Insect Control Without Neonics & Pollinator Safety

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Altogether. Better.

Pollinator Health is Mission Critical

- Bees pollinate more than 130 food crops
  - 1.7 M colonies for almonds alone
- 33% of food tied to bee pollination
- Over $15 billion annual crop value

Photo credits: Clockwise from upper left: University of Minnesota, University of Georgia, M. Libhart, C. Brittain

Bee Foraging is Well Understood

- Daily patterns easily observed
- Forage begins near sunrise
- Late morning and early afternoon peaks
- Forage greatly diminished by evening
- Generally 55˚F minimum for flight

Managed and Native Bees Differ

- Managed colonies
  - Average hive harvest is 50 lb honey/yr*
  - Typical forage range is 2 miles
  - Continuous foraging thru season
- Native bees
  - Majority are solitary, ground dwelling
  - Highly specialized, limited forage times

*Information from Dennis Crum Ghs Grower March 2014 article and Matt Libhart, Apiarist

Squash Bee

- Native bee that only visits flowers of squash and pumpkins
- While it will feed on nectar of other flowers, it's life cycle coincides with that of cucurbit flowering
- Shortened food gathering phase can make pesticide treatments more damaging.

Photo credit- University of Tennessee

Bee Decline Is Complicated

- *Varroa destructor* mite
- Pathogens (*Nosema*)
- Hive management
- Pesticide toxicity
- Habitat loss, hive nutrition, and more

Varroa Mites Weaken Colonies

- *Varroa destructor* considered to be "the most serious pest (parasite) of honey bee colonies worldwide"
  (NCSU Cooperative Extension)

Photo credits: USDA-ARS

Hive Management Challenges

Almond Pollination- 1.5M Hives: 3 week pollination season requires over 60% of the managed hives in the US, coming from as far away as Maine.

Pollinator Decline is Documented

- Managed colony count decreasing since post WWII
  - ▸Changing agricultural practices
  - ▸Changing demographics
- Documented general decline in natives
  - ▸Habitat loss is driving factor
  - ▸Some species not showing decline, but diversity generally viewed as lower

Pesticides and Bees

- Insecticides do impact bees
- Several possible exposure routes, impacts
  - ▸Direct toxicity and residual exposure
  - ▸Lethal and sub-lethal effects
- Insecticide toxicity and exposure risk varies by product and within product class
- Data also suggests toxicity risk from fungicides, tank mixes, adjuvants. More research needed!

Synergy Suspected to Play Role

- Synergistic effects between *Varroa* and pesticides, *Varroa* and disease, pesticides and disease
- Tank mixes may result in increased toxicity
- Fungicides may result in increased toxicity

Understanding the Neonics

- Neonicotinoids are the most commonly used class of insecticides in the world
- First released in 1993
- Systemic products, developed as safer alternative to organophosphates
  - ▸Far less toxic to mammals
  - ▸More specific in activity
  - ▸Do not bioaccumulate like OPs
  - ▸Bees have more neonic receptors than other insects, increases toxicity risk

Neonics in Agriculture and Horticulture

- Widespread use for pre-planting seed treatments in agriculture
- Greenhouse/nursery products
  - ▸Imidacloprid (ex. Marathon, Discus, Benefit, Mallet, Mantra)
  - ▸Dinotefuron (Safari)
  - ▸Thiamethoxam (Flagship)
  - ▸Acetamiprid (TriStar)

Colony Collapse Disorder (CCD)

Sudden, overwintering loss of adults; no dead bees present (normal loss ~ 15%)

- First observed in 2006 (>30% avg loss)
- 2012-13 30.5% hive loss
- 2013-14 23.2% hive loss
- 2014-15 23.1% hive loss
- Not much sign of CCD for several years, but high colony losses in the summer and year-round remain very troubling- *Jeff Pettis, senior entomologist, USDA's Agricultural Research Service Bee Research Laboratory in Beltsville, Maryland*

Confirmed: Dennis van Engelsdorp, Department of Entomology at the University of Maryland

CCD is Not a Global Problem

"…in Australia, honey bee populations are not in decline and insecticides are not a highly significant issue, even though they are clearly toxic to bees if used incorrectly…"

"…Australia has been fortunate to date to avoid any incursion of *Varroa* which presents a major threat to the health of honey bees. …"

-From the Overview Report: Neonicotinoids and the Health of Honey Bees In Australia, Australian Pesticides and Veterinary Medicine Authority, February 2014

Neonic Toxicity Varies

- Imidacloprid presents highest toxicity to honey bees
- TriStar presents much lower toxicity to honey bees

Neonic insecticides given to bees orally	Honey bees Lowest lethal concentration Acute (ppb)	Chronic (ppb)	
Acetamiprid	442,000	ND	TriStar
Clothianidin	>190	ND	
Dinotefuran	>380	ND	Safari
Imidacloprid	>185	0.10 >20	Marathon
Thiomethoxam	>250	ND	Flagship

Table: 2012 Xerces Society Report: 'Are Neonicotinoids Killing Bees?'

