

and screens in light oil. Store the sprayer in a clean, dry shed. If the pump cannot be drained completely, store the sprayer where it cannot freeze. Support the sprayer on blocks to take the weight off the tires.

## Pesticide Safety

### Toxicity of Pesticides

Pesticides are manufactured to be toxic, or poisonous, to pests. Because many pesticides are toxic to a broad range of organisms, they are potentially hazardous to humans, livestock, and other animals. Because the toxicity of different pesticides varies greatly, people who use pesticides should have a general knowledge of the relative toxicity of the chemicals that they apply.

The acute toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of the active ingredient in the pesticide product. In the most common of these tests, the active ingredient may be administered orally, by feeding the chemical to test animals, or dermally, by applying the chemical to the animals' skin. (Other methods of exposure may also be tested.) Results are analyzed to produce an estimate of an LD<sub>50</sub> — the lethal dose that kills 50% of the test animals. LD<sub>50</sub> values are expressed as mg of pesticide per kg of the test animal's weight.

Based on LD<sub>50</sub> values and similar estimates of acute toxicity, pesticide labels contain signal words that categorize the pesticide's acute toxicity. Labels for highly toxic pesticides (those with very low LD<sub>50</sub> values) display the words DANGER — POISON and a skull-and-crossbones symbol. Moderately

toxic pesticides have the word WARNING on the label, and the least toxic pesticides are labeled with the signal word CAUTION. Table 8-6 summarizes the relationships among pesticide toxicity ratings, LD<sub>50</sub> estimates, and estimated lethal doses for adult humans. All pesticide labels bear the statement: KEEP OUT OF REACH OF CHILDREN.

Table 8-7 summarizes LD<sub>50</sub> estimates for several common pesticides used in small fruit production. LD<sub>50</sub> values are useful indicators of danger, but they do not describe all aspects of pesticide toxicity. They do not, for example, indicate risks of eye injury, throat or lung irritation, chemical burns, or neurological damage. Additionally, the chronic effects of repeated low-dose exposures to pesticides are difficult to assess. As a result, applicators are urged to apply pesticides only when necessary and to use protective clothing and equipment to avoid exposures by oral, dermal, or inhalation routes.

### Pesticide Applicator Certification

The United States Environmental Protection Agency (EPA) has classified certain pesticides as Restricted-Use Pesticides. Growers who wish to use these pesticides must be certified as private applicators. A fruit grower may become certified as a private applicator by attending training sessions conducted by the Extension Service in each state. Training at these sessions covers pesticide labeling; safety factors, including employee safety; environmental concerns; identification of common pests; pesticides and their use; equipment and application techniques; and state and federal regulations. Extension staff members

**Table 8-6. Oral, Dermal, and Inhalation Toxicity Ratings of Pesticides.<sup>1</sup>**

Toxicity Rating	Label Signal Words	Oral LD <sub>50</sub> (Mg/kg)	Dermal LD <sub>50</sub> (Mg/kg)	Lethal Oral Dose, 150-Pound Man
High	Danger-Poison	0 - 50	0 - 200	few drops to teaspoon
Moderate	Warning	50 - 500	200 - 2,000	1 teaspoon to 1 ounce (2 tablespoons)
Low	Caution	500 - 5,000	2,000 - 20,000	1 ounce to 1 pint, or 2 pounds
Very low	Caution	5,000+	20,000+	1 pint or more, or 2 pounds or more

<sup>1</sup> Note that values in these categories indicate LETHAL (deadly) doses; much lower doses may cause severe injury or chronic health effects.



<b>Table 8-7. LD<sub>50</sub> Values for Common Small Fruit Pesticides.</b>			
<b>Trade Name<sup>TM</sup></b>	<b>Common Name</b>	<b>Oral LD<sub>50</sub><sup>1</sup> mg/kg</b>	<b>Dermal LD<sub>50</sub><sup>1</sup> mg/kg</b>
<b>Fungicides</b>			
Aliette	fosetyl-AL	2860	>2,000
Bayleton	triadimefon	1,020	>5,000
Benlate	benomyl	>10,000	>10,000
Captan	captan	9,000	--
Dithane M45	mancozeb	11,200	>15,000
Dyrene	anilazine	>5,000	>5,000
Funginex	triforine	6,000	>2,000
Karathane	dinocap	980	--
Manzate 200	mancozeb	11,200	>15,000
Nova	myclobutanil	1,600 to 2,290	>5,000
Penncozeb	mancozeb	11,200	>15,000
Ridomil	metalaxyl	669	>3,100
Ronilan	vinclozolin	>10,000	--
Rovral	iprodione	4,400	>2,000
Rubigan	fenarimol	2,500	--
Sulfur	sulfur	--	--
Thiram	thiram	780	>5,000
Topsin-M	thiophanate-methyl	7,500	--
Zineb	zineb	>5,200	>10,000
<b>Herbicides</b>			
Casoron	dichlobenil	603 to 3160	1,350
Dacthal	DCPA	>10,000	>10,000
Devrinol	napropamide	>5,000	>4,640
Dual	metolachlor	2,780	>10,000
2,4-D	2,4-D	300-1,000	--
Fusilade	fluazifop	2,712	>2,420
Goal	oxyfluorfen	>5,000	>10,000
Gramoxone Extra	paraquat	100	--
Karmex	diuron	3,400	>5,000
Kerb	pronamide	5,620	>3,160
Poast	sethoxydim	2,676	--
Princep	simazine	>5,000	>10,000
Prowl	pendimethalin	3,956	>2,200
Roundup	glyphosate	5,400	>5,000
Sinbar	terbacil	>5,000	>5,000
Snapshot	asoxaben/oryzalin	>5,000	--
Solicam	norfluazon	>10,000	>20,000
Surflan	oryzalin	>10,000	--
Touchdown	sulfosate	--	--



