

A Pesticide Decision-Making Guide to Protect Pollinators in Small Fruits including Vine Crops

> 2019 Edition By Maria van Dyke, Emma Mullen, Dan Wixted, and Scott McArt

A Pesticide Decision-Making Guide to Protect Pollinators in Tree Fruit Orchards

> 2018 Edition By Maria van Dyke, Emma Mullen, Dan Wixted, and Scott McArt

A Pesticide Decision-Making Guide to Protect Pollinators in Landscape, Ornamental and Turf Management

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HOW TO USE

The Pesticide Decision-Making Guides

Toxicities, Synergies & Suggested Alternatives

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https://pollinator.cals.cornell.edu/resources/grower-resources/

or

Pollinator Network @ Cornell Dyce Lab -> Grower Resources



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The Pesticide Decision-Making Guides

go beyond

EPA standards:

The Pesticide Decision-Making guides report on

- toxicity to non-honey bee species
- toxicity to life stages other than adults
- sublethal toxicity to bees
- **fungicide** toxicity to bee species
- **synergisitic (a)** effects on toxicity

<u>Synergy</u>

A combined toxicity of two or more active ingredients that's **greater than the sum** of the toxicity of each pesticide alone.

Most toxic and/or most collected pesticide residues in the pollen & wax of 3 bee species

	Chemical	Product Name(s)	Type of	Toxicity	Persistance
Known synergist			Pesticide		
	Thiamethoxam	Actara, Cruiser, Durivo, Platinum, Voliam	Neonic	Н	Mod
Known synergist 🗙	Cyfluthrin	Leverage, Defcon, Aztec, Tombstone,	Pyrethroid	Н	Mod
		Baythroid			
Known synergist 🔺	Chlorpyrifos	Lorsban, Cobalt, Hatchet	Organoph.	Н	Mod-H
	Indoxacarb	Avaunt	Oxadiazine	Н	?
Known synergist	Methidathion	Sumonic, Supracide, Somonil	Organoph.	Н	Low
	Imidacloprid	Macho, Admire, Couraze, Brigadaire	Neonic	Н	High
Known synergist	Carbaryl	Sevin	Carbamate	Н	Low
Known synergist	Acetamiprid	Assail	Neonic	Μ	Mod-H
	Piperonyl butoxide	Pyronyl Crop Spray	Synergist	Н	Low-M
Known synergist	Cyprodinil	InspireSuper, Vanguard	AP	L*	Mod
Known synergist ►	Iprodione	Rovral 4	Dicarb	L	Low
Known synergist	Pyraclostrobin	Insignia, Headline, Cabrio, Pristine	Qol	L*	High
	Fluxapyroxad	Priaxor	SDHI	L	High
Known synergist →	Difenoconazole	Aprovia Top, Inspire Super, QuadrisTop,	EBI	L*	High
		RevusTop			
Known synergist 🔺	Propiconazole	Bumper, Quilt, Propimax EG	EBI	L*	High
Known synergist	Trifloxystrobin	Flint, Gem, Luna Sensation	Qol	L*	Mod
	Myclobutanil	Rally 40 SWP	EBI	L*	High

Chlorothalonil as a Synergist

Chlorothalonil causes fluvalinate to become 5 times more toxic



Mortality of developing honey bee larvae

Synergistic toxicities can increase over time







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Understanding terms used in the guide



A combined toxicity of two or more active ingredients that's **greater than the sum** of the toxicity of each pesticide alone.

Systemic Pesticides

Systemic pesticides are mobile in the soil and within the plant. Bees are exposed to these chemicals via pollen, nectar, guttation droplets for days or weeks after application creating unintended synergistic reactions and toxicity beyond label warning.

Adjuvants and/or inert ingredients

Included because recent findings have demonstrated that some of these cause synergistic reactions or are toxic to bees.

