Pesticides are available that are effective against most of the life stages of most of the important insect pests of tomatoes and other vegetables; these pesticides can be less detrimental to certain natural enemies of these pests.

"Biorational" has only recently been proposed to describe those insecticides that are efficacious against the target pest but are less detrimental to natural enemies. The term at times has been used to describe only those products derived from natural sources, i.e. plant extracts, insect pathogens, etc. However, we choose to define a biorational pesticide as "any type of insecticide active against pest populations, but relatively innocuous to non-target organisms and therefore, non-disruptive to biological control." An insecticide can be "innocuous" by having low or no direct toxicity, or by having systemic or rapid translaminar activity or short field residual, thereby minimizing exposure of natural enemies to the insecticide.

Figure 1. Coverage is important when using oil on whitefly nymphs. Photograph by: James Castner.

Figure 2. Soap is a highly effective agent to whitefly adults when wet. Photographed by: James Castner.

OIL, SOAP AND NEEM

- **Oil** was also repellent to whitefly adults but reduced yields of tomato in the field when applied at a concentration higher than 2%. Studies showed that soap, neem and oil were all toxic to silverleaf whitefly nymphs, although coverage was particularly important for oil. Oil was relatively non-toxic to adults of two species of lacewings (*Chrysoperla rufilabris* and *Ceraochrysa cubana*) and to adults of a small lady beetle species (*Nephaspis oculatus*), and was moderately toxic to larvae of a major whitefly parasite species (*Encarsia pergandiella*) and to larvae of a non-trash bearing species of lacewing (*C. rufilabris*)). Oil was highly toxic to adults of the parasite species, to eggs of both lacewing species and, to a lesser extent, lady beetle eggs. Toxicity was again mitigated by coverage.

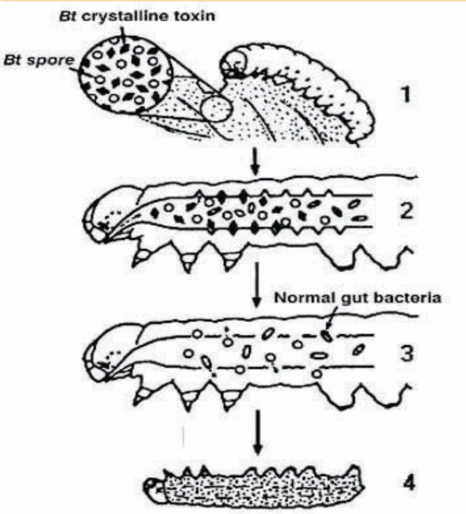
- **Soap** was highly toxic to whitefly adults but only when wet. Soap caused only slight effects on the parasite species and was moderately toxic to adults of both lacewing species and to larvae of the non-trash bearing lacewing species. Conversely, soap was highly toxic to young lady beetle larvae.

- **Neem** is reportedly an antifeedant to whitefly adults and is practically non-toxic to both species of lacewings and to the parasite. In general, trash bearing lacewing larvae were less susceptible to all three biorational pesticides than non-trash bearing larvae, even when considering the broad-spectrum pyrethroid bifenthrin.

- The potential of a **liquid dish detergent and a parafinnic oil (Ultrafine Oil™)** to cause phytotoxicity on tomato also was investigated. It was found that applications of 0.5% or more detergent applied twice weekly delayed production. Weekly applications were less damaging. On the other hand, no phytotoxic effect was seen on pepper from weekly applications of concentrations of oil up to 2% applied with or without mancozeb/maneb plus copper.

CHEMICAL CONTROL:
Biorational Insecticides

The non- or low toxic effects of products based upon the bacterium, Bacillus thuringiensis , are documented for numerous species of natural enemies of numerous pests.



BACILLUS THURINGIENSIS (*Bt*) PRODUCTS:

Products for control of lepidopterous larvae are based upon two subspecies of *B. thuringiensis* var. *kurstaki* (i.e. Dipel™, Javelin™) and *aizawai* (i.e. XenTari™) or a combination of the two (i.e. Agree™).

As with insecticidal products, there is a time line of product evolution.