<b>Table 8-7 (Continued). LD<sub>50</sub> Values for Common Small Fruit Pesticides.</b>			
<b>Trade Name<sup>TM</sup></b>	<b>Common Name</b>	<b>Oral LD<sub>50</sub><sup>1</sup> mg/kg</b>	<b>Dermal LD<sub>50</sub><sup>1</sup> mg/kg</b>
<b>Insecticides</b>			
Acramite	bifenazate	>5000	>5000
Admire	imidacloprid	4143-4870	>2000
Agri-Mek	abamectin	300	>1,800
Asana	esfenvalerate	458	>2000
Assail	acetamiprid	1064	>2000
Brigade	bifenthrin	375	>2,000
Capture	bifenthrin	262	>2000
Confirm	tebufenozide	>5000	>5000
Danitol	fenpropathrin	71-164	>2,000
Diazinon	diazinon	300-400	3,600
Dibrom	naled	191	360
Dipel <sup>2</sup>	<i>Bacillus thuringiensis</i>	Nontoxic	Nontoxic
Entrust	spinosad	>5000	>2000
Esteem	pyriproxyfen	>5000	>5000
Furadan	carbofuran	7	6783
Guthion	azinphosmethyl	5-20	220
Imidan	phosmet	147-316	>4,640
Intrepid	methoxyfenozide	>5000	>2000
Kelthane	dicofol	820-960	2,100
Lannate	methomyl	17-24	5,880
Lorsban	chlorpyrifos	96-270	2,000
Malathion	malathion	1,000-2,800	4,100
Metaldehyde	metaldehyde	630	--
M-Pede	fatty acid soap	16,500	Nontoxic
Neemix	azadirachtin	13,000	--
Provado	imidacloprid	4143-3870	>2000
Pyramite, Nexter	pyridaben	1930	>2000
Pyrellin	pyrethrins + rotenone	1620	NA
Pyronyl	pyrethrins	2370	>2000
Rotenone	rotenone	132-1,500	940-3,000
Savey	hexythiazox	>5000	>5000
Sevin	carbaryl	246-283	>2,000
Spintor	spinosad	>5000	>5000
Surround	kaolin	>5000	NA
Thiodan	endosulfan	160	359
Vendex	fenbutatin-oxide	2,631	>2,000
Zeal	etoxazole	>5000	>5000
<sup>TM</sup> Where names are used, no discrimination is intended and no endorsement by Extension is implied.			
<sup>1</sup> Expressed in milligrams of pesticide product per kilogram of body weight in mammalian tests.			
<sup>2</sup> Other trade names include Agree, Cutlass, and Javelin.			



usually conduct these training meetings, and a test may be required in addition to or in lieu of attending training sessions. Contact local Extension personnel for more information.

Among the pesticides registered for use in small fruit, those classified for Restricted Use include:

- Agri-Mek (abamectin)
- Asana (esfenvalerate)
- Brigade (bifenthrin)
- Capture (bifenthrin)

- Danitol (fenprothrin)
- Diazinon
- Gramoxone Extra (paraquat)
- Guthion (azinphosmethyl)
- Lannate (methomyl)
- Lorsban 4E (chlorpyrifos)
- All soil fumigants (see Table 8-8).

There are no Restricted-Use fungicides at the present time.

<b>Table 8-8. Fumigant Rates and Spectrums of Activity.</b>						
Common Name	Trade Name	Rates/ Acre	Level of Control <sup>a</sup>			Comments
			Nema- todes	Fungi	Weeds	
D-D Mixture <sup>b</sup>	Telone II	16-20 gal	4	1	0	Slight suppression of some soil-borne organisms
D-D Mixture <sup>b</sup> + chloropicrin	Telone C17	30-40 gal	4	5	1	Effective against most soil-borne diseases; some weed seed suppression.
	Terr-O-cide 15D	30-40 gal	4	5	1	
	Terr-O-cide 30D	25-35 gal	4	5	1	
methyl isothiocyanate compounds	Vapam	50-100 gal	4	4	3	Most effective when applied through over-head irrigation; incorporate thoroughly in soil.
	Basamid 99G	250-350 lb	4	4	3	
methyl bromide	Brom-O-Gas	275-350 lb	5	4	4-5	Requires a plastic seal; highly toxic to humans; weak against some Pythium species.
methyl bromide +	Terr-O-Gas 67	275-350 lb	5	5	4-5	Most effective for control of weeds, chloropicrin soil-borne disease; nema todes, and insects; requires plastic seal; highly toxic.
<sup>a</sup> 0 = no control; 5 = excellent control.						
<sup>b</sup> Mixture of dichloropropanes and dichloropropenes in various ratios.						
Courtesy of Rutgers University. Used with permission.						



## Record Keeping, Worker Protection, and Reentry Times

EPA regulations enacted in 1994 and 1995 include specific requirements for pesticide record-keeping and a Worker Protection Standard that covers worker training and reentry intervals (time periods, after pesticide application, during which unprotected workers are not to enter treated areas). Growers must keep records of applications of Restricted-Use Pesticides. Records must include:

- The brand name or product name and the EPA registration number of the pesticide.
- The total amount of the product (formulated material, not active ingredient) applied.
- The location of the application.
- The size of the treated area.
- The crop, commodity, or site treated.
- The month, day, and year of the application.
- The name and certification or license number of the applicator.

Although these record-keeping rules cover only Restricted-Use Pesticides, growers are urged to keep complete records on all pesticide applications.

