PESTICIDE SAFETY AND OTHER PESTICIDE INFORMATION
USE PESTICIDES SAFELY

Paul Smith, Extension Entomologist

Pesticides are poisonous chemicals that can injure or kill nontarget plants and animals, including man if they are handled improperly. Follow these guidelines to minimize the risk of pesticides to human health and the environment.

1. **Use Integrated Pest Management (IPM)**. IPM reduces dependence on pesticides by integrating nonchemical methods to help control or prevent damaging pest populations. Ask your county agent about IPM techniques that can be used for your situation.
2. **Apply pesticides only when they are needed**. Properly identify the pest and evaluate whether it will cause enough damage to justify a pesticide application. Your local extension office can help you identify and evaluate your pest problems.
3. **Choose the correct pesticide**. Refer to the pesticide label to make sure it is registered for the site you need to treat. This handbook and your local extension office can help you choose the right pesticide.
4. **FOLLOW THE LABEL DIRECTIONS!** Nearly all pesticide accidents are the result of not following all of the directions, restrictions, and precautions on the label. Avoid the temptation to use greater than the labeled rates; you increase your risk and you may injure or damage the site of application. Additionally, it is illegal to use any pesticide in a manner not prescribed on the label.
5. **Store pesticides safely**. Nearly 50% of U.S. households with a child under five years old have a pesticide stored within reach of children. Keep pesticides clearly labeled. The storage area should be clearly marked and locked if possible. Keep pesticides beyond the reach of children and animals. Do not store pesticides with food, feed, or clothing. NEVER store pesticides in any food or drink container!
6. **Prevent pesticide drift and runoff**. Never apply pesticide when the wind is blowing more than 5 mph or when rain is imminent. Crops that receive regular pesticide applications should not be planted near bodies of water or near sensitive areas, such as schools or wildlife habitat.
7. **Wear the proper protective clothing**. If you wear the right protective equipment, your risk from pesticides is very small. The label will tell you what protective clothing you need.
8. **Measure pesticides carefully**. Do not mix more pesticide than you need. It is much easier to use pesticides than to dispose of them.
9. **Dispose of pesticide waste properly**. Empty containers that are properly rinsed can be recycled or placed in landfills. Excess pesticides and rinse water can be applied to labeled sites if you will not exceed labeled rates. Refer to the pesticide label for proper disposal.
10. **Wash your hands** before you eat, drink, use tobacco, or go to the restroom. Shower as soon as you can, washing your hair and fingernails. Wash your clothes before wearing them again.
11. **If you or someone else is exposed to a pesticide, take immediate action**. Remove any contaminated clothing. If pesticide is on the skin, wash immediately. If pesticide is in the eye, rinse with clean water for at least 15 minutes. If pesticide is swallowed, give large amounts of water or milk to drink. DO NOT induce vomiting unless the label directs you to. Never give liquids or induce vomiting if a person is unconscious or convulsive. If pesticide is inhaled, move victim to fresh air. Seek medical attention.

Selecting and Purchasing the Pesticide

1. When you choose a pesticide, consider: 1) effectiveness, 2) hazard, 3) restrictions on use, 4) experience of the applicator, 5) required protective clothing, and 6) equipment needed to apply the product. You may want to choose a safer pesticide or formulation if the applicator is not well-trained.
2. You cannot use a restricted-use pesticide unless you or your supervisor are properly properly licensed through the Georgia Department of Agriculture Pesticide Applicator Licensing and Certification program (http://www.agr.georgia.gov/pesticides.aspx).

Transporting the Pesticide

1. NEVER transport pesticides in the passenger section of a vehicle.
2. NEVER transport pesticides with food, feed, or other products that may come in contact with humans or animals.
3. NEVER leave pesticides unattended. You are responsible for any accidents that may occur while you are away.
4. Secure pesticide containers in the back of a truck to prevent breaks and spills. Protect paper/cardboard from moisture.
5. Transport pesticides in properly labeled packages.
6. Report spills on roadways immediately to the local authorities.

Storing the Pesticide

1. Store pesticides in a locked and posted place that is accessible only to qualified personnel. Keep pesticides out of reach of children, unqualified people, or animals.
2. Store pesticides in their original containers with intact labels. NEVER place a pesticide in a food or beverage container.
3. Do not store pesticides with food, feed, or seed. Store pesticides at least 100 feet from wells and other waterways.
4. Make sure the storage place is fire-resistant (including a concrete floor), well ventilated, well lighted, locked, dry, protected from direct sunlight, and insulated against temperature extremes.
5. Check containers frequently for leaks or breaks. Transfer the content s of a damaged container into a labeled container that held exactly the same pesticide.
6. Immediately clean up any spills using the correct methods.
7. Store empty pesticide containers securely until proper disposal is available.

Mixing and Loading Pesticides

1. READ THE LABEL! Make sure you understand all directions and precautions. Mix only the amount you need.
2. Keep an adequate supply of clean water and soap nearby.
3. Check your protective equipment frequently for wear and leaks.
4. Know the early symptoms of pesticide poisoning.
5. Be sure that emergency equipment for spills and first-aid are readily available.
6. Keep unauthorized people and animals out of the mixing area.
7. Work in a well lighted and well ventilated area, preferably outdoors. Do not work alone.
8. Wear all of the protective equipment required by the pesticide label. Be sure you know how to use it properly.
9. Mix in an area where spills can be contained, at least 100 feet from wells and other waterways.
10. NEVER mix pesticides near a well or where other bodies of water may be contaminated. Be sure that the pesticide cannot back-siphon out of the spray tank.
11. NEVER eat, drink, or smoke while mixing pesticides.
12. NEVER mix or load pesticides at or above eye-level. Close containers that are not in use.
13. When you are mixing or loading, stand so that the wind does not blow pesticide on you.

Applying the Pesticide

1. Calibrate your equipment regularly. Check for leaks, clogged nozzles, and excessive wear.
2. Wear the protective clothing indicated on the label.
3. Check your protective equipment before, during, and after a pesticide application for wear or damage.
4. Clear the area of other people and animals.
5. Avoid drift and run off. Spray only when there is little or no wind. Do not spray when rain is imminent. Use the lowest spray pressure and largest nozzle orifices that are practical.
6. Be prepared for leaks, spills, or equipment failures.
7. Check the label to see what precautions are indicated. Post the area if required. Be sure that people entering the area during the re-entry interval are properly protected.

Cleaning Equipment

1. Thoroughly clean mixing, loading, and application equipment inside and out after each use.
2. Wear protective clothing while you are cleaning equipment or repairing it during use.
3. Clean equipment in an area where drainage will not endanger man or the environment.

Disposing of Excess Pesticides and Empty Containers*

1. Use excess pesticides according to label directions if possible. Otherwise follow label instructions for disposal.
2. Empty metal, plastic or glass containers should be pressure-rinsed or triple-rinsed. The rinse water should be directed into the spray tank. Properly rinsed containers can be placed in landfills or recycled. Contact your local extension office for recycling programs in your area.
3. Consult the label or your local extension office for other disposal information. Ask your local Extension office about the Georgia Clean Day program.

***See Waste Disposal under Pesticide Legislation and Regulations and telephone numbers under information numbers.**

PROTECT HONEY BEES FROM PESTICIDES

Keith S. Delaplane, Extension Entomologist

Many crops cannot be economically produced unless there are large numbers of honey bees to pollinate them. In addition, honey bees produce more than $50 million of honey and beeswax annually, and honey bee pollination accounts for over $14 billion added value to American agriculture each year. Beekeeping in Georgia adds an estimated $ 70 million annually to our state's economy.

Many pesticides are extremely hazardous to honey bees, but damage can be minimized if the pesticide user and the beekeeper cooperate and take proper precautions.

The Pesticide User's Role

1. Use pesticides only when needed.
2. If possible, select one of the least hazardous pesticides from the following list, especially on flowering plants that attract bees.
3. Use the least hazardous method of application. Granules are usually harmless to honey bees. Sprays drift less than dusts and are less likely to kill bees in nearby areas. Whenever possible, minimize drift by applying pesticides with ground application equipment rather than with airplanes.
4. Do not apply pesticides when honey bees are active in the field. Applications in late evening or night are least likely to k ill bees. Do not apply pesticides when plants are in flower unless it is absolutely necessary.
5. Avoid pesticide drift into apiaries or areas where crops or wild plants are flowering. With crops that require heavy pesticide applications, plant them in non-sensitive areas if possible.
6. Notify nearby beekeepers several days before you apply a pesticide.