Variable Toxicity Risk

- Acetamiprid with lower toxicity and shorter exposure risk
- Imidacloprid quite toxic to bees
- Thiamethoxam quickly metabolized to clothianidin
  - ▸Clothianidin more toxic to bees
  - ▸Clothianidin much more persistent

From D. Smitley (MSU), 30 Sept 14 presentation posted to his website

Weeks Before Shipping	Plant Type	Olefin (ppb)	Imidacloprid (ppb)
1	Portulaca	70	110*
1	Verbena	0	70
1	Salvia	20	200
1	Marigold	0	0.6
2	Portulaca	0	0
2	Verbena	30	430
2	Salvia	30	0
2	Marigold	0	0
4	Portulaca	0	0
4	Verbena	0	0
4	Salvia	0	0
4	Marigold	0	0

Pesticides Found in Hives?

- In-hive pollen studies provide insight
- 2011-14 study by Traynor et. al*
- Tested for 175 pesticides in 632 samples
  - ▸21% of samples free of pesticide
  - ▸50% of residues were Varroacides
  - ▸15% of samples had more than 5 pesticides
  - ▸3% of samples with neonicotinoids

*Traynor et. al. 2015, November. Pesticides in Pollen: a national survey of bee bread residues. 63rd annual meeting of The Entomological Society of America, Minneapolis, MN.

Neonics as Agricultural Seed Treatments

- Neonic seed treatments common practice: corn, cotton, canola, and soybean
- Research on cotton and soybeans showed no neonics in flowers or nectar
- Corn showed average 2.3 ppb in pollen
- Pesticide dust from seed hoppers is a big concern

Dr. Gus Lorenz, extension entomologist, University of Arkansas. Reported in Entomology Today Feb 2014

New Biopesticide for Bee Hives

- HopGuard® labeled to control Varroa mites in bee hives.
- Derived from hop flower compounds
- No negative impact on bees or hive activity
- No residual found in honey

Exposure Risk Via Forage

- Pesticide risk requires exposure
- Data indicates that chemicals are found in pollen and nectar
- Preliminary data also indicates that most garden center annuals are not preferred forage

Where are the Bees?

- Native bees more common in suburban yards and gardens; honeybees relatively uncommon in yards
- Vegetable gardens, native plantings do support native and managed bees
- Annual and perennial weeds provide desirable forage

Where are the Bees?

- Native annuals, perennials, shrubs, trees
- Perennial cultivars, especially asters and other composites
- Few garden annuals provide forage (Smitley, MSU)
  - ▸Top 25 garden center annuals: none
  - ▸Top 50 garden center annuals: blue salvia and sunflowers

Best Management Practices

- Avoid imidacloprid spray within 2-3 wks of shipping (Smitley, MSU)
- Avoid imidacloprid drench within 5 wks of shipping (Smitley, MSU)
- Avoid application of thiamethoxam to preferred perennial forage species that will bloom during production or in months following shipping (GGSPro)

Pesticides and Bee Safety

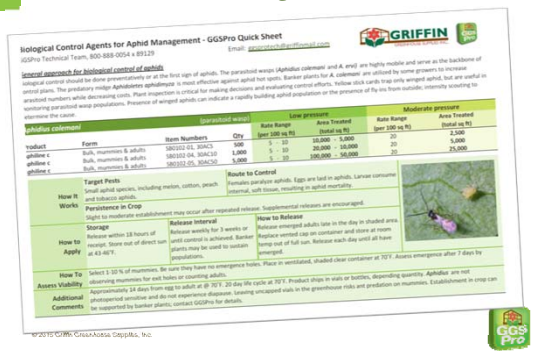
Photo credit: Matt Libhart

Biological Control Agents (BCAs)

- Effective option
- Strong GGSPro support, tools created.