- First generation products: Based on wild-type isolates collected directly from nature (i.e. Dipel, Javelin, XenTari).
- Second generation products: Based upon conjugation of the two sub-species (i.e. Agree).
- Third generation products: Based upon the so-called *Psuedomonas*-based delivery system (insertion of *B. thuringiensis* genes into *Psuedomonas* bacteria for the purpose of increasing field persistence, i.e. Mattch™).
- Fourth generation products: Based upon new *B. thuringiensis* strains constructed using recombinant DNA technology (i.e. Crymax™, Lepinox™).

Figure 3. Products containing *Bacillus thuringiensis* var. *kurstaki* kill the caterpillar stage of a wide array of butterflies and moths. Diagram by: UF/IFAS.

WHAT IS *Bt*?

- Bt is a bacterium that is pathogenic to larvae of certain insects, particularly lepidopterous insects, inducing mortality through infection.
- The resting stage, or endospore, of the bacterium contains endotoxins which are capable of paralyzing and lysing the insect gut, thereby causing mortality through starvation **(Figure 3)**.
- The endotoxins are not equally toxic to all species of Lepidoptera **(Table 1)**; therefore, wild strain selection, conjugation or recombinant DNA techniques have been used to develop *B. thuringiensis* products that have different arrays of endotoxins to alter or broaden the spectrum of activity of the product **(Table 2)**.
- In general, the products are effective against armyworm and fruitworm larvae.
- From the standpoint of resistance management, products with different arrays of endotoxins should be alternated; however, many products contain endotoxins in common **(Table 2)**.
- Rotate wild-type *B. thuringiensis* var. *kurstaki* products (i.e. Dipel, Javelin) with either wild-type *B. thuringiensis* var. *aizawai* products (i.e. XenTari) or with genetically modified *B. thuringiensis* products (i.e. Agree, Crymax, Lepinox, Mattch).

Table 1. Relative toxicity of *Bacillus thuringiensis* endotoxins to larvae of selected species of Lepidoptera.

	Endotoxin					
Species	IA(a)	IA(b)	IA(c)	IC	ID	IIA
Diamondback Moth	+++	+++	++++	+++	++	-
Cabbage Looper	+++	+	++++	+++	++	++++
Beet Armyworm	-	+	-	++	+	-
Fall Armyworm	-	+	-	-	++	+
Fruitworm/Earworm	+	++	+++	-	+	++

++++ = LC_{50} <10 μg/175mm^2; +++ = LC_{50} 10-100 μg/175mm^2; ++ = LC_{50} 100-1,000 μg/175mm^2; + = LC_{50} 1,000-10,000 μg/175mm^2; - = LC_{50} >10,000 μg/175mm^2

Table 2. Relative amounts (increasing number of "+s") of endotoxins present in selected *Bacillus thuringiensis* products. A "-" indicates the endotoxin was not present.

	Endotoxin					
Product	IA(a)	IA(b)	IA(c)	IC	ID	IIA
Dipel/Javelin	+	+	+	-	-	+
Mattch	-	+	-	+		-
Agree	+	+	+	+	+	-
XenTari	+	+	-	+	+	-
Crymax	-	-	+++	+	-	+
Lepinox			+	+*		+

Increasing numbers of "+s" indicate increasing relative concentration of the indicated endotoxin while a "-" indicates the endotoxin is not present.
*Hybrid

It is always necessary to consider the entire pest complex when designing an IPM system for a particular crop because actions taken to control one pest may impact another pest or its natural enemies.

NEW INSECTICIDES:

A number of new insecticides in new chemical classes have recently become available or will likely become available in the near future **(Table 3)**. Unfortunately, little or nothing is known about the relative toxicity of these compounds to the natural enemies of interest to Florida vegetable growers; however, the biorational nature of the compounds can be predicted by the spectrum of activity and other characteristics of the compounds.