The Beekeeper's Role

1. Whenever possible, locate colonies away from areas of heavy pesticide use.
2. Post your name, address, and phone number conspicuously at your apiary and tell nearby farmers where your hives are located.
3. Know which pesticides are commonly used in your area and be prepared to confine or remove your bees if you are notified that a pesticide will be applied. Commonly used pesticides are grouped according to hazard in the following list.

If you cannot move hives in time to avoid a pesticide application, you can cover each hive with a plastic sheet at night and in the early morning to confine the bees and protect them from short-residual pesticides. However, heat builds up rapidly once the plastic is exposed to the sun and it must be removed. An alternative - wet burlap, can be used for a day or more. This may be impractical for large numbers of hives. Colonies that are repeatedly exposed to pesticides in Groups I or II of the list below should be relocated.

Commonly Used Pesticides Grouped According To Their Relative Hazards To Honey Bees[1]

Group I Hazardous	Group II Moderately Hazardous	Group III Relatively Nonhazardous	Group III Relatively Nonhazardous (cont.)
abamectin (Agri-Mek)	aldicarb (Temik)	acetamiprid (Assail)	folpet (Phaltan)
acephate (Orthene, Address)	carbaryl (Sevin XLR formulation only)	allethrin (Pynamin)	Garlic Barrier
aminocarb (Matacil)	carbophenothion (Trithion)	amitraz (Mitac)	genite 923
avemectin (AVID)	coumaphos (Co-Ra l)	amitrole	glyodin (Glyoxide)
azinphosmethyl (Guthion)	cypermethrin (Ammo)	azadirachtin (Align)	kaolin (Surround)
bifenthrin (Capture)	cyromazine (Trigard)	azoxystrobin (Abound)	malathion (Malathion G)
carbaryl (Sevin, Sevin XLR-Plus)	diatomaceous earth (Diatect)	*Bacillus thuringiensis*	mancozeb (Dithane M-45)
carbofuran (Furadan)	disulfoton (Di-Syston)	(Biobit, DiPel, Full-Bac, Javelin, MVP)[3]	maneb (Dithane M-22)
chloropyrifos (Dursban, Lorsban)	DSMA	Beauveria (Mycotrol)	MCPA
chlorethoxyfos (Fortress)	emamectin benzoate (Proclaim)	benomyl (Benlate)	metaldehyde (Metaldehyde Bait)
clofentezine (Apollo)	ethoprop (Mocap)	binapacryl (Morocide)	methoxychlor (Marlate)
crotoxyphos (Cyodrin)	fonofos (Dyfonate)	bordeaux mixture	metiram (Polyram) - F
cyfluthrin (Baythroid)	malathion	bromoxynil	monuron (Telvar)
cyhalothrin (Warrior)	methyl demeton (Metasystox)	capsaicin (Hot Pepper Wax)	myclobutanil (Rally)
cypermethrin (Ammo)	MSMA	captan	nabam (Parzate)
deltamethrin (Decis)	neem (Azatin, Neemix)	carbaryl (Sevin G, Bait G)	nemagon
diazinon (Diazinon, Spectracide)	oxydemeton-methyl (Metasystox R)	carbofuran(Furadan G)	nicotine sulfate
dichlorvos (DDVP, Vapona)	paraquat	chloramben	oxythioquinox (Morestan)
dicrotophos (Bidrin)	perthane	chlorbenzide (Mitox)	propargite (Omite)
dimethoate (Cygon, Dimethoate,	pymetrozine (Fulfill)	chlorobenzilate (Acaraben)	pyrethrum (natural)
Rebelate)	pyriproxyfen (Esteem)	chlorothalonil (Bravo) [4]	pyrimidinamine (Vangard)
emamectin (Proclaim)	ronnel (Co-Ral, Korlan)	copper compounds (Kocide)	rotenone
endosulfan (Thiodan)	spinosad (Spin Tor)	copper oxychloride sulphate	ryania
esfenvalerate (Asana)	temephos (Abate)	copper 8-quinolinolate	silvex
ethyl parathion (Parathion)	terbufos (Counter)	copper sulfate (Monohydrated)	simazine (Princep)
fenpropathrin (Danitol)	thiamethoxam (Actara, Platinum)	cryolite (Cryolite, Kryocide)	soap (M -Pede)
fenthion (Baytex)	thiodicarb (Larvin)	cyromazine (Trigard)	sulfur
fipronil		dalapon	tebufenozide (Confirm)
hexythiazox (Savey)		dazomet (Mylone)	TDE (Rhothane)
imidacloprid (Provado)		demeton (Systox)	tetradifon (Tedion)
indoxacarb (Avaunt)		dexon	thioquinox (Eradex)
lambda-cyhalothrin (Warrior)		diazinon (Diazinon G)	thiram (Arasan)
methamidophos (Monitor)		dicamba (Banvel D)	toxaphene
methidathion (Supracide)		dichlone (Phygon)	trichlorfon (Dylox)
methiocarb (Mesurol)		dicofol (Kelthane)	trifloxystrobin (Flint)
methomyl (Lannate)		diflubenzuron (Dimilin)	zineb (Dithane)
methyl parathion (Penncap-M)		dimite (DMC)	ziram
mevinphos (Phosdrin)		dinocap (Karathane)	2,4-D
monocrotophos (Azodrin)		diquat	2,4-DB
naled (Dibrom)		disulfoton (Di-Syston G)	2,4,5-T
oxamyl (Vydate)		dodine (Cyprex)	
permethrin (Ambush, Pounce)		dyrene	
phorate (Thimet EC)		endothall	
phosmet (Imidan)		EPTC (Eptam)	
phosphamidon (Dimecron)		ethion (Ethion)	
propoxur (Baygon)		ethoprop (Mocap G)	
resmethrin (Synthrin)		fenbutatin-oxide (Vendex)	
tebufenozide (Confirm) TEPP[2]		fenhexamid (Elevate)	
tralomethrin (Scout)		ferbam	
zeta-cypermethrin (Fury, Mustang)		fluvalinate (Spur)	

[1] List derived in part from Johansen, C.A. and Mayer, D.F. Pollination Protection. 1990, Wicwas Press; Bulletin E-5 3-W, Hunt, G.J., Purdue University; Environmental Entomology 33(5):1151-1154.

[2] Mevinphos (Phosdrin*), naled (Dibrom*), and TEPP have short residual activity and kill only the bees contacted at time of treatment or shortly thereafter. They are usually safe to use when bees are not in flight; they are not safe to use around colonies.

[3] Not all *Bacillus thuringiensis* insecticides are safe for bees. The label for XenTari® (Valent BioSciences), with active ingredient *B. thuringiensis aizawai*, reads "This product is highly toxic to honey bees exposed to direct treatment. Do not apply this product while bees are actively visiting the treatment area."

[4] New data (2011) suggest that chlorothalonil fungicide expresses toxicity in honey bee brood in the context of crop applications at time of bloom. Additionally, lethal synergies occur between this product and the miticide fluvalinate used to control varroa mite in bee hives. Beekeepers should manage hives to avoid exposure to chlorothalonil.

NAMES, CLASSIFICATION AND TOXICITY OF PESTICIDES

Paul Guillebeau, Extension Entomologist

The tables on the following pages of this section will help you to identify specific pesticide active ingredients and give you an indication of their toxicities.

NAMES. The chemical names of pesticide active ingredients are usually so long and complex that they are generally used only in the active ingredient statement on the pesticide label and in scientific or technical publications. The common name of a pesticide active ingredient is one that is commonly used and has usually been approved by an appropriate scientific group. The trade name of a pesticide active ingredient is a copyrighted name used by its producer. A pesticide active ingredient will usually have only one common name but it may have several trade names. For example, glyphosphate is the common name for the chemical name isopropylamine salt of N-(phosphonomethyl) glycine, the active ingredient in Roundup. The trade names listed in the tables are capitalized and bear an asterisk (*).

CLASSIFICATION. Insecticides, herbicides, fungicides and other pesticides are primarily classified on the basis of their chemical structure or origin. The inorganic pesticides are those which contain no carbon in their chemical structure. The organic pesticides, those that contain carbon, are usually synthetic but some are obtained from natural sources such as plants or microorganisms. Some synthetic organic pesticides such as the pyrethroids are synthetic chemicals that are based on naturally occurring chemicals.