The Worker Protection Standard requires that:

- Workers be trained in pesticide safety.
- Growers display pesticide information at a location accessible to all workers.
- Workers be notified of pesticide applications and any reentry restrictions that apply.
- Unprotected workers be kept out of treated areas until the reentry restrictions have elapsed.
- Growers provide appropriate protective equipment to workers.
- Wash water, soap, and single-use towels be provided at a clean site for decontamination.
- Growers provide emergency assistance to workers who are poisoned or injured in a work-related pesticide exposure.

Growers must comply with the worker protection and reentry requirements stated on pesticide labels. Training programs for pesticide applicator certification include details on record-keeping and worker protection. Contact local Extension personnel for information on training programs.

## Pesticide Safety and Use

A few simple but important rules should be followed in all pesticide applications:

1. **USE PESTICIDES ONLY WHEN NECESSARY** and only at the recommended rates and times so that residues on crops do not exceed tolerances set by law.
2. **READ AND FOLLOW ALL PESTICIDE LABEL DIRECTIONS.**
3. Use the right pesticide. Consult up-to-date spray guides and check the pesticide label to be sure that what you spray is registered for the intended use and likely to control the target pest.
4. Avoid spray or dust drift from the target crop.
5. Wear protective clothing and use protective equipment according to instructions on the pesticide label. Never eat, drink, or smoke while applying pesticides.
6. Keep pesticides off your skin and clothing; wash immediately with soap and water and change clothing if accidents result in exposures to pesticides.
7. Bathe and change all clothing after applying pesticides. Wash clothing after each day's use.
8. See a physician immediately if pesticide poisoning is suspected. Show the physician the label from the pesticide suspected of causing the poisoning. Physicians should phone a Poison Control Center for complete information on treatment.

## Protecting the Birds and the Bees

Most fungicides and herbicides are only slightly toxic to birds, but many insecticides are highly toxic to birds. Labels for the following pesticides present warnings that poisonings may occur if birds feed in treated areas: azinphosmethyl (Guthion), carbofuran (Furadan), diazinon (Diazinon), endosulfan (Thiodan), fenamiphos (Nemacur), methomyl (Lannate), and oxydemeton-methyl (Metasystox-R). To reduce the risk of bird poisoning, granular insecticides should be incorporated during or immediately after application. Always read and follow label directions for precautions that protect birds and other wildlife.



Honey bees, several species of wild bees, and many other insects aid in pollination of small fruits and countless other crop and noncrop plants. Poor pollination results in smaller, misshapen, or crumbly berries, depending on crop species. Lower yields can result. This is particularly true for raspberries and blueberries. Although wind pollination plays an important role in strawberry fruit set, insect pollination also appears to be important in this crop as well.

The importance of honey bees to the small fruit industries demands that certain guidelines be used whenever a pesticide is considered, *particularly when the crop is in bloom*. The major ways to avoid poisoning bees are summarized here:

- Move honey bee colonies into berry fields only after prebloom insecticides have been applied. Remove colonies as soon as pollination is completed.
  - Do not apply insecticides that are toxic to bees to fruit crops, cover crops, adjacent crops, or interplantings if these crops are blooming. Similarly, do not apply insecticides that will kill bees to fruit plantings if blooming weeds will be treated. Mowing or otherwise controlling weeds is necessary if such insecticides must be used.
  - In aerial applications, do not repeatedly turn the aircraft or transport insecticides across blooming fields. Ground application is generally less hazardous to bees than aerial application.
  - Apply most insecticides (and other pesticides according to label directions) in late evening, at night, or early in the morning while few or no bees are foraging (generally between 6 p.m. and 7 a.m. in the north and 8:30 p.m. to 4 a.m. in the south). Evening applications are generally less hazardous to bees than early morning applications. When high temperatures cause bees to start foraging earlier or continue later than usual (5:30 a.m. to 8 p.m.), shift application times accordingly.
  - Do not apply insecticides when temperatures are expected to be unusually low following treatment or on nights when heavy dew forms. Residues will remain toxic to bees for a longer time under such conditions.
  - Use insecticides that are least hazardous to bees whenever possible (see Table 8-9).
- Choose the least hazardous insecticide formulations. Tests consistently indicate that dusts are more hazardous than sprays of the same insecticide. Emulsifiable (liquid) formulations usually have a shorter residual toxicity to bees than do wettable powders. Granular formulations are generally low in hazard to bees. Sevin XLR, a formulation that includes a sticker, is less hazardous to bees after application than wettable powder formulations of Sevin (carbaryl).
  - Ask beekeepers to remove colonies from the area (or keep bees confined during and shortly after application) before applying hazardous pesticides.

## Ground Water and Surface Water Protection

Ground water and surface water are invaluable natural resources. They are vulnerable to contamination, however, and pesticides have been detected in water resources in all states. To protect water supplies from contaminants, pesticide applicators must adopt sound practices that include site-specific selection of pesticides; adherence to label directions; accurate calibration and mixing; spill and back-siphon prevention; proper disposal; integrated pest management; and an overall pattern of judicious use of pesticides.

Many factors affect the movement of chemicals and their likelihood of reaching water supplies. Consideration of these factors can minimize contamination problems.

