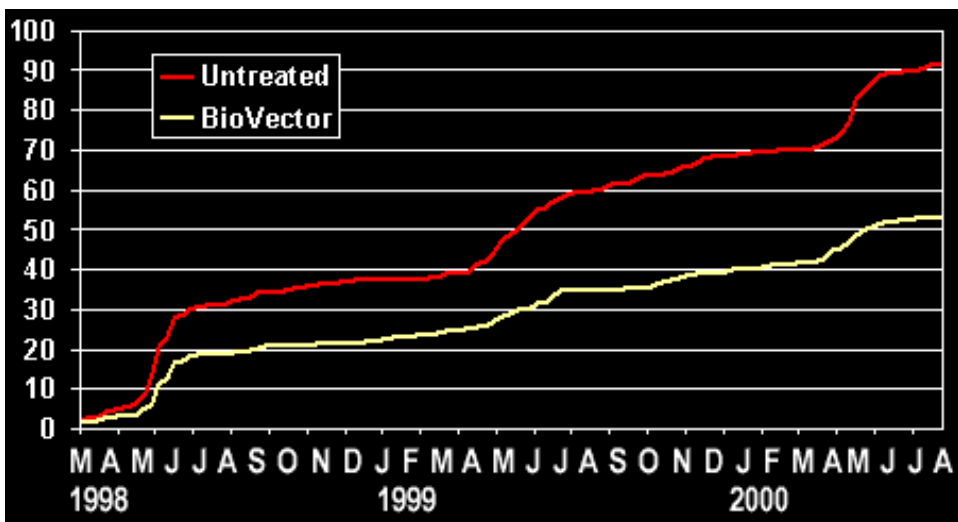
The preceding slide represents 3 years of Tedders trap data from 3 row plots, 30+ trees in length, of mature mandarin (2 rows of 'Fallglo' and 1 of 'Sunburst' in northwest Hendry county. Soil is primarily "Boca sand". Applications were made with a herbicide boom twice during the rainy season in 1999 and 2000 with microjets running. Eight Tedders traps per plot (20 per treatment) and the same number of cone emergence traps were monitored weekly.

No significant differences were observed from Aug 1998 to Aug 1999. The following year significantly fewer weevils than the control were trapped in plots treated with Grubstake. There was no clear rate response with BioVector. However, when cone trap counts were analyzed, captures from plots treated with BioVector lined up with rate, with fewest captured from the grubstake plots. Thus, Grubstake appeared to perform as well or better than even 10 times more BioVector.

Trap Captures



Cumulative Tedders Trap Captures: Bartow, Florida

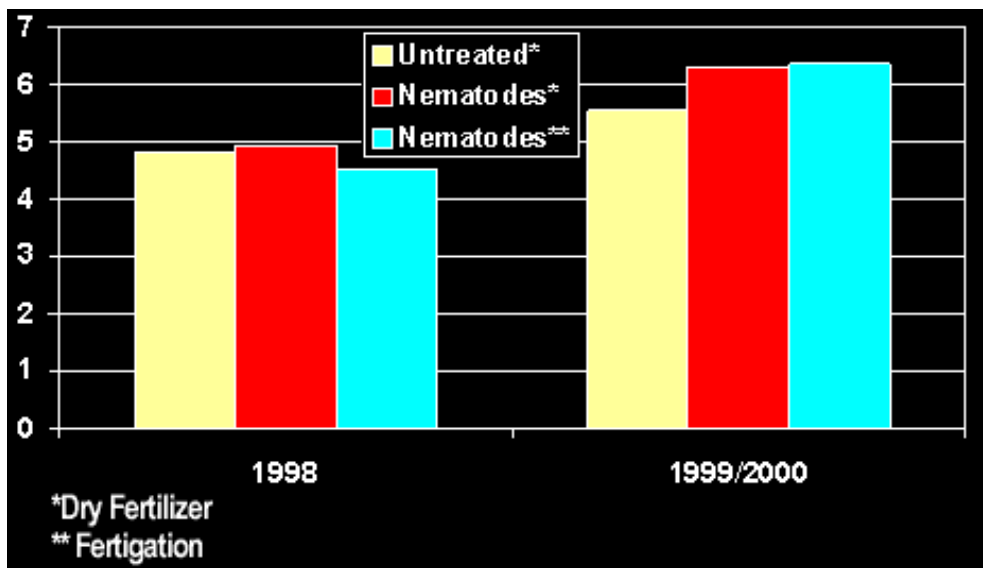


Data from L. Duncan, CREC

The proceeding and following slides represent results from a ridge grove near Bartow of 10 year-old Hamlin and Valencia on Carrizo. BioVector was injected through micro-sprinklers at 200 million/acre 2 times per year. Fertilizer treatments are 3 dry vs 15 fertigated /year. Weevil activity was monitored weekly with 12 traps/plot = 48 per treatment.