Table 1. Product formulations and their active ingredients

Product Name	Active ingredient	Product Name	Active ingredient	Product Name	Active ingredient	
Fungicides, antibi	otics and inert	Elatus	benzovindiflupyr	Polyram 80 DF	metiram	
ingredients		Elevate	fenhexamid	Presidio*	fluopicolide	
Abamectin	N-methyl-2-pyrrolidone	Empress Intrinsic	pyraclostrobin	Pristine fungicide	boscalid + pyraclostrobin	
(inaredient in)	(NMP)	Encartis	boscalid + chlorothalonil Procure*		triflumizole	
Abound	azoxystrobin	Endura	boscalid	Prophyt	phosphorous acid	
Academy	difenoconazole +	Equus products	chlorothalonil		(potassium phosphite)	
Adductiny	fludioxonil	Ethos§	Bacillus amyloliquefaciens	Propi Max	propiconazole	
Acadia	azoxystrohin	Exilis plus	N-methyl-2-pyrrolidone Pure Spray		mineral oil	
Actigard	acibenzolar-s-methyl	Exponent	piperonyl butoxide	Quadris F	azoxystrobin	
Aframo	azovystrobin	Ferbam	ferbam	Quadris Opti	azoxystrobin +	
Arranie	notassium bicarbonate	Fireline	oxytetracycline		chlorothalonil	
Agri_mycin	strentomycin	Firewall	streptomycin	Quadris Top	azoxystrobin +	
ΔσriTin*	trinhenvltin hydroxide	Flint	trifloxystrobin		difenoconazole	
Alamo	proniconazola	Flint Extra	<mark>trifloxystrobin</mark>	Quali-Pro	mefenoxam	
Aliette	fosetyl-al	Fontelis	penthiopyrad	Quash	metconazole	
Alea*	propicopazole	Fortix	flutriafol	Quilt	azoxystrobin +	
Anistar Amistar	difenoconazole	Fortuna	mancozeb		propiconazole	
Annovia	henzovindiflunyr	Freshgard	imazalil	QuiltXcel	azoxystrobin +	
AproviaTon	benzovindiflupyr + difenoconazole	Fungaflor	imazalil		propiconazole	
Аргоматор		Fungazil	imazalil	Quintec	quinoxyfen	
Ardont <i>lingredient</i>	N-methyl-2-pyrrolidone	Fungisol	debacarb	Rally 40 WSP	myclobutanil	
in)	(NMD)	Gem 500 SC	trifloxystrobin	Ranman 400SC	cyazofamid	
μη Δτογμεται	azovystrobin	Glacial Spray	mineral oil	Regalia	reynoutria	
Raduo SC & X28	copper oxychloride +	Heritage	azoxystrobin	Revitalize§	Bacillus amyloliquefaciens	
Dauge JC & AZS		Incognito 4.5F	thiophanate-methyl Rhyme fenbuconazole Ridomil Gold SL		flutriafol	
Ranner Mayy	propiconazola	Indar2F			mefenoxam	
Biocover	mineral oil	Initiate	chlorothalonil	Rovral 4 F*	iprodione	
Bonide complete	cantan	InspireSuper	difenoconazole + cyprodinil	Scala	pyrimethanil	
fruit tree snrav	captan	Iprodione2F Select*	iprodione	Scholar	fludioxonil	
Ronido Fruit Troo &	hoscalid+nyraclostropin+	Kaligreen	potassium bicarbonate	Serenade §	Bacillus subtilis	
Doniue Fruit free &	lambda_cybalothrin	Kasumin 2L	kasugamycin	Sonata§	Bacillus subtilis	
Rordeauv&	conner sulfate	Kestrel Mex*	propiconazole	Sonoma 20 EW AG	myclobutanil	
Bravol litrov	chlorothalonil	Kocide§	copper hydroxide	Sonoma 40 WSP	myclobutanil	
Bromazil	imazalil	Kodiak§	Bacillus subtilis	Sovran	kresoxim-methyl	
Diomazii Dumnor 2E0 EC*	propisopazolo	Liquid Copper	copper octanoate	Streptrol	streptomycin	
RVA	mineral oil	Products§		SubdueGR	mefenoxam- nonbearing	
000	copper ovychloride +	Luna Sensation [†]	na Sensation† fluopyram + trifloxystrobin Se		sulfur	
0.0.0.3.	conner sulfate	Luna Tranquility†	fluopyram + pyrimethanil	SuperTin*	triphenyltin hydroxide	
Cabrio EC	pyraclostrohin	ManKocide	mancozeb + copper	Syllit FL	dodine	
Camelat Of			hydroxide	Tartan	trifloxystrobin	

Table 2. Pesticide synergies and acute, chronic, and sublethal toxicities forhoney bees and other pollinators in tree fruit orchards