Nicotinoids:

- Highly systemic (i.e. they are distributed through the plant, primarily to new growth, when applied to the roots) and translaminar (i.e. readily absorbed into the leaf through the leaf surface).
- Soil-applied imidacloprid, thiamethoxam, and dinotefuran have provided control of the silverleaf whitefly for 8-12 weeks on tomato. Foliar applications of imidacloprid, thiamethoxam and dinotefuran controlled whitefly nymphs, but not as well as soil applications. Foliar applications of thiamethoxam and acetamiprid also controlled whitefly adults.
- Not only are soil applications of the nicotinoids more effective than foliar applications in controlling whitefly nymphs, the impact of soil applications on natural enemies would be expected to be less than that of foliar applications because most natural enemies would not be exposed directly to the compounds.

Table 3. New Insecticides in New Chemical Classes.

Chemical Action	Common Name	Trade Name	Target Pests
Systemics (nicotinoids)	Imidacloprid	Admire/Provado	whiteflies, aphids
	Thiamethoxam	Platinum/Actara	whiteflies, aphids
	Acetamiprid	Assail	whiteflies, aphids
Insect Growth Regulators	Pyriproxyfen	Knack	whiteflies, aphids
	Buprofezin	Applaud	whiteflies
	Tebufenozide	Confirm	leps
	Methoxyfenozide	Intrepid	leps
	Novaluron	Rimon	whiteflies, leps
Miscellaneous	Pymetrozine	Fulfill	aphids, whiteflies
	Spinosad	SpinTor	leps., leafminers
	Indozacarb	Avaunt	leps
	Emamectin benzoate	Proclaim	leps, leafminers
	Rynaxypyr	Coragen	leps, leafminers, whiteflies
	Metaflumizone	Alverde	leps
	Spinetoram	Radiant	leps, thrips, leafminers
	Flubendiamide	Synapse	leps
	Pyridalyl	Tesero	leps, thrips

Pymetrozine:

- Active against both nymphs and adults of aphids and whiteflies **(Figure 4)**.
- Has long residual activity because it is absorbed translaminarly and apparently is translocated to new foliage.
- Because the compound is translaminar and systemic and because it is highly specific to Homoptera (aphids and whiteflies), it should have minimal impact on natural enemies.

Pyriproxyfen and Buprofezin:

- Although both are insect growth regulators (IGRs) and both negatively impact development of immature life stages of whiteflies, they are in different chemical classes and affect whiteflies differently. Neither kills adults, but treated adults lay infertile eggs. Furthermore, eggs treated with pyriproxyfen fail to hatch while those treated with buprofezin tend to hatch normally. Pyriproxyfen interferes with the final molt of the whitefly from pupa to adult while buprofezin interferes with all nymphal molts.
- Both products are recommended for application to tomatoes as the effects of soil-applied imidacloprid diminishes.
- A threshold of 5 nymphs or pupae/10 leaflets has been established to time the applications.
- Because the IGRs affect development, control of whiteflies is not rapid. Although both of the IGRs would be expected to have minimal impact on natural enemies, pyriproxyfen has been shown to be highly toxic to pupae and moderately toxic to larvae of the whitefly parasite *Eretmocerous formosa*, but not to the whitefly parasites *E. pergandiella* and *E. transvena* . Buprofezin was toxic to larvae but not pupae of the whitefly parasite *E. tejanus* and was relatively non-toxic to larvae and adults of the parasite *E. mundus.*

Figure 4. New insecticides, such as pymetrozine are active against aphids and whiteflies. Photograph by: James Castner.

Prepared by: Drs. David Schuster and Phillip Stansly

The biorational nature of pesticides depends upon the time, pest and crop upon which they are used.

Tebufenozide, Methoxyfenozide and Novaluron:

- These IGRs affect development of the larval stages of the southern, beet and other species of armyworms. Novaluron also affects development of immature life stages of whiteflies.
- The controlling affect of the IGRs is not rapid.
- The IGRs would be expected to have minimal impact on natural enemies.

Other Miscellaneous Insecticides:

- Spinosad and spinetoram are in the same chemical class and provide control of armyworms, the tomato pinworm, thrips and have activity against leafminers.
- Indoxacarb, emamectin benzoate, rynaxypyr, metaflumizone, flubendiamide and pyridalyl all provide excellent control of larvae of several armyworm species **(Figure 5)**. The former two also provide control of the tomato pinworm. The activity of the remaining products against the tomato pinworm is not known at this time.
- Rynaxypyr also is active against leafminers and provides control of whitefly adults and nymphs when applied as either a soil drench or a foliar spray.
- Pyridalyl also is active against thrips.
- All of these new products have demonstrated minimal to very low toxicity to natural enemies.