TOXICITY. The U.S. Environmental Protection Agency uses the results of acute toxicity studies on test animals, usually rats and rabbits, to place pesticides in toxicity categories (I-IV) which determine what signal word must appear on the label. Although inhalation toxicity, eye corrosiveness and skin corrosiveness studies are also used, results of acute dermal and acute oral toxicity studies are more publicized and usually more important.

The below table shows the signal words that must appear on the pesticide label for each toxicity category and the range of the oral and dermal median lethal doses (LD_{50}) for each category. A pesticide that falls into category I only because of eye or skin corrosiveness must bear “Danger” but not “Poison” nor the skull and crossbones symbol on its label.

The LD_{50} is the dose of a substance at which one-half of the exposed test animals are killed. It is based on the body weight of the animal and is expressed in milligrams of the substance per kilogram of animal (mg/kg). One mg/kg is equivalent to 1 part per million (ppm). The lower the LD_{50}, the greater the toxicity. Although most LD_{50} values that are readily available in publications are for the pesticide active ingredient or actual toxicant, the signal word on each pesticide product is determined by the toxicity of that particular formulation. Formulated pesticides are usually, but not necessarily, less toxic than the active ingredient. The toxicity categories given in the following tables are based solely on the accompanying LD_{50} values which, unless stated otherwise, are for the active ingredient. EPA would not necessarily assign the same category shown in the tables.

TOXICITY CATEGORY	SIGNAL WORDS REQUIRED ON LABEL BY EPA	ORAL LD50 (mg/kg)	DERMAL LD50 (mg/kg) 24-HR. EXPOSURE	ORAL DOSAGE TO KILL AN ADULT*
I. Highly Toxic	DANGER, POISON, Plus Skull & Crossbones symbol	0 to 50	0 to 200	A few drops to 1 tsp.
II. Moderately Toxic	WARNING	50 to 500	200 to 2,000	1 tsp. to 2 Tbsp.
III. Slightly Toxic	CAUTION	500 to 5,000	2,000 to 20,000	1 oz. to 1 pt. (1 lb.)
IV. Low Toxicity	CAUTION	>5,000	>20,000	1 pt. (1 lb.) or more

Toxicity categories and signal words on the pesticide label are based on acute toxicity studies, but sub-acute and chronic toxicity studies are also conducted. Acute toxicity involves the short-term response of the test animal to a single large exposure to the pesticide. Sub-acute toxicity refers to the response of the animal to repeated or continuous exposure to smaller doses over less than one-half of its normal life span. In chronic toxicity studies exposures are repeated or continued for longer than one-half of the animal’s life span.

*Less for child/pet

INSECTICIDE / MITICIDE BRAND NAMES, ACTIVE INGREDIENTS, CHEMICAL CLASS, AND MODE OF ACTION

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
(s)-methoprene	Apex, Diacon II, Extinguish, Precor	juvenile hormone analogue	7A
1,3-dichloropropene + chloropicrin	Telone C-17, Telone C-35, Telone II	halogenated organic fumigant + chloropicrin	8 + 8B
Abacus	abamectin	avermectin, milbemycin	6
abamectin	Abacus, Abba, Agri-Mek, Avid, Clinch Ant Bait, Epi-mek, Lucid, Reaper, Temprano, Zephyr, Zoro miticide/insecticide	avermectin, milbemycin	6
Abba	abamectin	avermectin, milbemycin	6
acephate	Acephate, Acephate Pro, Bracket, Orthene, Orthene PCO Pellets, Orthene Turf, Tree & Ornamental	organophosphate	1B
Acephate, Acephate Pro	acephate	organophosphate	1B
acequinocyl	Kanemite, Shuttle	acequinocyl	20B
acetamiprid	Assail, Tristar	neonicotinoid	4A
Acramite	bifenazate	bifenazate	25
Actara	thiamethoxam	neonicotinoid	4A
Actellic	pirimiphos-methyl	organophosphate	1B
Adept	diflubenzuron	benzoylurea	15
Adjourn	esfenvalerate	pyrethroid	3
Admire, Admire Pro	imidacloprid	neonicotinoid	4A
Advise	imidacloprid	neonicotinoid	4A
Agree WG	Bacillus thuringiensis subspecies aizawai strain GC91	B.t. var. aizawai	11B1
Agri-Mek	abamectin	avermectin, milbemycin	6
aldicarb	Temik, Temik Lock 'n Load	carbamate	1A
Alias	imidacloprid	neonicotinoid	4A
Altacor	chlorantraniliprole	diamide	28
Ambush	permethrin	pyrethroid	3
Ammo	cypermethrin	pyrethroid	3
Annex	bifenthrin	pyrethroid	3
Apex	(s)-methoprene	juvenile hormone analogue	7A
Apollo	clofentezine	clofentezine	10A
Arctic	permethrin	pyrethroid	3
Arena	clothianidin	neonicotinoid	4A
Armortech Imd	imidacloprid	neonicotinoid	4A
Asana XL	esfenvalerate	pyrethroid	3
Assail	acetamiprid	neonicotinoid	4A
Avaunt	indoxacarb	oxadiazine	22
Avid	abamectin	avermectin, milbemycin	6
Award	fenoxycarb	insect growth regulator	7B
azadirachtin	Aza-Direct, Azatin, Azatrol, Ecozin, Neemix	botanical	18B
Aza-Direct	azadirachtin	botanical	18B
Azatin	azadirachtin	botanical	18B
Azatrol	azadirachtin	botanical	18B
Azinphosmethyl	azinphos-methyl	organophosphate	1B
azinphos-methyl	Azinphosmethyl, Guthion Solupak	organophosphate	1B

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Bacillus thuringiensis subspecies aizawai strain ABTS-1857	Xentari	B.t. var. aizawai	11B1
Bacillus thuringiensis subspecies aizawai strain GC91	Agree WG	B.t. var. aizawai	11B1
Bacillus thuringiensis sub species israelensis strain 65-52	Gnatrol Larvicide	B.t. var. israelensis	11A1
Bacillus thuringiensis subspecies kurstaki	Deliver, Javelin-WG	B.t. var. kurstaki	11B2
Bacillus thuringiensis subspecies kurstaki strain ABTS-351	Biobit HP	B.t. var. kurstaki	11B2
Bacillus thuringiensis subspecies kurstaki strain BMP123	Baritone Bio-Insecticide	B.t. var. kurstaki	11B2
Bacillus thuringiensis subspecies kurstaki strain EG7826	Lepinox	B.t. var. kurstaki	11B2
Bacillus thuringiensis subspecies kurstaki strain EG7841	Crymax Bioinsecticide	B.t. var. kurstaki	11B2
Bacillus thuringiensis subspecies kurstaki strain HD1	Dipel ES, Dipel DF, Dipel Pro DF	B.t. var. kurstaki	11B2
Baritone Bio-Insecticide	Bacillus thuringiensis subspecies kurstaki strain BMP123	B.t. var. kurstaki	11B2
Battalion	deltamethrin	pyrethroid	3
Battery	cypermethrin	pyrethroid	3
Baythroid 2	cyfluthrin	pyrethroid	3
Baythroid XL	beta-cyfluthrin	pyrethroid	3
Belay	clothianidin	neonicotinoid	4A
Beleaf	flonicamid	neonicotinoid	9C
Belt	flubendiamide	diamide	28
beta-cyfluthrin	Baythroid XL	pyrethroid	3
bifenazate	Acramite, Floramite	carbazate acaricide	25
Bifenthrin	bifenthrin	pyrethroid	3
bifenthrin	Annex, Bifenthrin, Bifenture, Bisect, Brigade, Capture, Capture LFR, Discipline, Fanfare, Menace, Sniper, Tundra, Up-Star, Up-Star Gold, Up-Star Nursery Granular	pyrethroid	3
bifenthrin + imidacloprid	Brigadier	pyrethroid + neonicotinoid	3 + 4A
bifenthrin + indole-3-butyric acid	Empower 2	pyrethroid + botanical	3 + NS
bifenthrin + zeta-cypermethrin	Hero Insecticide	pyrethroid + pyrethroid	3 + 3
Bifenture	bifenthrin	pyrethroid	3
Biobit HP	Bacillus thuringiensis subspecies kurstaki strain ABTS-351	B.t. var. kurstaki	11B2
Bisect	bifenthrin	pyrethroid	3
Bracket	acephate	organophosphate	1B
Brigade	bifenthrin	pyrethroid	3
Brigadier	bifenthrin + imidacloprid	pyrethroid + neonicotinoid	3 + 4A
buprofezin	Centaur, Courier	insect growth regulator	16
Calypso	thiacloprid	neonicotinoid	4A
Capture, Capture LFR	bifenthrin	pyrethroid	3
Carbaryl	carbaryl	carbamate	1A
carbaryl	Carbaryl, Prokoz Sevin SL, Sevin, Sevin XLR Plus	carbamate	1A
Carbine	flonicamid	neonicotinoid	9C
carbofuran	Furadan, Furadan LFR	carbamate	1A