Photo Credit: John Speaker, Speaker's Gardens

GGSPro BCA "Quick Sheets"



Biological Control Agents for Aphid Management - GGSPro Quick Sheet

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GRIFFIN

General approach for biological control of aphids

Biological control should be done preventatively or at the first sign of aphids. The parasitoid wasps (*Aphidius colemani* and *A. ervi*) are highly mobile and serve as the backbone of control plans. The predatory midge *Aphidoletes aphidimyza* is most effective against aphid hot spots. Banker plants for *A. colemani* are utilized by some growers to increase parasitoid numbers while decreasing costs. Plant inspection is critical for making decisions and evaluating control efforts. Yellow stick cards trap only winged aphid, but are useful in monitoring parasitoid wasp populations. Presence of winged aphids can indicate a rapidly building aphid population or the presence of fly ins from outside; intensity scouting to determine the cause.

Aphidius colemani (parasitoid wasp)

Product	Form	Item Numbers	Qty	Low pressure: Rate Range (per 100 sq ft)	Low pressure: Area Treated (total sq ft)	Moderate pressure: Rate Range (per 100 sq ft)	Moderate pressure: Area Treated (total sq ft)
aphilinc	Bulk, mummies & adults	SB0102-01, 30ACS	500	5 - 10	10,000 - 5,000	20	2,500
aphilinc	Bulk, mummies & adults	SB0102-04, 30AC10	1,000	5 - 10	20,000 - 10,000	20	5,000
aphilinc	Bulk, mummies & adults	SB0102-05, 30AC50	5,000	5 - 10	100,000 - 50,000	20	25,000

How It Works: Target Pests: Small aphid species, including melon, cotton, peach and tobacco aphids. Persistence in Crop: Slight to moderate establishment may occur after repeated release. Supplemental releases are encouraged.

How to Apply: Storage: Release within 18 hours of receipt. Store out of direct sun at 43-46°F. Release Interval: Release weekly for 3 weeks or until control is achieved. Banker plants may be used to sustain populations. How to Release: Release emerged adults late in the day in shaded area. Replace vented cap on container and store at room temp out of full sun. Release each day until all have emerged. Route to Control: Females paralyze aphids. Eggs are laid in aphids. Larvae consume internal, soft tissue, resulting in aphid mortality.

How To Assess Viability: Select 1-10 % of mummies. Be sure they have no emergence holes. Place in ventilated, shaded clear container at 70°F. Assess emergence after 7 days by observing mummies for exit holes or counting adults.

Additional Comments: Approximately 14 days from egg to adult at @ 70°F. 20 day life cycle at 70°F. Product ships in vials or bottles, depending quantity. *Aphidius* are not photoperiod sensitive and do not experience diapause. Leaving uncapped vials in the greenhouse risks and predation on mummies. Establishment in crop can be supported by banker plants; contact GGSPro for details.

GGSPro BCA Compatibility Chart - Insecticide Sprays

COLOR KEY: Toxic; Moderately Toxic; Slightly Toxic; Safe

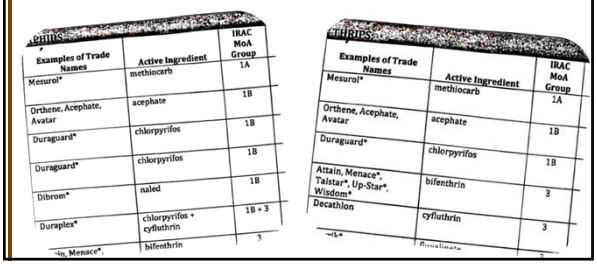
LIFESTAGE KEY: I Immature; A Adult

NUMBER IN COLORED BOX: Number of weeks residual toxicity to indicated BCA

Product	Amblyseius andersoni I	Amblyseius andersoni A	Amblyseius californicus I	Amblyseius californicus A	Amblyseius cucumeris I	Amblyseius cucumeris A	Amblyseius swirskii I	Amblyseius swirskii A	Aphelinus abdominalis I	Aphelinus abdominalis A	Aphidoletes aphidimyza I	Aphidoletes aphidimyza A	Aphidius colemani I	Aphidius colemani A
1300 Orthene TR			4		12		12		12		12			12
1600 X-dude Formula 2			1		1				1		1			1
Acephate 97UP			4		12		12		12		12			12
Akari 5SC		3		3		3								3
Ardent EC		2		2		2		2		3		3		2
Aria 50% WDG								2						
Attain TR		12		12		12		12		12		12		12
Avid		2		2		2		2		3		3		2
AzaGuard														
Azatin XL														
Azatin O														

Neonic Free = Bee Safe?