Figure 5. Tebufenozide, indoxacarb, spinosad and emamectin benzoate can control southern armyworm. Photograph by: Lyle Buss.

Figure 6. Reflective mulch is being used together with the reduced-risk insecticide, spinosad, that poses little threat to field workers or the environment. Photograph by: Eric Zamora.

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Florida growers produce tomato and bell pepper throughout the majority of the year. Continuous propagation of a certain type of plant eventually leads to pest infestations. If infestations are managed chemically, and the same pesticide, or class of pesticide, is used to manage the pest, resistance is likely to occur. The rate of resistance development depends on the genetics of the pest and the number of times the pest population is exposed to the pesticide.

If infestations are managed chemically, and the same pesticide, or class of pesticide, is used to manage the pest, resistance is likely to occur.

WHAT IS RESISTANCE?

Resistance is a decrease in the sensitivity of a pest population to a toxicant (pesticide). The evidence of this occurrence is reduced mortality at application rates historically capable of killing the vast majority of the pest. Resistance can develop in two different ways that are not exclusive:

- The organism either limits the amount of toxicant that gets to the target site (by behavior, exclusion or metabolic inactivation).
- The target site itself has changed in a way that the toxicant no longer interacts with it, yet the target pathway still functions well enough for the pest population to thrive.

Figure 7. Bacterial spot is known to have resistance to copper fungicides. Photograph by: Ken Pernezny.

WHERE HAS RESISTANCE BEEN OBSERVED?

- **Arthropods** — Pyrethroid-resistant whitefly developed in the late 1980s, and this problem was not alleviated until new chemistry (imidacloprid, spinosad) supplanted the pyrethroids. Resistance monitoring is now being conducted for the neonicotinoids, so that resistant populations can be identified and managed.
- **Fungal** — Organisms such as *Phytophthora* spp. are known to have multiple biotypes that dictate management.
- **Bacterial** — Bacterial spot is a disease known to have resistance to copper fungicides; copper must be mixed with mancozeb/maneb to overcome this problem.
- **Weed pests** of tomato, and to a lesser degree pepper — Weeds such as American black nightshade and goosegrass have become resistant to paraquat due to the long-term use of this herbicide in row middles.

PESTICIDE MODE-OF-ACTION (MoA)

In order to address resistance, three action committees have been formed to categorize pesticide mode-of-action (MoA):

- Insecticide Resistance Action Committee (IRAC) — insecticides and miticides (See Appendix 5)
- Fungicide Resistance Action Committee (FRAC) — fungicides (See Appendix 6)
- Herbicide Resistance Action Committee (HRAC) — herbicides (See Appendix 7)

Herbicides (HRAC) Mode-of-Class for Tomatoes and Peppers

Herbicide	HRAC Mode-of-Action Class
Bensulide*	8
Carfentrazone	14
Clethodim	1
Clomazone*	13
DCPA	3
Diquat	22
Glyphosate	9
Halosulfuron	2
MCDS	no class
Metribuzin**	5

Herbicide	HRAC Mode-of-Action Class
Nepropamide	15
Oxyfluorfen	14
Paraquat	22
Pelargonic acid	no class
Rimsulfuron**	2
Sethoxydim	1
S-metolachlor	15
Trifloxysulfuron**	2
Trifluralin	3

* Bell pepper only
** Tomato only

Prepared by: Dr. Mark Mossler

CHEMICAL CONTROL:
Pest Resistance

Managing Resistance:

Resistance is most effectively managed by switching to a different category of pesticide. Other methods (using more material, making more applications, using several categories of pesticide at once) are generally more expensive (more pesticide to buy, more fuel and time required for application) and less desirable (loss of beneficial insects, greater environmental load, increased loader/applicator exposure).