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
carboxin + diazinon + lindane	Kickstart Seed Treatment	carboximide + organophosphate + cyclodiene organochlorine	7 fungicide + 1B insecticide + 2A insecticide
Carzol SP	formetanate hydrochloride	carbamate	1A
Celero	clothianidin	neonicotinoid	4A
Centaur	buprofezin	insect growth regulator	16
Centric	thiamethoxam	neonicotinoid	4A
Checkmate BAW	pheromone (Z)-11-Hexadecen-1-yl acetate; pheromone (Z,E)-9,12-Tetradecadien-1-yl Acetate	mating disruptor pheramone	
Cheminova Methyl 4 EC	methyl parathion	organophosphate	1B
Chipco Choice	fipronil	fipronil (or phenylpyrazole)	2B
chlorantraniliprolerole	Altacor, Coragen	diamide	28
chlorfenapyr	Pylon Miticide	pyrrole	13
chloropicrin + iodomethane	Midas	chloropicrin	8B + 8B
Chlorpyrifos	chlorpyrifos	organophosphate	1B
chlorpyrifos	Chlorpyrifos, Dursban, Govern, Hatchet, Lorsban, Nufos, Warhawk, Whirlwind, Yuma	organophosphate	1B
chlorpyrifos + gamma-cyhalothrin	Cobalt	organophosphate + pyrethroid	1B + 3
cinnamon oil + clove oil + thyme oil	Ecotrol G	botanical	NS
Citation	cyromazine	insect growth regulator	17
Citrus oil	oil, paraffinic	botanical	NS
Clinch Ant Bait	abamectin	avermectin, milbemycin	6
clofentezine	Apollo	clofentezine	10A
clothianidin	Arena, Belay, Celero, Clutch	neonicotinoid	4A
Clutch	clothianidin	neonicotinoid	4A
Cobalt	chlorpyrifos + gamma-cyhalothrin	organophosphate + pyrethroid	1B + 3
Comite	propargite	propargite	12C
Concur	imidacloprid + metalaxyl	neonicotinoid + acylalanine	4A insecticide + 4 fungicide
Confirm	tebufenozide	insect growth regulator	18A
Conserve	spinosad	spinosad	5
Coragen	chlorantraniliprole	diamide	28
Counter Lock'n Load, Counter Smartbox	terbufos	organophosphate	1B
Couraze, Couraze Max, Couraze SoluPak	imidacloprid	neonicotinoid	4A
Courier	buprofezin	insect growth regulator	16
Covert	permethrin	pyrethroid	3
Cruiser	thiamethoxam	neonicotinoid	4A
Cruisermaxx	fludioxonil + mefenoxam + thiamethoxam	phenylpyrrole + acylalanine + neonicotinoid	12 fungicide + 4 fungicide + 4A insecticide
Crymax Bioinsecticide	Bacillus thuringiensis subspecies kurstaki strain EG7841	B.t. var. kurstaki	11B2
cryolite	Cryolite 96, Kryocide, Prokil	cryolite	9A
Cryolite	cryolite	cryolite	9A
Curacron	profenofos	organophosphate	1B
Cydia pomonella granulovirus	Cyd-X	insect virus	
Cyd-X	Cydia pomonella granulovirus	insect virus	

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
cyfluthrin	Baythroid 2, Decathlon, Renounce, Tempo, Tempo SC Ultra, Tombstone	pyrethroid	3
cyfluthrin + imidacloprid	Discus, Leverage	pyrethroid + neonicotinoid	3 + 4A
Cypercede	cypermethrin	pyrethroid	3
Cypermethrin	cypermethrin	pyrethroid	3
cypermethrin	Ammo, Battery, Cypercede, Cypermethrin, Holster, Up-Cyde, Up-Cyde Pro	pyrethroid	3
cyromazine	Citation, Trigard	insect growth regulator	17
Danitol	fenpropathrin	pyrethroid	3
Decathlon	cyfluthrin	pyrethroid	3
Delegate	spinetoram	spinosyn	5
Deliver	Bacillus thuringiensis subspecies kurstaki	B.t. var. kurstaki	11B2
Delta Gold	deltamethrin	pyrethroid	3
Deltagard GC, Deltagard T&O	deltamethrin	pyrethroid	3
deltamethrin	Battalion, Delta Gold, Deltagard GC, Deltagard T&O	pyrethroid	3
Denim	emamectin benzoate	avermectin, milbemycin	6
Diacon II	(s)-methoprene	juvenile hormone analogue	7A
Diamond	novaluron	benzoylurea	15
Diazinon	diazinon	organophosphate	1B
Dibrom	naled	organophosphate	1B
Dicofol	dicofol	organochlorine	UN C
dicofol	Dicofol, Kelthane	organochlorine	UN C
diflubenzuron	Adept, Dimilin	benzoylurea	15
Dimate	dimethoate	organophosphate	1B
Dimethoate	dimethoate	organophosphate	1B
dimethoate	Dimate, Dimethoate	organophosphate	1B
Dimilin	diflubenzuron	benzoylurea	15
dinotefuran	Safari, Venom	neonicotinoid	4A
Dipel ES, Dipel DF, Dipel Pro DF	Bacillus thuringiensis subspecies kurstaki strain HD1	B.t. var. kurstaki	11B2
Discipline	bifenthrin	pyrethroid	3
Discus	cyfluthrin + imidacloprid	pyrethroid + neonicotinoid	3 + 4A
Distancepyriproxyfen	pyriproxyfen	insect growth regulator	7C
disulfoton	Di-syston	organophosphate	1B
Di-syston	disulfoton	organophosphate	1B
Dryacidesilicon dioxide	diatomaceous earth	diatomaceous earth	NS
Dursban	chlorpyrifos	organophosphate	1B
Dusting sulfur-IAP	sulfur	inorganic	M2 fungicide
Ecotrol EC	peppermint oil + rosemary oil	botanical	NS
Ecotrol G	cinnamon oil + clove oil + thyme oil	botanical	NS
Ecozin	azadirachtin	botanical	18B
emamectin benzoate	Denim, Proclaim	avermectin, milbemycin	6
Empower 2	bifenthrin + indole-3-butyric acid	pyrethroid + botanical	3 + NS

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Endeavor	pymetrozine	pyridine azomethines	9B
Endigo ZC	lambda-cyhalothrin + thiamethoxam	pyrethroid + neonicotinoid	3 + 4A
Endosulfan	endosulfan	cyclodiene organochlorine	2A
endosulfan	Endosulfan, Thiodan, Thionex	cyclodiene organochlorine	2A
Enstar IIs	kinoprene	juvenile hormone analogue	7A
Entrust	spinosad	spinosad	5
Envidor	spirodiclofen	tetronic acid derivative	23
Epi-mek	abamectin	avermectin, milbemycin	6
esfenvalerate	Adjourn, Asana XL, S-Fenvalostar	pyrethroid	3
Esteem, Esteem Ant Bait	pyriproxyfen	insect growth regulator	7C
ethoprop	Mocap, Mocap Lock 'n Load	organophosphate	1B
etoxazole	Tetrasan, Zeal Miticide, Zeal Miticide-1	etoxazole	10C
Evergreen	piperonyl butoxide + pyrethrins	P450 monooxygenase inhibitor + pyrethrin	27A + 3
Exponent	piperonyl butoxide	P450 monooxygenase inhibitor	27A
Extinguish	(s)-methoprene	juvenile hormone analogue	7A
Fanfare	bifenthrin	pyrethroid	3
fenamiphos	Nemacur-3	organophosphate	1B
fenbutatin-oxide	Vendex	organotin miticide	12B
fenoxycarb	Award	juvenile hormone analogue	7B
fenpropathrin	Danitol, Tame	pyrethroid	3
fenpyroximate	Portal	METI acaricide	21
fipronil	Chipco Choice, Regent, Regent TS	fipronil (or phenylpyrazole)	2B
flonicamid	Beleaf, Carbine	neonicotinoid	9C
Floramite	bifenazate	carbazate acaricide	25
flubendiamide	Belt, Synapse	diamide	28
fludioxonil + mefenoxam + thiamethoxam	Cruisermaxx	phenylpyrrole + acylalanine + neonicotinoid	12 fungicide + 4 fungicide + 4A insecticide
Force	tefluthrin	pyrethroid	3
formetanate hydrochloride	Carzol SP	carbamate	1A
Fulfill	pymetrozine	pyridine azomethines	9B
Furadan, Furadan LFR	carbofuran	carbamate	1A
Fyfanon, Fyfanon ULV	malathion	organophosphate	1B
gamma-cyhalothrin	Proaxis, Prolex	pyrethroid	3
Gf-120 NF	spinosad	spinosad	5
Glacial Spray Fluid	oil, petroleum	horticultural oil	NS
Gnatrol Larvicide	Bacillus thuringiensis subspecies israelensis strain 65-52	B.t. var. israelensis	11A1
Govern	chlorpyrifos	organophosphate	1B
Grizzly Z	lambda-cyhalothrin	pyrethroid	3
Guthion Solupak	azinphos-methyl	organophosphate	1B