Key to table abbreviation, symbols, and colors

* - Restricted-usepesticide

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- Not for use in Nassau and Suffolk counties of New York
- Meets USDA organic standards
- Identifies a chemical that at least one study has shown synergy with other active ingredients or products.
- Identifies a formulation containing more than one active ingredient, at least one of which has been shown to synergize with other chemicals

EPA standard toxicity ratings: acute oral and/or contact toxicity to the honey bee (Apis mellifera)

- Highly toxic (acute LD₅₀ < 2μg/bee)
- Moderately toxic (acute LD₅₀ 2 10.99µg/bee)
- Practically non-toxic (acute LD₅₀ >11 µg/bee)

Fungicides, antibiotics and inert ingredients for use on tree fruit

Active Ingredient Chemical group [Resistance code]	New York Trade Name Examples	High toxicity	Moderate toxicity	Practically non-toxic	Synergies, sublethal effects, and toxicity to bee species other than the honey bee
captan phthalimide fungicide [M4]	Captan 50 WP, Captan, 80 WDG, Captec 4L				Studies have found captan to increase honey bee brood mortality to a moderately toxic level ^{9,10} and alter larval feeding capacity ¹¹ . Astudy conducted by the USDA Bee Lab in Weslaco, TX found that the inert ingredients mixed with captan make it highly toxic ¹² . Other laboratory studies report captan to be highly toxic to mason bees ¹³ and leafcutter bees ^{14,15} but practically non-toxic to bumble bees at recommended field rates ¹⁶ .
chlorothalonil chloronitrile fungicide [M5]	Bravo ZN, Bravo Ultrex, Echo Products, Equus, Initiate			8	Synergizes with <i>alpha</i> -cypermethrin and lambda- cyhalothrin ¹⁷ and the beekeeping miticides <i>tau</i> - fluvalinate, coumaphos ^{18,19} , and thymol ¹⁸ . Also synergizes with Cerconil [®] (thiophanate-methyl). Chlorothalonil exhibits cumulative oral toxicity in honey bee larvae reared on field relevant doses for 6 days ¹⁹ and increases honey bee and bumble bee susceptibility to <i>Nosema</i> infection ^{20,21} and entombed pollen inside the honey bee hive ²⁰

Active Ingredient	New York Trade Name	High toxicity	Moderate toxicity	Practically non-toxic	Synergies, sublethal effects, and toxicity to bee species other than the honey bee
[Resistance code]	Examples	· ·			openeo oner man menoney bee
copper octanoate inorganic fungicide/bacteriacide [M1]	Camelot O§, Cueva§, Liquid copper Products§, Ortho Elements Garden§				
copper oxychloride/ copper hydroxide inorganic fungicide/bacteriacide [M1]	Badge SC & X2§			8	Copper oxychloride synergizes with imidacloprid ²² .
copper oxychloride/copper sulfate inorganic fungicide/bacteriacide [M1]	C.O.C.S.			8	Copper oxychloride synergizes with imidacloprid ²² .
copper sulfate inorganic fungicide/bacteriacide [M1]	Bordeaux§, Cuprofix Ultra§, Cuproxat§, Mastercop§				Highly toxic to a stingless beespecies via oral exposure ²³ .
cyprodinil anilino-pyrimidine fungicide, [9]	Vanguard WG			8	Moderate toxicity when it synergizes with thiacloprid ² .
difenoconazole DMI-triazole fungicide [3]	Quadris-Top, Amistar, etc.			8	Synergizes with deltamethrin ²⁴ and the <i>tou</i> -fluvalinate ²³ product Mavrik [®] inducing hypothermia in honey bees.
difenoconazole + fludioxonil DMI-triazole + phenylpyrroles fungicides [3+12]	Academy			×	See difenoconazole and fludioxonil separately for synergy information.
difenoconazole + cyprodinil DMI-triazole + anilino- pyrimidine fungicides [3+9]	Inspire Super			*	See difenoconazole and cyprodinil separately for synergy information.
dodine guanidine fungicide [U12]	Syllit FL				
fenbuconazole DMI-triazole fungicide [3]	Indar 2F			8	Synergizes with <i>tau</i> -fluvalinate ¹⁸ making it highly toxic to honey bees. At a field relevant dose Indar 2F ⁶ (fenbuconazole) synergizes with a cetamiprid ²⁶ in a solitary bee, doubling the toxicity of a cetamiprid, making it borderline highly toxic (LD ₁₀ 2.1).