Although there are over two dozen categories for each of these groups, it is important to realize that a pesticide from each group may not be available to tomato or pepper growers. Pesticide manufacturers are starting to place the MoA category on pesticide labels. The EPA has recently released voluntary guidelines that suggest that this information should be placed in the upper right quadrant of the first page of the label. The category number should be in black, on white background, enclosed in a narrow black rectangular box. This labeling will make future pesticide selection easier with regard to resistance management.

SOME PESTICIDES DO NOT HAVE A TRUE MoA:

It should be noted that some pesticides do not have a true MoA. Insecticides such as petroleum oil, soaps and boric acid work by either smothering an insect or stripping the wax off the pest which then dies of dehydration. These materials can be used to break the cycle of resistance just as efficiently as switching to another category of pesticide. However, the application and timing of these materials is critical as they do not move within the plant. Fungicides may have several sites of activity such as the case for sulfur and the dithiocarbamates (maneb, mancozeb, etc.). These multi-site fungicides are useful for decreasing resistance due to this activity. Herbicides such as pelargonic acid and acetic acid (vinegar) work by stripping away protective wax cuticles of the plant causing death by desiccation much like the action of boric acid on insects.

Tomato and pepper growers should be aware of chemical management options available, keep records on pest response and consult with pest management professionals when questions arise. Managing resistance will ultimately be rewarded with reduced effort and associated costs of pest control.

Fungicides (FRAC) Mode-of-Action Class for Tomatoes and Peppers:

Fungicide	FRAC Mode-of-Action Class
Acibenzolar-methyl*	P
Axoxystrobin	11
Bascalid	7
Chlorothalonil*	M4
Coppers	M1/M9
Cymoxanil	27
Dicloran*	14
Dimethomorph	15
Famoxadone	11
Fludioxonil**	12
Fosetyl-Al*	33
Mancozeb*	M2
Maneb	M2
Mefenoxam	4
Myclobutanil*	3
Pentachloronitrobenzene (PCNB)	14
Potassium bicarbonate	no class
Potassium phosphate	P
Propamocarb	28
Pyraclostrobin	11
Pyrimethanil*	9
Streptomycin	25
Sulfur	M1
Trifloxystrobin	11
Ziram*	M2
Zoxamide*	22

* Tomato only
** Seed treatment only

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IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension

The Worker Protection Standard (WPS) is a Federal regulation designed to protect agricultural workers (people involved in the production of agricultural plants) and pesticide handlers (people mixing, loading, or applying pesticides or doing other tasks involving direct contact with pesticides).

Figure 7. Disbursements of important information by the commercial handler about a particular pesticide is required to protect employees. Photograph by: Milt Putnam.

WPS has been in full implementation since 1995.

A complete reference for the WPS is provided by: How to comply with the worker protection standard for agricultural pesticides: what employers need to know ***http://www.epa.gov/agriculture/epa-735-b-05-002.pdf.***

INTRODUCTION:

Employers of commercial pesticide handlers must make sure that their customer, the operator of the farm, forest, nursery, or greenhouse, knows certain information about the pesticide before it is applied on the establishment. Operators of farms, forests, nurseries and greenhouses (agricultural employers) must make sure that whenever a commercial handler will be doing pesticide handling tasks (including tasks as a crop advisor) on their establishment, the commercial handler's employer knows specific information concerning treated areas.

INFORMATION FOR ESTABLISHMENT OPERATORS:

Commercial handler employers must inform their customer – the operator of the farm, forest, nursery or greenhouse about:

- The specific location and description of the area(s) on the agricultural establishment that are to be treated with a pesticide
- Time and date the pesticide is scheduled to be applied
- Product name, EPA registration number and active ingredient(s)
- Restricted-entry interval for the pesticide
- Whether the pesticide labeling requires both treated-area posting and oral notification
- Any other specific requirements on the pesticide labeling concerning protection of workers and other persons during or after application

Operators of agricultural establishments must have this information to protect their employees.