**Solubility:** Chemicals that are highly soluble in water are easily leached. To minimize leaching, use the least soluble chemicals at the lowest effective rates (see Table 8-10). Nitrogen (N) fertilizers are easily leached. Apply only the needed amount of N. Split applications are most effective for many crops and can reduce leaching because less N is applied at any one time, allowing the crop to use it more efficiently. Winter cover crops also take up leftover N, reducing leaching and erosion. Among pesticides that are now used or that have been used in recent years in small fruits, the insecticides Furadan (carbofuran) and Lannate (methomyl), the fungicides Ridomil

*Continued*



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**Table 8-9. Categories of Pesticide Toxicity to Honey Bees.**

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**EXTREMELY TOXIC:**

**DO NOT apply on blooming crops or weeds.**

Asana (esfenvalerate)	Imidan (phosmet)
Danitol (fenpropathrin)	Lannate (methomyl)
Diazinon	Lorsban (chlorpyrifos)
Furadan (carbofuran)	Malathion D or WP
Guthion (azinphos methyl)	Sevin (carbaryl)

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**HIGHLY TOXIC:**

**Apply ONLY during late evening.**

Admire (imidacloprid)	Malathion EC
Confirm (tebufenozide)	Provado (imidacloprid)
Dibrom EC (naled)	Thiodan (endosulfan)

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**MODERATELY TOXIC:**

**Apply ONLY during late evening, night, or early morning.**

Fusilade (fluzifop-P-butyl)	Pyramite (pyridaben)
Neemix (azadirachtin)	Pyrellin
Oil sprays (superior types)	Rotenone
Princep (simazine)	Spintor (spinosad)

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**SLIGHTLY TOXIC OR NONTOXIC:**

**Can be applied at any time with reasonable safety to bees.**

<i>Bacillus thuringiensis</i>	Kyrocide (cryolite)
Benlate (benomyl)	lime-sulfur
Bordeaux mixture	M-Pede (insecticidal soap)
Captan	Metaldehyde baits
Ethrel (ethephon)	Naturalis ( <i>Beauveria</i> )
Funginex (triforine)	Paraquat/Gramoxone
Karmex (diuron)	Savey (hexythiazox)
Kelthane (dicofol)	Sinbar (terbacil)
Kerb (pronamide)	Vendex (fenbutatin-oxide)

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D = Dust; EC = Emulsifiable Concentrate; WP = Wettable Powder.

Caution: Information is unavailable on the hazards posed to honey bees by pesticides not listed in this table.

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<b>Table 8-10. Physical Characteristics of Common Small Fruit Pesticides<sup>1</sup>.</b>				
<b>Trade Name</b>	<b>Common Name</b>	<b>Solubility (ppm)<sup>2</sup></b>	<b>Soil Adsorption (K<sub>oc</sub>)<sup>3</sup></b>	<b>Soil 1/2-Life (days)</b>
<b>Fungicides</b>				
Aliette	fosetyl-AL	122	-- <sup>1</sup>	--
Bayleton	tradimefon	260	273	21
Benlate	benomyl	2	190	240
Bordeaux		--	--	--
Captan	captan	4	100	3
Carbamate	ferbam	120	300	17
Fixed copper	fixed copper	--	--	--
Funginex	triforine	6	--	--
Manzate (also Dithane, Penncozeb)	mancozeb	0.5	2,000	70
Nova	myclobutanil	142	--	--
Ridomil	metalaxyl	7,100	16	21
Ronilan	vinclozolin	3	43,000	20
Rovral	iprodione	13.9	1,000	14
Rubigan	fenarimol	14	600	360
Sulfur	sulfur	--	--	--
Syllit	dodine	630	1,000,000	10
Topsin-M	thiophanate methyl	3.5	1,000	10
Thiram	thiram	30	--	--
<b>Herbicides</b>				
Casoron, Norosac	dichlobenil	18	224	60
Dacthal	DCPA	0.5	5,000	100
Devrinol	napropamide	73	--	--
Dual	metalochlor	530	200	20
2,4-D amine	2,4-D amine	796,000	20	10
2,4-D ester	2,4-D ester	1	1,000	10
Fusilade	fluazifop	2	3,000	20
Goal	oxyfluorfen	0.1	1000,000	35
Gramoxone Extra	paraquat	1,000,000	100,000	--
Karmex	diuron	42	--	--
Kerb	pronamide	15	990	60
Poast	sethoxydim	pH	pH	10
Princep	simiazine	6.2	138	75
Prowl	pendimethalin	0.28	24,000	90
Roundup	glyphosate	900,000	24,000	47
Sinbar	terbacil	710	55	120
Snapshot	asoxaben plus	--	--	--
	oryzalin	2.5	600	20



<b>Table 8-10 (Continued). Physical Characteristics of Common Small Fruit Pesticides<sup>1</sup>.</b>				
<b>Trade Name</b>	<b>Common Name</b>	<b>Solubility (ppm)<sup>2</sup></b>	<b>Soil Adsorption (K<sub>OC</sub>)<sup>3</sup></b>	<b>Soil 1/2-Life (days)</b>
Solicam	norfluazon	28	--	24
Surflan	oryzalin	2.5	600	20
Touchdown	sulfosate	430	--	--
<b>Insecticides</b>				
Agri-Mek	abamectin	5	5,000	28
Asana	esgfenvalerate	0.002	5,300	35
Brigade	bifenthrin	0.1	240,000	26
Capture	bifenthrin	0.1	240,000	26
Danitrol	fenpropathrin	0.33	5,000	5
Diazinon	diazinon	60	1,000	40
Dibrom	naled	2000	180	1
Dipel, others	<i>Bacillus thuringiensis</i>	--	--	--
Furadan	carbofuran	351	22	50
Guthion	aziphosmethyl	29	1,000	10
Imidan	phosmet	20	820	19
Kelthane	dicofol	0.8	>5,000	45
Lannate	methomyl	58,000	72	30
Lorsban	chlorpyrifos	0.4	6,070	30
Malathion	malathion	130	1,800	1
Metaldehyde	metaldehyde	230	240	10
M-Pede	fatty acids (soaps)	--	--	--
Neemix	azadirachtin	--	--	--
pyrethrins	pyrethrins	0.001	100,000	12
Rotenone	rotenone	0.2	10,000	3
Savey	hexythiazox	0.5	6,200	30
Sevin	carbaryl	120	300	10
Thiodan	endosulfan	0.32	12,040	50
Vendex	fenbutatin-oxide	0.0127	2,300	90
<sup>1</sup> Denotes that information was unavailable. <sup>2</sup> Water solubility expressed in parts per million. <sup>3</sup> Higher K <sub>OC</sub> values indicate greater soil adsorption and a lower potential to leach.				