After more than 2 years, almost 40% more weevils have been trapped from non-treated plots. Yield estimates are almost 15% greater from treated plots during the 1999-2000 season, or an increase of 0.8 boxes per tree. At an average price of \$3.80/box, the value of the yield increase would have been \$304, more than enough to have paid for the 6 treatments of BioVector applied.

Yield in Bartow Grove:



Data from L. Duncan, CREC

Root Rot Control: Questions

- Under what conditions does Diaprepes Increase Phytophthora?
- Which species of Phytophthora predominates?
- Rootstock susceptibility?
- When will fungicides help?
- Soil type, Disease intensity, Inoculum, Rootstock, Drainage, etc.

Soil type is the main consideration determining risk from root rot and probable response to curative measures.

Risk increases as the soil texture continuum increases from large to small particulates (sand to clay).

In very sandy soils Diaprepes is unlikely to exacerbate root rot except when propagule counts exceed 20 per cm³.

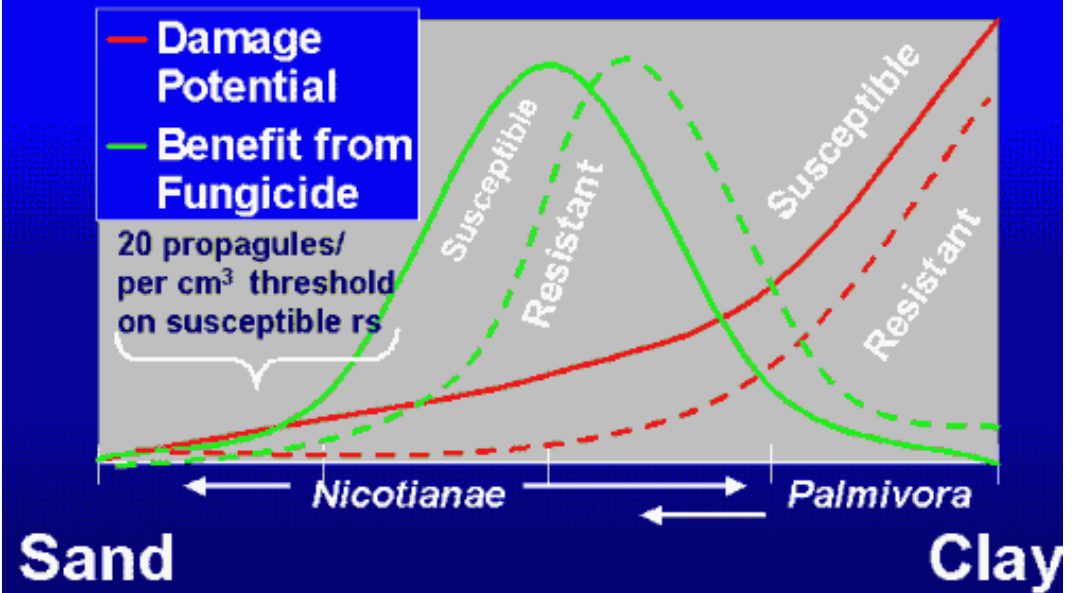
Therefore, the mere presence of Diaprepes does not warrant Phytophthora control.

At the other extreme, Ph. Palmivora is likely to predominate and control becomes non-economical.

In between, root rot control could be justified depending on other factors effecting risk such as rootstock, drainage, initial inoculum level and disease progression.

Influence of Soil Type on Damage Potential from Phytophthora and benefits of control with fungicide

Influence of Soil Type on Damage Potential from *Phytophthora* and benefits of control with fungicide



Grower Program
 Sevin spring emergence peak
 Micromite first summer oil
 Nutriphyte 2nd summer oil
 Ridomil in Fall
 Nematodes early summer

↑ River Grove
Sandy Soil

River Grove
Heavy Soil
→



This grove in northwestern Hendry county has both light (Boca sand) and heavy (Chobee fine sandy loam) soils and exemplifies the effect of soil type control of the Diaprepes/ Phytophthora complex. Trees growing on the heavy soils have been unthrifty in spite of an aggressive treatment program, and large areas were recently removed. Trees in the sandy areas remain healthy and profitable.

Take Home Message

- Combination of strategies necessary

- Control best on sandy soils, worst on heavy soils
- At least 1 spray for adults and/or eggs always warranted
- Some encouraging results with nematodes on sandy soils
- Root rot control usually not necessary on ridge, may be beneficial in Flatwoods