INFORMATION FOR COMMERCIAL HANDLER EMPLOYERS:

Operators of agricultural establishments must inform hired commercial pesticide handler employers the location and description of areas that may be treated with a pesticide or be under a restricted-entry interval. Operators of commercial pesticide handling establishments must have this information to protect their employees. For example, if custom applicators are scheduled to use ground equipment to apply a pesticide on a farm, they need to be informed of any nearby areas on the farm that they should stay out of because the area has a restricted-entry interval in effect. Or if commercial crop advisors are scheduled to scout in an area on a farm that remains under a restricted-entry interval, they need to be told what personal protective equipment they must wear while in that area.

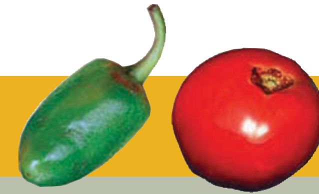
Additional information

Fishel, F.M. 2006. Worker Protection Standard: Information at a Central Location. EDIS Extension Document PI-149.

Fishel, F.M. 2006. Worker Protection Standard: Notice about Applications. EDIS Extension Document PI-149.

How to Comply with the Worker Protection Standard for Agricultural Pesticides: What Employers Need to Know. United States Environmental Protection Agency. Revised 2005. http://www.epa.gov/agriculture/epa-735-b-05-002.pdf.

Prepared by: Dr. Fred Fishel



*Some pesticide labels require you to notify workers both orally **and** with signs posted at entrances to the treated area.*

NOTIFICATIONS ON FARMS, FORESTS AND NURSERIES:

Under most circumstances, worker employers must make sure that workers are notified about areas where pesticide applications are taking place or where restricted-entry intervals are in effect. The restricted-entry interval refers to the length of time that workers are not allowed to enter the treated areas in most cases. With the majority of pesticide products, employers have a choice of orally ***or*** posting treated areas with signs to warn workers. If labels don't specifically include language regarding warning workers by posting signs at treated areas, then an oral warning is all that is required. Some pesticide labels require you to notify workers both orally ***and*** with signs posted at entrances to the treated area. The warnings are in effect for those workers who are or will be within ¼ mile of the treated area. Notification requirements will be in the "Directions for Use" section of the pesticide labeling under the heading "Agricultural Use Requirements" **(Figure 8)**: If both types of notification are required, the following statement will be provided: "Notify workers of the application by warning them orally and by posting warning signs at entrances to treated areas."

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment(PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI). REI Summary: apple, cotton, grapefruit, lemon, nectarines, oranges, tangelo, tangerine = 3 day REI; peaches = 4 day REI; grapes = 7 day REI; all other WPS uses = 48 hour REI.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

Coveralls.
Chemical-resistant gloves, such as barrier laminate or butyl rubber.
Shoes plus socks.
Protective eyewear.

Discard clothing or other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them.
Notify workers of the application to grapes by warning them orally and by posting warning signs at entrances to treated areas.

Figure 8. The "Agricultural Use Requirements" on the pesticide label states how to warn workers of pesticide applications. Excerpt from: Fred Fishel.

NOTIFICATIONS IN GREENHOUSES:

In greenhouses, you must post all treated areas, except those described below. If the labeling requires both types of notification, you must also notify workers orally.

EXCEPTIONS TO WORKER NOTIFICATION:

Oral warnings need not be given to:

- Any worker on your farm, forest, or nursery who will not be in the treated area, or walk within ¼ mile of a treated area, during the pesticide application or while the restricted-entry interval is in effect.
- Any worker who will not be in your greenhouse during a pesticide application or while a restricted-entry interval is in effect there.
- Any worker who applied (or supervised the application of) the pesticide and is aware of all of the information required to be given in the oral warning.

Treated area posting is not required if:

No workers on your farm, forest, or nursery will be in the treated area, or walk within ¼ mile of the treated area, during the pesticide application or while the restricted-entry interval is in effect. No workers will be in the greenhouse during the pesticide application or while the restricted-entry interval is in effect there. The only workers for whom you need to post applied (or supervised the application of) the pesticide and are aware of all the information required to be given in the oral warning.

Sources for WPS Publications:

Dept. of Ag and Consumer Services
http://www.doacs.state.fl.us/onestop/forms/13361.pdf

U.S. Environmental Protection Agency
http://www.epa.gov/agriculture/apes.html
http://nepis.epa.gov/pubtitleOPPTS.htm

Prepared by: Dr. Fred Fishel

Table 4. Pesticide products requiring oral and posting warnings to workers.