(metalaxyl) and Syllit (dodine), and the herbicides Dual (metolachlor), Gramoxone Extra (paraquat), Roundup (glyphosate), Sinbar (terbacil), Touchdown (sulfosate), and 2,4-D amine are moderately to highly soluble. Not all of these compounds are equally likely to leach into groundwater; however, their use patterns, persistence, and soil sorption characteristics also influence leaching and movement in surface waters.

**Adsorption:** Some chemicals are tightly attached (adsorbed) to soil particles or organic matter and are not easily moved. Nitrogen in the ammonium form attaches to soil particles, whereas nitrogen in the nitrate form does not. The use of ammonium N is acceptable in many situations and can reduce leaching. Pesticides with high soil adsorption values (see Table 8-10) are less likely to leach than those that do not attach tightly to soil. Pesticides that are bound to soil particles can contaminate surface water, if water or wind erosion carries soil particles and attached pesticide molecules into streams, rivers, or other bodies of water.

**Persistence:** Persistent chemicals break down slowly and, therefore, have more time to move into surface water and ground water. Many pesticides are broken down by sunlight (photodegradation) and/or microbial action, but incorporation of pesticides into soil reduces or eliminates photodegradation, and microbial activity declines at greater depths in the soil. See Table 8-10 for a listing of the soil half-lives (time required for the half of the original amount of the chemical to break down) of pesticides used in small fruits.

**Soil Characteristics:** Soil texture and organic matter content greatly influence the movement of pesticides and fertilizers. Fine-textured soils and those with high amounts of organic matter retain more water and allow greater adsorption of agricultural chemicals. Conversely, sandy soils are more permeable to water and allow less adsorption. Highly permeable soils with permeable underlying layers allow rapid downward movement of water and dissolved chemicals, leading to groundwater contamination.

**Water Table:** High water tables are especially vulnerable to contamination because chemicals must travel only a short distance to reach groundwater. In areas with high water tables, highly soluble or

persistent pesticides should not be applied directly to bare soils.

In summary, some risk of groundwater or surface water contamination exists whenever pesticides are used. Where risks are particularly high (coarse soils, low organic matter, high water table, bare soil, or slopes that favor runoff), producers should not apply directly to soil any pesticides that are likely to leach. In general, pesticides with a water solubility of greater than 30 ppm, a soil sorption index of less than 300 to 500, and/or a soil half-life of greater than 21 days are most likely to leach. To protect surface water, do not apply pesticides directly to soil if slopes favor runoff. To slow runoff, maintain vegetation in waterways and ditches.

## Safe Storage of Pesticides

- Store pesticides in a clean, cool, dry, well-ventilated building. The building should be locked so that children and other unauthorized people cannot gain access to pesticides. Mark the storage facility with an appropriate warning sign.
- Storages should be equipped with absorbent materials such as clay, sawdust, paper, or kitty litter. Other equipment should include a fire extinguisher (ABC rated), a shovel, broom, dustpan, detergent, hand cleaner, and water. All of this equipment should be dedicated exclusively to the pesticide storage area.
- Never store herbicides alongside other pesticides; the danger of cross-contamination is too great.
- Do not store pesticides where food, water, feed, seeds, fertilizers, or pesticide safety equipment (such as respirators) can become contaminated.
- Store all pesticides in their original containers.
- Check containers frequently for leaks and breaks.
- Clean up spilled chemicals promptly and properly. If the spill is large, inform your state and local emergency response office. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner.
- Keep an inventory of all chemicals. Mark each container with the year of purchase. Do not remove labels.
- Inform your local fire department and Emergency Response Office of any agricultural chemicals (including fertilizers) stored in large quantity.



- Conform with federal and state regulations concerning reportable quantities of hazardous materials. Consult with your pesticide dealer or local Extension office for further information.
- READ THE LABEL for specific storage instructions and precautions.

## Winter Storage of Pesticides

Emulsifiable concentrates should not be subjected to freezing temperatures. Freezing will destroy the emulsion, resulting in loss of effectiveness and increased likelihood of plant injury if the product is applied. Signs of deterioration due to freezing or other poor storage conditions include:

**Emulsifiable concentrate (EC):** Sludge, sediment, or other evidence of separation of components.

**Oils:** Milky appearance does not develop when water is added.

**Wettable powder (WP):** Excessive lumping; powder does not suspend in water.

**Dry flowable (DF):** Excessive lumping or caking.

If a pesticide is damaged by freezing, move it to a warm storage (50°F to 80°F) area and shake or roll the container every few hours to mix the components and eliminate layering. If layering persists or if crystals do not dissolve completely, do not use the pesticide. If you are unsure about the quality of a pesticide, call the manufacturer.

## Safe Disposal of Pesticides

- Avoid disposal problems associated with excess amounts of pesticides by purchasing only the amount of pesticides that you need for planned applications (or at most, for the current growing season). DO NOT STOCKPILE.
- Follow disposal instructions on the pesticide containers. READ AND FOLLOW LABEL DIRECTIONS.
- Use proper safety equipment when disposing of pesticide wastes and containers.
- Mix only as much pesticide as you will need for a particular application. If you mix too much, it is best to apply the spray mix in the recommended manner to one of the crops listed on the label.
- Do not dump pesticides on the ground or pour them down sinks, toilets, or other drains.