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
halofenozide	Mach 2	ecdysone agonist / moulting disruptor	18A
Hatchet	chlorpyrifos	organophosphate	1B
Helena Lambda	lambda-cyhalothrin	pyrethroid	3
Hero Insecticide	bifenthrin + zeta-cypermethrin	pyrethroid + pyrethroid	3 + 3
Hexygon DF	hexythiazox	hexythiazox	10B
hexythiazox	Hexygon DF, Savey	hexythiazox	10B
Holster	cypermethrin	pyrethroid	3
Imida E-Ag	imidacloprid	neonicotinoid	4A
Imidacloprid	imidacloprid	neonicotinoid	4A
imidacloprid	Admire, Admire Pro, Advise, Alias 2F, Armortech Imd, Couraze, Couraze Max, Couraze SoluPak, Imida E-Ag, Imidacloprid, Imidastar, Impulse, Mach o, Macho Max, Malice, Mallet, Marathon, Marathon-II, Merit, Montana, Nuprid, Pasada, Prey, Provado, Provado Solupak, Torrent, Tri max PRO, Widow, Wrangler	neonicotinoid	4A
imidacloprid + metalaxyl	Concur	neonicotinoid + acylalanine	4A insecticide + 4 fungicide
Imidan	phosmet	organophosphate	1B
Imidastar	imidacloprid	neonicotinoid	4A
Impulse	imidacloprid	neonicotinoid	4A
indoxacarb	Avaunt, Provaunt, Steward EC	oxadiazine	22
Intrepid	methoxyfenozide	insect growth regulator	18A
Javelin-WG	Bacillus thuringiensis subspecies kurstaki	B.t. var. kurstaki	11B2
Jms Stylet-Oil	oil, paraffinic	horticultural oil	NS
Judo	spiromesifen	tetronic acid derivative	23
Kaiso	lambda-cyhalothrin	pyrethroid	3
Kanemite	acequinocyl	acequinocyl	20B
kaolin	Surround WP	organic (microground clay)	NS
Karate, Karate with Zeon	lambda-cyhalothrin	pyrethroid	3
Kelthane	dicofol	organochlorine	UN C
Kickstart Seed Treatment	carboxin + diazinon + lindane	carboximide + organophosphate + cyclodiene organochlorine	7 fungicide + 1B insecticide + 2A insecticide
Knack Insect Growth Regulator	pyriproxyfen	insect growth regulator	7C
Kryocide	cryolite	cryolite	9A
Kumulus DF fungicide/acaricide	sulfur	inorganic	M2 fungicide
Lambda T, Lambda-CY	lambda-cyhalothrin	pyrethroid	3
lambda-cyhalothrin	Grizzly Z, Helena Lambda, Kaiso, Karate, Karate with Zeon, Lambda T, Lambda-CY, Lambdastar, Mystic Z, Silencer, Taiga Z, Warrior with Zeon	pyrethroid	3
lambda-cyhalothrin + thiamethoxam	Endigo ZC	pyrethroid + neonicotinoid	3 + 4A
Lambdastar	lambda-cyhalothrin	pyrethroid	3

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Lannate	methomyl	carbamate	1A
Larvin	thiodicarb	carbamate	1A
Lepinox	Bacillus thuringiensis subspecies kurstaki strain EG7826	B.t. var. kurstaki	11B2
Leverage	cyfluthrin + imidacloprid	pyrethroid + neonicotinoid	3 + 4A
Liquid Sulfur Six	sulfur	inorganic	M2 fungicide
Lorsban	chlorpyrifos	organophosphate	1B
Lucid	abamectin	avermectin, milbemycin	6
Mach 2	halofenozide	ecdysone agonist / moulting disruptor	18A
Macho, Macho Max	imidacloprid	neonicotinoid	4A
Malathion	malathion	organophosphate	1B
malathion	Fyfanon, Fyfanon ULV, Malathion	organophosphate	1B
Malice	imidacloprid	neonicotinoid	4A
Mallet	imidacloprid	neonicotinoid	4A
Marathon, Marathon-II	imidacloprid	neonicotinoid	4A
Mavrik Aquaflow	tau-fluvalinate	pyrethroid	3
Menace	bifenthrin	pyrethroid	3
Merit	imidacloprid	neonicotinoid	4A
Mesurol	methiocarb	carbamate	1A
methamidophos	Monitor-4	organophosphate	1B
methidathion	Supracide	organophosphate	1B
methiocarb	Mesurol	carbamate	1A
methomyl	Lannate	carbamate	1A
methoxyfenozide	Intrepid	methoxyfenozide	18A
methyl parathion	Cheminova Methyl 4 EC, Penncap-M	organophosphate	1B
Microthiol Dispers	ssulfur	inorganic	M2 fungicide
Midas	chloropicrin + iodomethane	chloropicrin	8B + 8B
milbemectin	Ultiflora	avermectin, milbemycin	6
Mimic	tebufenozide	insect growth regulator	18A
Mite-E-Oil	oil, petroleum	horticultural oil	NS
Mocap, Mocap Lock 'n Load	ethoprop	organophosphate	1B
Monitor-4	methamidophos	organophosphate	1B
Montana	imidacloprid	neonicotinoid	4A
Movento	spirotetramat	tetronic acid derivative	23
M-Pede	potassium salts of fatty acids	soap	NS
MSR Spray Concentrate	oxydemeton-methyl	organophosphate	1B
Mustang, Mustang Max	zeta-cypermethrin	pyrethroid	3
Mystic Z	lambda-cyhalothrin	pyrethroid	3
naled	Dibrom	organophosphate	1B
Neemix	azadirachtin	botanical	18B
Nemacur-3	fenamiphos	organophosphate	1B
Nexter	pyridaben	METI acaricide	21