Product name	Active ingredient	EPA registration number	Restricted entry interval
Banol	propamocarb hydrochloride	432-942	24 hrs
Captan 80W	captan	19713-405	24 - 96 hrs (see label) SI*
Captan 80WDG	captan	66222-58-19713	24 - 96 hrs (see label) SI*
Captan Pro 80WDG	captan	66330-29	24 - 96 hrs (see label) SI*
Comite	propargite	400-104	7 days - see label
Counter 15G	terbufos	241-238	48 hrs RUP** SI*
Counter 20CR	terbufos	241-314	48 hrs RUP** SI*
Curacron 8E	profenofos	100-669	48 hrs RUP**
Di-Syston 15%	disulfoton	264-723	48 hrs RUP** SI*
Di-Syston 8	disulfoton	264-734	48 hrs RUP** SI*
Finish 6	ethephon + cyclanilide	264-585	48 hrs
Finish 6 Pro	ethephon + cyclanilide	264-703	48 hrs
Furadan 4F	carbofuran	279-2876	48 hrs - 14 days (see label) RUP**
Guthion Solupak 50%	azinphos-methyl	264-733	Varies by crop (see label) RUP**
Methyl 4EC	methyl parathion	67760-43	96 hrs RUP**
Monitor 4	methamidophos	264-729	48 hrs RUP**
Nemacur 15% G	fenamiphos	264-726	48 hrs RUP** SI*
Nemacur 3	fenamiphos	264-731	48 hrs RUP** SI*
Prep	ethephon	264-418	48 hrs
Syllit 65W	dodine	264-508-34704	48 hrs
Syllit 65W	dodine	55260-5-34704	48 hrs
Syllit FL	dodine	55260-6	48 hrs
Telone C-17	dichloropropene + chloropicrin	62719-12	5 days RUP**
Telone C-35	dichloropropene + chloropicrin	62719-302	5 days RUP**
Telone EC	dichloropropene	62719-321	5 days RUP**
Telone II	dichloropropene	62719-32	5 days RUP**
Temik 15G CP	aldicarb	264-417	48 hrs RUP** SI*
Temik 15G Lock 'n' Load	aldicarb	264-330	48 hrs RUP** SI*
Temik 15G	aldicarb	264-330	48 hrs RUP** SI*
Terraclor 6.5% + Di-Syston 6.5%	PCNB + disulfoton	400-411	48 hrs RUP** SI*
Terraclor Super X with Di-Syston G	PCNB + disulfoton	400-408	48 hrs SI*
Terraclor Super X plus Di-Syston EC	PCNB + disulfoton	400-475	48 hrs RUP** SI*
Thimet 20-G	phorate	241-257-51036	48 hrs RUP** SI*
Thimet 20-G Lock 'n' Load	phorate	241-257-51036	48 hrs RUP** SI*

*SI: no restricted re-entry may apply when soil injected/incorporated or in some situations where the worker does not touch or disrupt the soil subsurface or anything that was treated (refer to individual product labels).

**RUP = Restricted use pesticide.

CHEMICAL CONTROL: Worker Protection Standard Notice about Applications

POSTED WARNING SIGNS:

Use WPS-design signs **(Figure 9)** when you post warnings at entrances to treated areas. If posting fumigant applications, use fumigant warning signs **(Figure 10)**.

On farms, forests and nurseries, post the signs so they can be seen from all points where workers usually enter the treated area, including at least:

- Each access road
- Each border with any labor camp adjacent to the treated area
- Each established walking route that enters the treated area

When there are no usual points of worker entry, post the signs in the corners of the treated area or in places where they will be most easily seen. In greenhouses, post the signs so they can be seen from all points where workers usually enter the treated area, including doorways, aisles and other walking routes. When there are no usual points of worker entry to the treated area, post the signs in the corners of the treated area or in places where they will be easily seen.