Alternatives are not always bee friendly



Examples of Trade Names	Active Ingredient	IRAC MoA Group
Mesurol*	methiocarb	1A
Orthene, Acephate, Avatar	acephate	1B
Duraguard*	chlorpyrifos	1B
Duraguard*	chlorpyrifos	1B
Dibrom*	naled	1B
Duraplex*	chlorpyrifos + cyfluthrin	1B + 3
-tin, Menace*	bifenthrin	3

Examples of Trade Names	Active Ingredient	IRAC MoA Group
Mesurol*	methiocarb	1A
Orthene, Acephate, Avatar	acephate	1B
Duraguard*	chlorpyrifos	1B
Attain, Menace*, Talstar*, Up-Star*, Wisdom*	bifenthrin	3
Decathlon	cyfluthrin	3

GGSPro Bee Friendly Alternatives

Bee Friendly Non-Neonicotinoid Pesticide Options 9.9.2014 rev. 10.5.2015
Tami Van Gaal, GGSPro Technical Specialist and Rick Yates, GGSPro Technical Support Manager; Email: ggsprotech@griffinmail.com, 800-888-0054 x89129

Different factors play into product choices for pest control, including the target pest, the crop on which the product will be used, REI limitations, a need for immediate knock down, a need for OMRI products, a desire for a soft product option, BCA compatibility, spray history, etc. There are also times when bee safety plays a factor in the decision.

GGSPro has developed Bee Safety Codes to help growers make sound decisions and demonstrate good stewardship. Our Bee Safety Codes reflect EPA labeling and provide a quick, visual reference to indicate

Table 1. Pesticides with Reduced Exposure Risk to Bees.

Products Without Residual Exposure Risk				Products With Some Residual Exposure Risk			
Product	MOA	Rank	Bee Safety Code	Product	MOA	Rank	Bee Safety Code
Aphids							
Aria 50% WDG	9C	1		BotaniGard EC 11.3%	UN	1	
Endeavor	9B	1		BotaniGard 22WP	UN	1	
Enstar AQ	7A	2		Kontos SC*	23	1	
Fulfill	7A	2		Mainspring (drench)	28	1	

Bee Safety Codes – Easy Reference

- Convey EPA's bee caution statements
- Help growers select products appropriate to their use
- Provide quick indicator for need to review label
- Emphasize wise and effective use

Understand the Label

- Current environmental hazard statements describe bee toxicity and exposure risk
- Toxicity: low toxicity, toxic, highly toxic, very highly toxic
- Exposure: direct, residual
  - Label language implies exposure
  - Direct: "when bees are actively visiting or foraging"
  - Residual: "when bees are visiting or foraging"

GGSPro Bee Safety Codes

Toxicity Key

Highly Toxic
EPA describes as very highly toxic, highly toxic or very toxic to bees

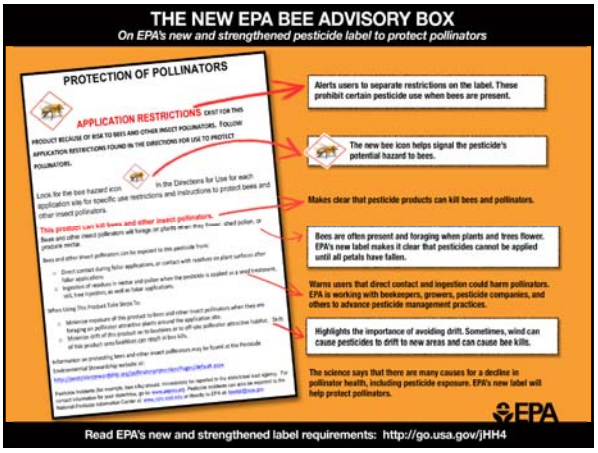
Low Toxicity
EPA describes as a potential pathogen or with low toxicity to bees

Toxic
EPA describes as toxic to bees

Special Case
Special use notes per label; contact GGSPro for more information.