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
novaluron	Diamond, Pedestal, Rimon	benzoylurea	15
Nufos	chlorpyrifos	organophosphate	1B
Nuprid	imidacloprid	neonicotinoid	4A
Oberon	spiromesifen	tetronic acid derivative	23
oil, paraffinic	Citrus oil, Jms Stylet-Oil, Organic JMS Stylet-Oil	botanical	NS
oil, petroleum	Glacial Spray Fluid, Mite-E-Oil, Omni Supreme Sp ray, Par F70 Soluble Oil, Purespray, Saf-T-Side	horticultural oil	NS
Omite	propargite	propargite	12C
Omni Supreme Spray	oil, petroleum	horticultural oil	NS
Organic JMS Stylet-Oil	oil, paraffinic	horticultural oil	NS
Orthene, Orthene PCO Pellets, and Turf, Tree & Ornamental	acephate	organophosphate	1B
other associated resins + pyrethrins + rotenone	Pyrellin E.C.	-- + pyrethrin + rotenone	-- + 3 + 21
oxamyl	Vydate	carbamate	1A
oxydemeton-methyl	MSR Spray Concentrate	organophosphate	1B
Pasada	imidacloprid	neonicotinoid	4A
Pedestal	novaluron	benzoylurea	15
Penncap-M	methyl parathion	organophosphate	1B
peppermint oil + rosemary oil	Ecotrol EC	botanical	NS
Permastar	permethrin	pyrethroid	3
Permethrin	permethrin	pyrethroid	3
permethrin	Ambush, Arctic, Covert, Permastar, Permethrin, Perm- Up, Pounce, Tengard SFR	pyrethroid	3
Perm-Up	permethrin	pyrethroid	3
pheromone (Z)-11-Hexadecen-1-yl acetate; pheromone (Z,E)-9,12-Tetradeca dien -1-yl Acetate	Checkmate BAW	mating disruptor	
Phorate	phorate	organophosphate	1B
phorate	Phorate, Thimet Lock'n Load, Thimet Smartbox	organophosphate	1B
phosmet	Imidan	organophosphate	1B
piperonyl butoxide	Exponent	P450 monooxygenase inhibitor	27A
piperonyl butoxide + pyrethrins	Evergreen	P450 monooxygenase inhibitor + pyrethrin	27A + 3
pirimiphos-methyl	Actellic	organophosphate	1B
Platinum	thiamethoxam	neonicotinoid	4A
Portal	fenpyroximate	METI acaricide	21
potassium salts of fatty acids	M-Pede	soap	NS
Pounce	permethrin	pyrethroid	3
Prev-Am	sodium tetraborohydrate decahydrate	borax	NS A (abrasive)
Prey	imidacloprid	neonicotinoid	4A
Proaxis	gamma-cyhalothrin	pyrethroid	3
Proclaim	emamectin benzoate	avermectin, milbemycin	6
profenofos	Curacron	organophosphate	1B
Prokil Cryolite 96	cryolite	cryolite	9A
Prokoz Sevin SL	carbaryl	carbamate	1A

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Prolex, Tenkoz	gamma-cyhalothrin	pyrethroid	3
propargite	Comite, Omite	propargite	12C
Provado, Provado Solupak	imidacloprid	neonicotinoid	4A
Provaunt	indoxacarb	oxadiazinc	22
Purespray	oil, petroleum	horticultural oil	NS
Pyganic EC	pyrethrin	pyrethrin	3
Pylon Miticide	chlorfenapyr	pyrrole	13
pymetrozine	Endeavor, Fulfill	pymetrozine	9B
Pyramite	pyridaben	METI acaricide	21
Pyrellin E.C.	other associated resins + pyrethrins + rotenone	-- + pyrethrin + rotenone	-- + 3 + 21
pyrethrin	Pyganic EC	pyrethrin	3
pyridaben	Nexter, Pyramite, Sanmite	METI acaricide	21
pyriproxyfen	Distance, Esteem, Esteem Ant Bait, Knack Insect Growth Regulator	insect growth regulator	7C
Radiant	spinetoram	spinosyn	5
Reaper	abamectin	avermectin, milbemycin	6
Regent, Regent TS	fipronil (or phenylpyrazole)	fipronil (or phenylpyrazole)	2B
Renounce	cyfluthrin	pyrethroid	3
Respect	zeta-cypermethrin	pyrethroid	3
Rimon	novaluron	benzoylurea	15
Safari	dinotefuran	neonicotinoid	4A
Saf-T-Side	oil, petroleum	horticultural oil	NS
Sanmite	pyridaben	METI acaricide	21
Savey	hexythiazox	mite growth regulator	10B
Sevin , Sevin XLR Plus	carbaryl	carbamate	1A
S-Fenvalostar	esfenvalerate	pyrethroid	3
Shuttle	acequinocyl	acequinocyl	20B
Silencer	lambda-cyhalothrin	pyrethroid	3
silicon dioxide	Dryacide	diatomaceous earth	NS
s-k inoprene	En star II	juvenile hormone analogue	7A
Sniper	bifenthrin	pyrethroid	3
sodium tetraborohydrate decahydrate	Prev-Am	borax	NS A (abrasive)
spinetoram	Delegate, Radiant	spinosyn	5
spinosad	Conserve, En trust, Gf-120 NF, Spintor, Tracer	spinosad	5
Spintor	spinosad	spinosad	5
spirodiclofen	Envidor	tetronic acid derivative	23
spiromesifen	Judo, Oberon	tetronic acid derivative	23
spirotetramat	Movento	tetronic acid derivative	23
Spray Sulfur	sulfur	inorganic	M2 fungicide
Steward EC	indoxacarb	oxadiazine	22

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Sulfur	sulfur	inorganic	M2 fungicide
sulfur	Dusting sulfur-IAP, Kumulus DF fungicide/acaricide, Liquid Sulfur Six, Microthiol Disperss, Spray Sulfur, Sulfur, Super-Six, Thiolux Jet, Thiosperse, Wettable sulfur (CSC)	inorganic	M2 fungicide
Super-Six	sulfur	inorganic	M2 fungicide
Supracide	methidathion	organophosphate	1B
Surround WP	kaolin	organic (microground clay)	NS
Synapse	flubendiamide	diamide	28
Taiga Z	lambda-cyhalothrin	pyrethroid	3
Tame	fenpropathrin	pyrethroid	3
tau-fluvalinate	Mavrik Aquaflow	pyrethroid	3
tebufenozide	Confirm, Mimic	tebufenozide	18A
tefluthrin	Force	pyrethroid	3
Telone C-17, Telone C-35, Telone II	1,3-dichloropropene + chloropicrin	halogenated organic fumigant + chloropicrin	8 + 8B
Temik, Temik Lock 'n Load	aldicarb	carbamate	1A
Tempo, Tempo SC Ultra	cyfluthrin	pyrethroid	3
Temprano	abamectin	avermectin	6
Tengard SFR	permethrin	pyrethroid	3
terbufos	Counter Lock'n Load, Counter Smartbox	organophosphate	1B
Tetrasan	etoxazole	etoxazole	etoxazole
thiacloprid	Calypso	neonicotinoid	4A
thiamethoxam	Actara, Centric, Cruiser, Platinum	neonicotinoid	4A
Thimet Lock'n Load, Thimet Smartbox	phorate	organophosphate	1B
Thiodan	endosulfan	cyclodiene organochlorine	2A
thiodicarb	Larvin	carbamate	1A
Thiolux Jet	sulfur	inorganic	M2 fungicide
Thionex	endosulfan	cyclodiene organochlorine	2A
Thiosperse	sulfur	inorganic	M2 fungicide
Tombstone	cyfluthrin	pyrethroid	3
Torrent	imidacloprid	neonicotinoid	4A
Tracer	spinosad	spinosad	5
Trigard	cyromazine	insect growth regulator	17
Trimax Pro	imidacloprid	neonicotinoid	4A
Tristar	acetamiprid	neonicotinoid	4A
Tundra	bifenthrin	pyrethroid	3
Ultiflora	milbemectin	avermectin, milbemycin	6
Up-Cyde, Up-Cyde Pro	cypermethrin	pyrethroid	3
Up-Star, Up-Star Gold, Up-Star Nursery Granular	bifenthrin	pyrethroid	3
Vendex	fenbutatin-oxide	organotin miticide	12B
Venom	dinotefuran	neonicotinoid	4A
Vydate	oxamyl	carbamate	1A
Warhawk	chlorpyrifos	organophosphate	1B
Warrior with Zeon	lambda-cyhalothrin	pyrethroid	3
Wettable sulfur (CSC)	sulfur	inorganic	M2 fungicide

BRAND NAME(S) OR ACTIVE INGREDIENT(S)	BRAND NAME(S) OR ACTIVE INGREDIENT(S)	CHEMICAL CLASS OR EXEMPLIFYING ACTIVE INGREDIENT	IRAC MODE OF ACTION GROUP[1]
Whirlwind	chlorpyrifos	organophosphate	1B
Widow	imidacloprid	neonicotinoid	4A
Wrangler	imidacloprid	neonicotinoid	4A
Xentari	Bacillus thuringiensis subspecies aizawai strain ABTS-1857	B.t. var. aizawai	11B1
Yuma	chlorpyrifos	organophosphate	1B
Zeal Miticide, Zeal Miticide-1	etoxazole	etoxazole	10C
Zephyr	abamectin	avermectin, milbemycin	6
zeta-cypermethrin	Mustang, Mustang Max, Respect	pyrethroid	3
Zoro miticide/insecticide	abamectin	avermectin, milbemycin	6

[1] IRAC (Insecticide Resistance Action Committee) is an insecticide specialist technical group of the industry association Croplife. The IRAC classification of insecticides and acaricides by mode of action and chemical class is considered the standard for classification of pest control products for insects and mites. www.irac-online.org/eclassification/