Timing and visibility of warning signs:

- Post signs 24 hours or less before the scheduled application of the pesticide.
- Keep signs posted during application and throughout the restricted-entry interval (if any).
- Remove the signs within 3 days after the end of the restricted-entry interval. If there is no restricted-entry interval for that application, remove the signs within 3 days after the end of the application.
- Keep workers out during the entire time the signs are posted (except for trained and equipped early-entry workers entering as permitted under WPS).
- Keep signs visible and legible while they are posted.

Figure 9

Figure 10

When several adjoining areas are to be treated with pesticides on a rotating or sequential basis, you may post the entire area at the same time. Worker entry, except for early entry permitted by the WPS, is prohibited for the entire area while the signs are posted.

Figure 9. WPS-design sign for posting pesticide application warnings to workers. Photograph by: UF/IFAS.
Figure 10. WPS-design sign for posting fumigant application warnings to workers. Photograph by: UF/IFAS.
Figure 11. The majority of pesticides regulated under the WPS require an oral warning to workers. Photograph by: UF/IFAS.

Oral warnings **(Figure 11)** must include:

- The location and description of the treated area
- The time during which entry is restricted
- Instructions not to enter the treated area until the restricted-entry interval has expired

Oral warnings must be communicated to workers in a manner they can understand. The timing of oral warnings should be such that:

- Workers who are on your establishment at the start of an application must be orally warned before the application takes place;
- Workers who are not on your establishment at the start of an application must be orally warned at the beginning of their first work period if (1) the application is still taking place or (2) the restricted-entry interval for the pesticide is in effect.

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ADDITIONAL INFORMATION:

How to comply with the worker protection standard for agricultural pesticides: what employers need to know. United States Environmental Protection Agency. Revised 2005: http://www.epa.gov/agriculture/epa-735-b-05-002.pdf.

Reduced Use of Restricted and Danger-Labeled Pesticides in Florida Tomato and Bell Pepper Production (1992-2004):

REDUCTION IN PESTICIDE USE:

Tomato

Pesticide use values for 2004 compared to peak usage data for the period 1992 through 2004 demonstrate a 75% reduction in the application of restricted or "Danger"-labeled insecticides in fresh market tomato. This value was 31% for the herbicide paraquat, while the value for fumigants was 17%.

Pepper

Pesticide use values for 2004 compared to peak usage data for the period 1992 through 2004 demonstrate a 56% reduction in the application of restricted or "Danger"-labeled insecticides in bell pepper. Paraquat use was reduced by 89%. Fumigant use (35% reduction) was mainly influenced by rate reduction, rather than reduction of use.

The impetus for reduction in use has come mainly from the methyl bromide phaseout that is occurring under the Montreal Protocol on Substances that Deplete the Ozone Layer. The use of methyl bromide will continue to decline, until it is completely phased out as an agricultural pesticide. However, its use may well be supplanted by methyl iodide or other fumigants, which would likely carry the restricted use status and "Danger" labeling.

REDUCTION IN RESIDUES:

Tomato

Increased IPM adoption and reduced spraying of these ingredients is reflected in a 50% decrease in methamidophos residues (from 0.016 PPM to 0.008 PPM) in fresh market tomato from the period 1997-1998 to 2003. These values are far from the tolerance in tomato for methamidophos (1.0 PPM).

Pepper

Increased IPM adoption and reduced spraying of these ingredients is reflected in a 58% decrease in methomyl residues (from 0.019 PPM to 0.008 PPM) in bell pepper from the period 1999 to 2003. These values are far below the tolerance in bell pepper for methomyl (0.2 PPM).

These active ingredients account for over 95% of the restricted or exclusively labeled "Danger" pesticides employed in Florida tomato and pepper production.

- *Endosulfan*
- *Esfenvalerate*
- *Methamidophos*
- *Methomyl*
- *Oxamyl*
- *Permethrin*
- *Paraquat*
- *Chloropicrin*
- *Methyl bromide*

The reduction in use of the restricted use and "Danger"-labeled pesticides is believed to be due to strong adoption of integrated pest management (IPM) principles by Florida tomato and pepper growers, working in conjunction with Extension agents and professionals.

Figure 12. Fumigants are applied through specialized equipment that integrates it into the soil and covers with a mulch. Photograph by: Fred Fishel.

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