- Rinse empty pesticide containers three times with water and pour the rinse water into the spray tank.
- After metal, plastic, or glass containers are rinsed, they should be punctured, broken, or crushed. Disposal of properly rinsed containers in a sanitary landfill is permissible if in accordance with local regulations.
- Combustible containers can be burned according to instructions on the label if local ordinances permit. Do not burn pesticide containers near residential areas or where people will be exposed to the smoke. Avoid smoke from burning pesticide packages; it is likely to contain toxic vapors.
- Large metal drums should be returned to pesticide suppliers for recycling or sent to a reconditioning company.
- Never reuse empty pesticide containers for any purpose.
- Wash thoroughly after handling and disposing of pesticides.

## Fungicides and Insecticides for Small Fruits

### Fungicides

Several fungicides are labelled for use on small fruits, and each may be very effective against some diseases and yet have little or no effect against others. Most fungicides are effective primarily as protectants — they must be applied before infection to prevent damage. Some locally systemic fungicides have curative activity, which provides some control of infections that have already started. These include Bayleton, Nova, Procure, Ridomil, and Rubigan. Table 8-11 summarizes general information on the fungicides currently registered for use on small fruits; see product labels and an up-to-date annual spray guide for further details on rates, restrictions, and application methods.



<b>Table 8-11. Small Fruit Fungicides.</b>				
<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
Abound	Azoxystrobin	2.08F	Grapes	Controls black rot, powdery mildew, downy mildew and is moderately effective against Botrytis bunch rot. Same fungicide as Quadris.
Aliette	fosetyl-Al	80 WDG	Brambles, Strawberries	Controls Phytophthora root rot of brambles; leather rot and red stele in strawberries.
Bayleton	triadimefon	50 DG	Grapes	Controls black rot and powdery mildew of grapes, but not downy mildew. Some “kickback” curative activity. Tank mix with another fungicide if downy mildew control is needed.
Bordeaux Mix		See comments	Grapes	Controls downy mildew, and powdery mildew of grapes. Provides fair control of black rot. Copper sulfate + hydrated lime may cause plant injury; incompatible with most other pesticides. Most effective if prepared fresh by mixing 2 lbs copper sulfate (“snow form”) and 6 lbs lime per 100 gallons water. Vigorous agitation required.
Cabrio	pyraclostrobin	20 EG	Blueberries Brambles Strawberry	Controls anthracnose, spur blight, leaf spot, powdery mildew and rusts on brambles. On blueberry it controls alternaria leaf spot and fruit rot, leaf blotch, phomopsis twig blight and powdery mildew. On strawberry it controls anthracnose fruit rot, leaf spot, and powdery mildew.
Captan	captan	50 WP, 80WP, 4L	Blueberries Grapes Strawberries	Controls stem canker and stem blight of blueberries; Phomopsis cane and leaf spot, downy mildew, and bitter rot in grapes; and is useful in tank mixes with Rovral, Elevate, Switch, or Topsin-M for the control of Botrytis gray mold, leaf spot, and anthracnose fruit rot in strawberries.
Carbamate	ferbam	76 WP	Grapes	Controls black rot but not downy mildew or powdery mildew in grapes. Because the black wettable powder leaves unsightly residues, late-season use is rarely recommended.
Elevate	fenheximide	50 WG	Brambles Strawberry Grapes	Controls Botrytis fruit rot on strawberry and brambles, and Botrytis bunch rot on grapes.
Elite	tebuconazole	45 DF	Grapes	Controls black rot and powdery mildew on grapes, but not downy mildew. Some “kickback” curative activity. Tank mix with another fungicide if downy mildew control is needed.
Endura	boscalid	70WG	Grapes	Provides excellent control of powdery mildew and moderate to good control of Botrytis bunch rot. Has little or no activity on the other grape diseases.



<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
"Fixed" Copper		See comments	Grapes	Controls black rot, downy mildew, and powdery mildew of grapes. Fixed copper sprays are relatively insoluble in water and are less injurious to plants than Bordeaux; use is limited by incompatibility with other pesticides and tendency to injure plants. Usually prepared by mixing 2 lbs spray lime with 1 lb fixed copper.
Flint	trifloxystrobin	50 WG	Grapes	Controls black rot and powdery mildew. Not highly effective for downy mildew. Do not apply to Concord grapes.
Potassium Salts Armcarb 100 Nutrol Kaligreen	Potassium Salts	See comments	Grapes Various other small fruits	Armcarb 100 and Kaligreen are formulations of potassium bicarbonate. Nutrol is a formulation of monopotassium phosphate. All of these products are registered for use on grape, and some are registered on other small fruit crops as well (see the label). They have been reported to provide good control of powdery mildew but provide little or no control of other diseases.
Phosphorous Acid ProPhyt Phostrol Agri-Fos	Phosphorous Acid	See comments	Blueberry Brambles Grape Strawberry	Various phosphorous acid products (also called phosphite or phosphonate) are currently registered in various formulations as a fungicide. They provide good to excellent control of downy mildew on grapes. Most are also registered for use as a foliar spray to control phytophthora root rot on blueberry and brambles, and are registered for control of red stele root rot and leather rot on strawberry.
Pristine	pyraclostrobin plus boscalid	38WG	Blueberries Brambles Strawberries Grapes	Controls Alternaria fruit rot, Botrytis gray mold, mummy berry, Phomopsis twig blight and fruit rot, and powdery mildew on blueberry. On brambles, it controls Anthracnose, Botrytis gray mold, leaf spot, powdery mildew, rust diseases, and spur blight. On strawberry, it controls Anthracnose, Botrytis gray mold, leaf spot, and powdery mildew. On grapes, it controls angular leaf spot, Anthracnose, black rot, downy mildew, Phomopsis cane and leaf spot, powdery mildew, and ripe rot.
Mancozeb	See comments	80% WP, 75% DF	Grapes	Controls black rot, Phomopsis cane and leaf spot, and downy mildew of grape. Some common trade names are Dithane M-45, Manzate 200, and Penncozeb. Long pre-harvest interval (66 days) limits use to early season.