1 - Acetylcholine esterase inhibitor
2 - GABA-gated chloride channel antagonists
3 - Sodium channel modulators
4 - Nicotinic Acetylcholine receptor agonists / antagonists
5 - Nicotinic Acetylcholine receptor agonists (allosteric) (not group 4)
6 - Chloride channel activators
7 - Juvenile hormone mimics
8 - Compounds of unknown or non-specific mode of action (fumigants)
9 - Compounds of unknown or non-specific mode of action (selective feeding blockers)
10 - Compounds of unknown or non-specific mode of action (mite growth inhibitors)
11 - Microbial disruptors of insect midgut membranes (includes transgenic crops expressing B.t. toxins)
12 - Inhibitors of oxidative phosphorylation, disruptors of ATP formation (inhibitors of ATP synthase)
13 - Uncouplers of oxidative phosphorylation via disruption of proton gradient
14 - (vacant)
15 - Inhibitors of chitin biosynthesis, type 0, Lepidopteran
16 - Inhibitors of chitin biosynthesis, type 1, Homopteran
17 - Moulting disruptor, Dipteran
18 - Ecdysone agonists / moulting disruptors
19 - Octopaminergic agonists
20 - Mitochondrial complex III electron transport inhibitors (Coupling site II)
21 - Mitochondrial complex I electron transport inhibitors
22 - Voltage-dependent sodium channel blockers
23 - Inhibitors of lipid synthesis
24 - Mitochondrial complex IV electron transport inhibitors
25 - Neuronal inhibitors (unknown mode of action)
26 - Aconitase inhibitors
27 - Synergists
28 - Ryanodine receptor modulator
UN - Compounds with unknown mode of action
NS - Miscellaneous non-specific (multi-site) inhibitors

HERBICIDE BRAND NAMES, ACTIVE INGREDIENTS, CHEMICAL FAMILIES, AND MODES OF ACTION

Eric P. Prostko, Extension Agronomist - Weed Science
A. Stanley Culpepper, Extension Agronomist - Weed Science
Tim R. Murphy, Extension Agronomist - Weed Science
Patrick McCullough, Extension Agronomist – Weed Science

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
AAtrex	atrazine	Triazine	5
Accent	nicosulfuron	Sulfonylurea	2
Acclaim Extra	fenoxaprop	Aryloxyphenoxy-propionate	1
Acumen	pendimethalin	Dinitroaniline	3
Aim	carfentrazone	Triazolinone	14
Alachlor	alachlor	Chloroacetamide	15
Alanap	naptalam	Phthalamate simicarbazone	19
Anthem	fluthiacet methyl + pyroxasulfone	Thiadiazole + isoxazoline	14+15
Arrow	clethodim	Cyclohexanedione	1
Arsenal	imazapyr	Imidazolinone	2
Assure II	quizalofop	Aryloxyphenoxy-propionate	1
Atrazine	atrazine	Triazine	5
Axial	pinoxaden	phenylpyrazoline	1
Axiom	flufenacet + metribuzin	Oxyacetamide + triazinone	15 + 5
Authority Assist	sulfentrazone + imazethapyr	Triazolinone + imidazolinone	14 + 2
Authority First	sulfentrazone + cloransulam	Triazolinone + triazolopyrimidine	14 + 2
Authority XL	sulfentrazone + chlorimuron	Triazolinone + sulfonylurea	14 + 2
Authority MTZ	Sulfentrazone + metribuzin	Triazolinone + triazinone	14 + 5
Backdraft	glyphosate + imazaquin	Glycine + imidazolinone	9 + 2
Balan	benefin	Dinitroaniline	3
Balance Flexx	isoxaflutole	isoxazole	28
Banvel	dicamba	Benzoic acid	4
Banvel-K + Atrazine	dicamba + a 2 trazine	Benzoic acid + triazine	4 + 5
Barricade	prodiamine	Dinitroaniline	3
Basagran	bentazon	Benzothiadiazinone	6
Basis	rimsulfuron + thifensulfuron	Sulfonylurea	2 + 2
Basis Gold	rimsulfuron + thifensulfuron + atrazine	Sulfonylurea + sulfonylurea + triazine	2 + 2 + 5
Beacon	primisulfuron	Sulfonylurea	2
Bensumec	bensulide	Unclassified	17
Beyond	imazamox	Imidazolinone	2
Bicep II Magnum	atrazine + s-metolachlor	Triazine + chloroacetamide	5 + 15
Blade	metsulfuron	Sulfonylurea	2
Boundary	s-metolachlor + metribuzin	Chloroacetamide + triazine	15 + 5
Brawl, Brawl II	s-metolachlor	Chloroacetamide	15
Brawl II ATZ	s-metolachlor + atrazine	Chloroacetamide + triazine	15 + 5
Breakfree	acetochlor	Chloroacetamide	15
Breakfree ATZ	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Break-Up	pronamide	Benzamide	3
Buctril	bromoxynil	Nitrile	6
Bullet	alachlor + atrazine	Chloroacetamide + triazine	15 + 5
Butoxone	2,4-DB	Phenoxy-carboxylic acid	4
Butyrac	2,4-DB	Phenoxy-carboxylic acid	4
Cadet	Fluthiacet-methyl	thiadiazole	14
Cadre	imazapic	Imidazolinone	2
Callisto	mesotrione	Triketone	27

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
Callisto Xtra	mesotrione + atrazine	Triketone + triazine	27 + 5
Camix	s-metolachlor + mesiotrione	Chloroacetamide + triketone	15 + 27
Canopy	metribuzin + chlorimuron	Triazinone + sulfonylurea	5 + 2
Canopy EX	chlorimuron + tribenuron	Sulfonylurea + sulfonylurea	2 + 2
Canopy XL	sulfentrazone + chlorimuron	Diphenylether + sulfonylurea	14 + 2
Caparol	prometryn	Triazine	5
Capreno	Thiencarbazone + tembotrione	Triazolone + triketone	2 + 27
Celebrity, Celebrity Plus	nicosulfuron + dicamba	Sulfonylurea + benzoic acid	2 + 4
Celsius	Iodosulfuron + thiencarbzone + dicamba	Sulfonylurea + triazolone + benzoic acid	2 + 2 + 4
Certainty	Sulfosulfuron	Sulfonylurea	2
Charger Basic, Charger MAX	s-metolachlor	Chloroacetamide	15
Charger MAX ATZ 15	atrazine + s-metolachlor	Triazine + chloroacetamide	5 + 15
Chateau	flumioxazin	N-phenylphthalimide	14
Cimarron Max	metsulfuron + 2,4-D + dicamba	Sulfonylurea + phenoxy-carboxylic acid + benzoic acid	2 + 4 + 4
Cimarron Plus	metsulfuron + chlorsulfuron	Sulfonylurea	2 + 2
Cinch	s-metolachlor	Chloroacetamide	15
Cinch ATZ	s-metolachlor + atrazine	Chloroacetamide + triazine	15 + 5
Clarity	dicamba	Benzoic acid	4
Classic	chlorimuron	Sulfonylurea	2
Clethodim	clethodim	Cyclohexanedione	1
Clopyr AG	clopyralid	Pyridine carboxylic acid	4
Cobra	lactofen	Diphenylether	14
Command	clomazone	Isoxazolidinone	13
Confidence	acetochlor	Chloroacetamide	15
Confidence Xtra	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Confront	Clopyralid + triclopyr	Pyridine carboxylic acid + pyridine carboxylic acid	4 + 4
Corsair	sulfometuron	Sulfonylurea	2
Cotoran	fluometuron	Urea	7
Corvus	thiencarbazone + isoxaflutole	Triazolone + isoxazole	2 + 27
Crossbow	2,4-D + triclopyr	Phenoxy-carboxylic acid + pyridine carboxylic acid	4 + 4
Curbit	ethalfluralin	Dinitroaniline	3
Dacthal	DCPA	Benzoic acid	3
Define	flufenacet	Oxyacetamide	15
Degree	acetochlor	Chloroacetamide	15
Degree Xtra	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Devrinol	napropamide	Acetamide	15
Diablo	dicamba	Benzoic acid	4
Dicamba	dicamba	Benzoic acid	4
Dimension	dithiopyr	Pyridine	3
Direx	diuron	Urea	7
Dismiss	sulfentrazone	Triazolinone	14
Distinct	dicamba + diflufenzopyr	Benzoic acid + semicarbazone	4 + 19
Diuron	diuron	Urea	7
Double Team	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Drive, Drive XLR8	quinclorac	Quinaline carboxcylic acid	4 - dicots
DSMA, numerous brands	DSMA	Organoarsenical	17
Dual II, Dual II Magnum	s-metolachlor	Chloroacetamide	15