Potential For Synergies

- Wildflowers along field edges & in between crop rows (wild bees & honey bees)
- Pre-Bloom or Pink (wild bees & honey bees)





Early bloom



Petal fall



 Inside Honey bee hives (miticide & fungicide treatments) (honey bees only)



Synergies with BeeKeeping Miticides

- 1. Chlorothalonil (tau-fluvalinate, thymol, and coumaphos)
- 2. Fenbuconazole (tau-fluvalinate)
- 3. Metconazole (tau-fluvalinate)
- 4. Myclobutanil (tau-fluvalinate)
- 5. Propiconazole (tau-fluvalinate)
- 6. Thiophanate-methyl (tau-fluvalinate)
- 7. Pyraclostrobin (tau-fluvalinate)

Synergy potential at Pink in apple

Pink (Insecticides)

Pink (Fungicides)

Warrior II lambda cyhalothrin (black stem borer/TPB/leafminer)



Rally 40WSP myclobutanil (Pmildew) Manzate ProStik/Penncozeb Mancozeb (scat Topguard flutriafol (scab

Assail acetamiprid (Dogwood borer/leafminer/aphid)



Indar 2F fenbuconazole (scab, rust, P mildew) Procure 480SC triflumizole (P mildew)

Voliam Flexi thiamethoxam (TPB/Rosy aphid/leafminer)



Rally 40WSP myclobutanil (rust, P mildew)

Alternatives at Pink in apple

Pink (Insecticides)

Pink (Fungicides)

- For black stem borer, TPB, & leafminers use:
 Danitol fenpropathrin,
 Beleaf (flonicamid),
 Avaunt (indoxacarb),
 Delegate (spinetoram)
- For leaf rust use: Fontelis (penthiopyrad) Or Polyram (metiram)
- For powdery mildew use:
 Vivando
 Sovran
 Luna tranquility (lower synergy potential) Or
 Merivon (lower synergy potential)

Synergy potential at Bloom in apple

Bloom (Insecticides) Bloom (Fungicides)

Insecticide exposure from other fruit trees nearby -cherry

-plum

-pear



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Cedar apple rust and powdery mildew fungicide products that synergize with neonics sprayed nearby in pear, cherry, and apricot are: (Indar/Procure/Rally 40WSP/ mancozeb products/Inspire Super/Flint/ thiophanate-methyl products)

Fireblight fungicides (Fireline/Mycoshield/ Badge) can synergize with **beekeeping miticides** (tau-fluvalinate/ coumaphos/ amitraz/thymol/oxalic acid)



Triflumizole (Procure 480SC) could synergize with acetamiprid and imidacloprid being sprayed on other tree fruit.

Synergy potential in apple

Petal Fall (insecticides)

Aphid Leaf miner Leafroller/plum curculio: Admire Pro (imidacloprid)

Codling Moth: Assail (acetamiprid), Baythroid (cyfluthrin), or Imidan (phosmet)



Petal Fall (fungicides)

Badge (copper mix) for Fireblight

Cedar apple rust and powdery mildew fungicides: (Indar/procure/Rally 40WSP/mancozeb products/Inspire Super/Flint/ thiophanate-methyl products)

Powdery mildew: Procure 480SC (triflumizole) Indar 2 (fenbuconazole), Tilt (propiconazole)

Fireblight TRT: (Fireline/Mycoshield/Badge) often synergize with beekeeping miticides (tau-fluvalinate/coumaphos/ amitraz/thymol/oxalic acid)

Alternatives at Petal Fall in apple

Petal Fall (insecticides)

- For Aphid Lea, leafrollers, or plum cuculio use: Exirel (cyantranilprole), Avaunt (indoxacarb-less toxic neonic), Danitol (fenpropathrin)
- For coddling moth instead use: pheromones
 Dipel (Bt), Danitol (fenpropathrin),
 Esteem (pyroproxyfen), Neemix (azadirachtin)

Petal Fall (fungicides)

- For Fireblight TRT instead use: Agri-mycin, Firewall, or Double Nickel
- For Cedar apple rust and powdery mildew fungicides instead use:
 Polyram (metiram) or maybe Merivon (lower synergy potential bc it's a mix)
- For Powdery mildew instead use: Vivando (emtrafenone) or Sovran (kresoxim-methyl)

Fireblight TRT: (Fireline/Mycoshield/Badge) often synergize with beekeeping miticides (tau-fluvalinate/coumaphos/ amitraz/thymol/oxalic acid)

Questions?



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