Exposure Key

1	**Toxicity risk through direct exposure only - avoid treatment when bees are actively visiting or actively foraging in the treatment area.** *Actively visiting the treatment area refers to bees you see on the plants and pertains to products that do not show residual effect. Bee are protected when bees are absent during treatment.**
2	**Toxicity risk through residual exposure only - avoid treatment when bees are visiting the treatment area.** *Visiting the treatment area refers to bees that may visit the plants after treatment. Bee are protected when bees are absent from the area following treatment. Avoid use of these products when crops and/or weeds are in bloom.**
3	**Toxicity risk through both direct exposure and residual exposure - avoid treatment when bees are visiting the treatment area.** *Visiting the treatment area refers to bees that may visit the plants after treatment. Bee are protected when bees are absent from the treatment area both during and following treatment. Avoid use of these products when crops and/or weeds are in bloom.**



Bee Friendly Application Strategies

- When outdoor exposure risk exists, select less toxic products
- Plan applications to minimize direct exposure
  - ►Conduct outdoor applications late in day, preferably early evening
  - ►When possible, conduct outdoor applications when temps remain below 50˚F

Bee Friendly Application Strategies

- Minimize risk of residual exposure: avoid treating crops which will come into bloom within a risk period
- Avoid direct and drift exposure to flowering non-crop plants
- Grandevo PTO- repellency
- Provide 48 hour courtesy notice to nearby beekeepers regarding applications

Aphids- No Residual Exposure

Product	MOA	Efficacy Rank
Aria 50% WDG	9C	1
Endeavor	9B	1
Enstar AQ	7A	2
Fulfill	9B	1
Rycar^	UN	1

^Greenhouse Use Only

Aphid- Some Residual Exposure

Product	MOA	Efficacy Rank	Bee Code
BotaniGard EC	UN	1	
BotaniGard 22WP	UN	1	
Kontos SC	23	1	
Mainspring (drench)^	28	1	
Mycotrol O	UN	1	

^Greenhouse Use Only

Aphid Summary- Bee Friendly

- Mainspring and Kontos provide long lasting control from drenches
- Foliar sprays of Rycar, Endeavor (or Aria)
- Edible crops (ck label)- Kontos, Fulfill, Botanigard

Fungus Gnat/ Shorefly- No Residual Exposure

Product	MOA	Efficacy Rank
Adept^	15	1
Citation	17	1
Distance	7C	1
Fulcrum	7C	1
Gnatrol	11A	2
Steinernema feltiae (Fungus gnats)	NC	1
S. Carpocapsae (Shoreflies)	NC	1

^Greenhouse Use Only

Fungus Gnat/Shorefly Summary- Bee Friendly

- Nematodes fastest knockdown
- IGR's slower but effective: Distance/Fulcrum, Citation, Adept
- Adept preferred for floor treatments due to low cost in use
- Edible (ck label)- Nematodes, Distance, Citation

Spider Mites- No Residual Exposure

Product	MOA	Efficacy Rank
Akari 5SC	21A	1
Beethoven TR^	10B	1
Hexygon 50 DF	10A	1
Judo	23	1
Shuttle O	20B	1
SuffOil-X	UN	1
Sultan	25	1
TetraSan 5 WDG	10B	1
UltraPure Oil	UN	1

^Greenhouse Use Only

Spider Mites- Some Residual Exposure

Product	MOA	Efficacy Rank	Bee Code
Kontos SC (drench)	23	1	
Sanmite	21A	1	
Floramite SC	UN	1	

Spider Mite Summary- Bee Friendly

- Kontos drench effective for several weeks, best applied when crop is young
- Foliar sprays of Sultan, Shuttle, Akari
- Hort oils very effective if coverage is excellent
- Edible crops (ck label)- Kontos (drench), Akari, Hort oils

Thrips- No Residual Exposure

Product	MOA	Efficacy Rank
Aria	9C	2
AzaGuard	UN	1
Azatin O	UN	1
Enstar AQ	7A	2
Grandevo PTO	UN	2
Met 52 EC	UN	2
Molt-X	UN	1
Overture ^	UN	1
Pedestal SC	15	1
S. feltiae	NC	1

^Greenhouse Use Only

Thrips- Some Residual Exposure

Product	MOA	Efficacy Rank	Bee Code
BotaniGard EC	UN	1	
BotaniGard 22WP	UN	1	
Kontos SC (drench)	23	1	
Mainspring^	28	1	
Mycotrol O	UN	1	
Pylon^	13	1	
Pylon TR^	13	1	