<b>Table 8-11 (Continued). Small Fruit Fungicides.</b>				
<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
Nova	myclobutanil	40 WP	Brambles Grapes Strawberry	Controls black rot and powdery mildew of grapes. Some “kickback” or curative activity. Controls powdery mildew, leaf spot and leaf blight on strawberry, and rust diseases, leaf spot, and powdery mildew on brambles.
Procure	triflumizole	50 WSP	Grapes Strawberry	Controls black rot and powdery mildew on grapes, but not downy mildew. Some “kickback” curative activity. Tank mix with another fungicide if downy mildew control is needed. Controls powdery mildew on strawberry.
Ridomil Gold	mefanoxam	EC, WP	Blueberry Brambles Grapes Strawberry	Controls phytophthora root rot on blueberries and brambles, and red stele root rot and leather rot. Does not control Verticillium wilt. On grapes, Ridomil Gold MZ and Ridomil Gold/Copper are wettable powder formulations registered as a foliar application for control of downy mildew.
Rovral	iprodione	50 WP, 4 F	Brambles Grapes Strawberries	Controls Botrytis bunch rot or gray mold of grapes. Also controls Botrytis fruit rot of brambles and strawberries. Tank mix with other fungicides to slow the development of resistant strains of fungi.
Rubigan	fenarimol	1 EC	Grapes	Controls powdery mildew on grapes. Provides moderate control of black rot. Will not control downy mildew.
Sovran	kresoxim-methyl	50 WG	Grapes	Controls black rot and powdery mildew on grapes. Provides good to moderate control of downy mildew if used at higher rates. Moderately effective against Botrytis bunch rot.
Sulfur		See comments	Blueberries Brambles Grapes Strawberries	Available as wettable powder and flowable formulations for control of powdery mildew on brambles, grapes, and strawberries. On strawberry and brambles, alternative fungicides are preferred for powdery mildew control. Important on grape for powdery mildew control, but can damage some cultivars such as Concord (see Table 5-2). Can cause plant damage if applied at temperatures of 85°F or above.
Switch	cyprodinil plus fludioxinil	62.5 WG	Brambles Strawberries	Controls Botrytis fruit rot on strawberry. Has moderate activity against anthracnose fruit rot.
Syllit	dodine	65 WP	Strawberries	Controls leaf spot, leaf scorch, and leaf blight of strawberries.



Trade Name	Common Name	Formulations	For Use On	Comments
Topsin-M	thiophanate-methyl	70 WP	Strawberries	Controls leaf blight, leaf scorch, and Botrytis fruit rot (gray mold) of strawberries. Does not control leather rot. Always tank mix Topsin-M with other fungicides to slow the development of resistant strains of fungi.
Thiram	thiram	65 WP	Strawberries	Controls leaf spot and fruit rot (gray mold) of strawberries; can be tank-mixed with Rovral, Topsin-M, Elevate, or Switch.
JMS Stylet-oil		See comments	Grapes	A highly refined petroleum distillate registered for control of powdery mildew on grapes. Cannot be mixed with Captan or Sulfur and should not be applied within 2 weeks of a Captan or Sulfur application.
Liquid Lime Sulfur		29% solution	Brambles Grapes	Controls anthracnose, cane blight, and spur blight on brambles if applied at the delayed dormant stage (1/4- to 1/2-inch green). A very important spray for these diseases. Also registered as a dormant application on grapes for control of anthracnose and powdery mildew. Not registered for use on any other small fruit crop.
Vanguard	cyprodinil	75 WG	Grapes	Controls Botrytis bunch rot on grapes.
Ziram	ziram	76 DF	Grapes	Provides good control of black rot and moderate control of downy mildew and Phomopsis cane and leaf spot on grapes.

## Insecticides

Insecticides and miticides also differ greatly in effectiveness against specific pests and in toxicity to beneficial insects. Most insecticides are contact poisons that offer some residual effectiveness for a few days after application by killing insects that contact the residues that remain after spraying. Some insecticides, however, must be eaten by insects to be effective. Among these are formulations of *Bacillus thuringiensis* (*Bt*); *Bt* products used in small fruits kill

only caterpillars that consume *Bt* spores or toxins. Fatty acid insecticides (insecticidal soaps), such as M-Pede, are effective only if insects are contacted by the spray solution while it is still wet. This limits the effectiveness of such sprays but also reduces mortality in nontarget beneficial insects. Table 8-12 summarizes general information on the insecticides currently registered for use on small fruits.