^Greenhouse Use Only

Thrips Summary- Bee Friendly

- Kontos or Mainspring (ghse only) drenches provide a few weeks of excellent control
- Foliar sprays in ghses of Overture, Met 52 EC, Mainspring, Pylon
- Foliar sprays outdoors: Botanigard plus azadirachtin tank mix, Pedestal, Met 52 EC
- Edible crops (ck label)- Kontos (drench), Met 52 EC, Botanigard plus azadirachtin tank mix, Pylon (indoors)

Whitefly- No Residual Exposure

Product	MOA	Efficacy Rank
Aria	9C	2
AzaGuard	UN	1
Azatin O	UN	1
Distance	7C	2
Endeavor	9B	2
Enstar AQ	7A	2
Fulcrum	7C	2
Fulfill	9B	2

^Greenhouse Use Only

Whitefly- No Residual Exposure

Product	MOA	Efficacy Rank
Grandevo PTO	UN	2
Judo	23	1
Met 52 EC	UN	2
Molt-X	UN	1
Rycar^	UN	1
Suffoil-X	UN	1
Talus	16	2
Ultra-Pure Oil	UN	1

^Greenhouse Use Only

Whitefly- Some Residual Exposure

Product	MOA	Efficacy Rank	Bee Code
BotaniGard EC	UN	1	
BotaniGard 22WP	UN	1	
Kontos SC	23	1	
Mycotrol O	UN	1	
Sanmite	21A	1	

Whitefly Summary- Bee Friendly

- Kontos drench provides several weeks of control
- Foliar Sprays- Rycar, Sanmite, Botanigard plus azadirachtin tank mix
- Edible crops- Kontos (drench), Botanigard plus azadirachtin tank mix, Met 52 EC, Hort oils

Growers as Stewardship Leaders

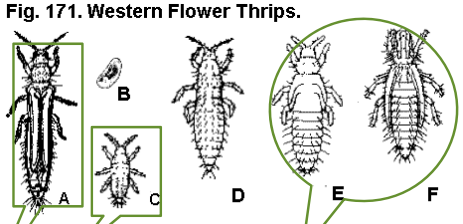
- Understand bee ecology
- Follow the label – IT IS THE LAW!
- Make educated product choices
- Use bee friendly application strategies
- Support industry research, industry cohesiveness
- Our industry is good for bees, lets talk about it!

Nematodes and Thrips

Altogether. Better.

Target Shooting with BCAs

Fig. 171. Western Flower Thrips.



A, Adult. B, Egg. C-D, Larvae. E, Prepupa. F, Pupa.

Orius insidiosus

A. cucumeris, A. swirskii

Nematodes- *Steinernema feltiae*

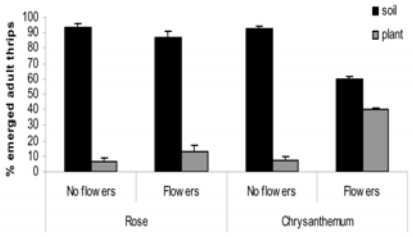
Image: North Carolina State University IPM Program

Thrips Pupae and Pre-Pupae

- Most vulnerable stage to nematodes.
- Immobile stages
- Where are they?
  - ▸No buds and blooms present? 90% on soil surface
  - ▸Buds and blooms present- 20-40% on plants, rest on soil surface.

Western Flower Thrips Applications

Plant growth stage, plant variety, flower color, etc., can make a different in where WFT's pupate



Buitenhuis & Shipp, J. Appl. Entomol., 2008

Nematodes vs WFT Strategy

- Early in the crop soil drenches every 2-3 weeks.
- Buds and blooms present- Bi-weekly sprenches overhead. Enough volume to treat the soil surface also.

Nematodes vs WFT

- Soil treatments also provide excellent fungus gnat control.
- Nematodes can be used to supplement a chemical or a biological program.
- Shoreflies require a different nematode and treatment strategy.

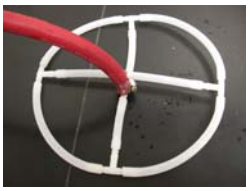
Successful Nematode Applications

- Insure adequate soil moisture
- No tank mixing in stock solution
- Avoid high UV light
- Cool water, gentle agitation and aeration in stick tank
- Remove screen finer than 50 mesh

Nematode Agitation/Aeration

5- Tee compressor fittings, plastic air hose, 2 ss hose clamps

Air compressor hose, adjustable air valve



Drill or punch holes every ½-1". Courtesy: Peter Armando, Griffin

Dramm Nematode Agitation/Aeration