<b>Family</b>	<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
Organo-phosphates	Diazinon	diazinon	50 WP, AG 500 (4EC), AG600	Blueberries Grapes Strawberries	Controls fruitworms and blueberry maggot on blueberries; fruit flies, grape berry moth, leafhoppers on grapes; aphids, leafrollers on strawberries.
	Dibrom	naled	8 EC	Grapes Strawberries	Controls fruit flies on grapes; spittlebugs, plant bugs on strawberries.
	Guthion, Sniper	azinphos-methyl	50 WP	Blueberries Brambles Grapes Strawberries	Controls grape berry moth, leafrollers, leafhoppers, grape cane girdler on grapes; leafrollers, spittlebug on strawberries; leafroller on brambles; curculio, fruitworms, maggot on blueberries.
	Imidan (by 24c in some states)	phosmet	70 WP	Blueberries Grapes	Controls grape berry moth, leafrollers, Japanese beetle, leafhoppers on grapes; some plum curculio, fruitworms, Japanese beetle, blueberry maggot on blueberries.
	Lorsban	chlorpyrifos	4 EC	Grapes Strawberries	Controls grape root borer on grapes; bud weevil (clipper) on strawberries.
	Malathion	malathion	8 EC, 8 F, 5 EC, ULV (95%)	Blueberries Brambles Grapes Strawberries	Controls fruit flies, leafhoppers, Japanese beetle, mealybug on grapes; Japanese beetle on brambles; maggot, fruitworms, curculio, tip borer on blueberries.
Organo-chlorines	Kelthane	dicofol	50 WP	Grapes Strawberries	Controls two-spotted spider mite, European red mite, cyclamen mite.
	Thiodan, Thionex, Phaser	endosulfan	50 WP, 3 EC	Blueberries Grapes Strawberries	Controls phylloxera, leafhoppers, rose chafer on grapes; spittlebug, tarnished plant bug, cyclamen mite on strawberries. Used for post-harvest control of blueberry bud mite.
Carbamates	Furadan (by 24c in some states)	carbofuran	4 F	Strawberries	Controls root weevils when used post-harvest.
	Lannate	methomyl	90 SP, LV (2.4 EC)	Blueberries Grapes Strawberries	Controls grape berry moth, leafhoppers on grapes; plant bugs on strawberries; fruitworms on blueberries.
	Sevin	carbaryl	XLR (4EC), 80 S, 4F	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, rose chafer, leafhoppers, flea beetle, cutworms, 8-spotted forester, spittlebug, fruitworms.
Pyrethroids	Asana	esfen-valerate	0.66 EC	Blueberries	Controls fruitworms, blueberry maggot
	Brigade	bifenthrin	10 WP	Strawberries	Controls plant bugs, spittlebug, clipper, sap beetle, spider mites, root weevil.
	Capture	bifenthrin	2 EC	Brambles	Controls leafrollers and root weevils.
	Danitol	fenpro-pathrin	2.4 EC	Grapes Strawberries	Controls leafhoppers, flea beetle, berry moth, phylloxera (foliar), Japanese beetle, rose chafer, spider mites on grapes; spittlebug, tarnished plant bug, spider mites on strawberries.



<b>Table 8-12 (Continued). Small Fruit Insecticides.</b>					
<b>Family</b>	<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
Neonico- tinoids	Assail	acetamiprid	70 WP	Grapes	Controls leafhoppers.
	Provado, Admire	imidacloprid	75 WP 1.6 F 2 F	Grapes Strawberries	Controls leafhoppers and mealybugs. Has some systemic activity.
Insect Growth Regulators	Applaud	buprofezin	70 WP	Grapes	Controls leafhopper nymphs.
	Confirm	tebufen- ozide	2 F	Blueberries Brambles	Controls fruitworms, leafrollers, gypsy moth.
	Esteem	pyriproxyfen	35 WP	Blueberries	Controls fruitworms.
	Intrepid	methoxy- fenozide	2 F	Grapes	Controls grape berry moth.
Microbials	Biobit Condor CryMax Deliver DiPel Javelin Lepinox	<i>Bacillus thuringiensis</i> , subspecies kurstaki	DF, WG, oil flowable	Blueberries Brambles Grapes Strawberries	Controls caterpillars such as gypsy moth, leafrollers. Pests must eat treated plants. Works best on young caterpillars.
	Agree Ketch XenTari	<i>Bacillus thuringiensis</i> , subspecies aizawai	DF, WG	Blueberries Brambles Grapes Strawberries	Controls caterpillars such as gypsy moth, leafrollers. Pests must eat treated plants. Works best on young caterpillars.
	Mycotrol	<i>Beauveria bassiana</i>	ES	Blueberries Brambles Grapes Strawberries	Controls whiteflies, aphids, mealybugs, leafhoppers, beetles, plant bugs, weevils.
Botanicals	Aza-Direct Ecozin Neemix	azadirachtin	EC	Blueberries Brambles Grapes Strawberries	Controls plant bugs, leafhoppers, beetles, caterpillars, thrips.
	Pyronyl	pyrethrins	EC	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, yellowjackets, sap beetles, vinegar fruit flies, many other pests.
	Pyrellin	pyrethrins + rotenone	EC	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, aphids, caterpillars, leafhoppers, thrips, many other pests.
	Rotenone	rotenone	D, WP	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, flea beetles, rose chafer, fruitworms, cane borers, blueberry maggot.
Miscel- laneous	Acramite	bifenazate	50 WP	Grapes Strawberries	Controls two-spotted spider mite
	Agri-Mek	abamectin	0.15 EC	Grapes Strawberries	Controls two-spotted spider mite.
	Deadline MPs	metalde- hyde	Mini-pellet bait	Blueberries Brambles Grapes Strawberries	Controls slugs. Apply as a soil surface treatment.



<b>Table 8-12 (Continued). Small Fruit Insecticides.</b>					
<b>Family</b>	<b>Trade Name</b>	<b>Common Name</b>	<b>Formulations</b>	<b>For Use On</b>	<b>Comments</b>
Miscellaneous (continued)	M-Pede	soap	Liquid concentrates	Blueberries Brambles Grapes Strawberries	Controls aphids, leafhoppers, spider mites. Thorough coverage required.
	Pyramite, Nexter	pyridaben	60 WP	Grapes	Controls European red mite, two-spotted spider mite, leafhoppers.
	Savey	hexythiazox	50 DF	Brambles Strawberries	Controls two-spotted spider mite.
	Sluggo	iron phosphate	1% Bait	All	Controls slugs.
	SpinTor, Entrust	spinosad	2 SC	Blueberries Brambles Grapes Strawberries	Controls caterpillars and thrips.
	Vendex	fenbutatin-oxide	50 WP	Grapes Strawberries	Controls European red mite, two-spotted spider mite.
	Zeal	etoxazole	5 WG	Strawberries	Controls two-spotted spider mite, European spider mite.