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
Echelon	Prodiamine + sulfentrazone	Dinitroaniline + Triazolinone	3 + 14
Envoke	trifloxysulfuron	Sulfonylurea	2
Envoy	clethodim	Cyclohexanedione	1
Eptam	EPTC	Thiocarbamate	8
Equip	foramsulfuron + iodosulfuron	Sulfonylurea	2 + 2
Eradicane	EPTC	Thiocarbamate	8
Escalade	2,4-D + dicamba + fluroxypyr	Phenoxy + benzoic acid + pryridine carboxylic acid	4 + 4 + 4
Establish	dimethenamid-p	Chloroacetamide	15
Establish ATZ	dimethenamid-p + atrazine	Chloroacetamide + triazine	15 + 5
ET	pyraflufen ethyl	Phenylpyrazole	14
Evik	ametryne	Triazine	5
Exceed	primisulfuron + prosulfuron	Sulfonylurea + Sulfonylurea	2 + 2
Expert	glyphosate + s-metolachlor + atrazine	Glycine + chloroacetamide + triazine	9 + 15 + 5
Express	tribenuron	Sulfonylurea	2
Extreme	glyphosate + imazethapyr	Glycine + imidazolinone	9 + 2
Fierce	flumioxazin + pyroxasulfone	N-phenylphthalimide + isoxazoline	14 + 15
Finesse	chlorsulfuron + metsulfuron	Sulfonylurea + sulfonylurea	2 + 2
Firestorm	paraquat	Bipyridylium	22
Firstrate	cloransulam	Triazolopyrimidine	2
Firstshot	Tribenuron + thifensulfuron	Sulfonylurea + Sulfonylurea	2 + 2
Flexstar	Fomesafen	Diphenylether	14
Flexstar GT 3.5	Fomesafen + glyphosate	Diphenylether + glycine	14 + 9
Fluometuron	fluometuron	Urea	7
ForeFront	aminopyralid + 2,4-D	pyridinecarboxylic acid + phenoxy-carboxylic acid	4 + 4
Freehand	Dimethenamid + pendimethalin	Chloracetamide + dinitroaniline	15 + 3
FulTime	acetochlor	Chloroacetamide	15
Fusilade DX, II	fluazifop	Aryloxyphenoxy-propionate	1
Fusion	fluazifop + fenoxaprop	Aryloxyphenoxy-propionate + aryloxyphenoxy-propionate	1 + 1
Gallery	isoxaben	Benzamide	21
Galligan	oxyfluorfen	Diphenylether	14
Gangster	flumioxazin + cloransulam	N-phenylphthalimide + triazolopyrimidine	14 + 2
Garlon	triclopyr	pyridinecarboxylic acid	4
Glyphosate (numerous brands)	glyphosate	Glycine	9
Goal/GoalTender	oxyfluorfen	Diphenylether	14
Gramoxone	paraquat	Bipyridylium	22
Grazon P+D	2,4-D + picloram	Phenoxy-carboxylic acid + pyridinecarboxylic acid	4 + 4
Guardsman Max	dimethenamid-p + atrazine	Chloroacetamide + triazine	15 + 5
Gunslinger	2,4-D + picloram	Phenoxy-carboxylic acid + pyridinecarboxylic acid	4 + 4
Halex GT	mesiotrione + atrazine + glyphosate	Triketone + triazine + glycine	27 + 5 + 9
Harmony Extra	thifensulfuron + tribenuron	Sulfonylurea + sulfonylurea	2 + 2
Harmony GT	thifensulfuron	Sulfonylurea	2
Harness	acetochlor	Chloroacetamide	15
Harness Xtra	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Hoelon	diclofop	Aryloxyphenoxy-propionate	1
Huskie	Bromoxynil + pyrasulfotole	Nitrile + benzoylpyrazole	6 + 27
Hyvar	bromacil	uracil	5
Ignite, Ignite 280	glufosinate	Phosphinic acid	10
Illoxan	diclofop	Aryloxyphenoxy-propionate	1

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
Impact	topramezone	benzoylpyrazole	27
Image	imazaquin	Imidazolinone	2
Impose	imazapic	Imidazolinone	2
Intrro	alachlor	Chloroacetamide	15
Karmex	diuron	Urea	7
Kerb	pronamide	Benzamide	3
Keystone	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Lariat	alachlor + atrazine	Chloroacetamide + triazine	15 + 5
Laudis	tembotrione	Triketone	27
Layby Pro	diuron + linuron	Urea + urea	7 + 7
Lexar	mesotrione + s-metolachlor + atrazine	Triketone + chloroacetamide + triazine	27 + 15 + 5
Liberty	glufosinate	Phosphinic acid	10
Liberty ATZ	glufosinate + atrazine	Phosphinic acid + triazine	10 + 5
Lightning	imazethapyr + imazapyr	Imidazolinone + imidazolinone	2 + 2
Linex	linuron	Urea	7
Lontrel	Clopyralid	pyridinecarboxylic acid	4
Lorox	linuron	Urea	7
Lumax	mesotrione + s-metolachlor + atrazine	Triketone + chloroacetamide + atrazine	27 + 15 + 5
Manor	metsulfuron	Sulfonylurea	2
Marksman	dicamba + atrazine	Benzoic acid + triazine	4 + 5
Matrix	rimsulfuron	Sulfonylurea	2
Maverick	sulfosulfuron	Sulfonylurea	2
Medal, Medal II	s-metolachlor Chloroacetamide	Chloroacetamide	15
Me-Too-Lachlor, Me-Too-Lachlor II	metolachlor	Chloroacetamide	15
Metri	metribuzin	Triazinone	5
Metribuzin	metribuzin	Triazinone	5
Micro-Tech	alachlor Nitrile	Chloroacetamide	15
Milestone	aminopyralid	pyridinecarboxylic acid	4
Monument	trifloxysulfuron	Sulfonylurea	2
Moxy	bromoxynil	Nitrile	6
MSMA (numerous brands)	MSMA	Organoarsenical	17
One-Time	Dicamba + MCPP + quinclorac	Benzoic acid + phenoxy + quinaline carboxylic acid	4 + 4 + 4
Option	foramsulfuron	Sulfonylurea	2
Osprey	mesosulfuron	Sulfonylurea	2
Oust	sulfometuron	Sulfonylurea	2
Outlaw	2,4-D + dicamba	Phenoxy-carboxylic acid + benzoic acid	4 + 4
Outlook	dimethenamid-p	Chloroacetamide	15
OxiFlo	oxyfluorfen	Diphenylether	14
Parallel, Parallel PCS	metolachlor	Chloroacetamide	15
Panoramic	imazapic	Imidazolinone	2
Parazone	paraquat	Bipyridilium	22
Parrlay	metolachlor	Chloroacetamide	15
PastureGard	Triclopyr + fluroxypyr	pyridinecarboxylic acid	4 + 4
Peak	prosulfuron	Sulfonylurea	2
Pendant	pendimethalin	Dinitroaniline	3
Pendimax	pendimethalin	Dinitroaniline	3
Pendulum	pendimethalin	Dinitroaniline	3
Pennant	s-metolachlor	Chloroacetamide	15
Permit	halosulfuron	Sulfonylurea	2

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
Phoenix	lactofen	Diphenylether	14
Plateau	imazapic	Imidazolinone	2
Poast, Poast Plus	sethoxydim	Cyclohexanedione	1
Prefar	bensulide	Phosphorodithioate	8
Prefix	s-metolachlor + fomesafen	Chloracetamide + diphenylether	15 + 14
Princep	simazine	Triazine	5
Priority	carfentrazone + halosulfuron	Triazolinone + sulfonylurea	14 + 2
Prograss	ethofumesate	Benzofuran	16
Prometryn	prometryn	Triazine	5
Prowl, Prowl H2O	pendimethalin	Dinitroaniline	3
Pursuit	imazethapyr	Imidazolinone	2
Python	flumetsulam	Triazolopyrimidine	2
Q4	2,4-D + dicamba + quinclorac + sulfentrazone	Phenoxy + benzoic acid + quinaline carboxylic acid + triazolinone	4 + 4 + 4 + 14
Quincept	2,4-D + dicamba + quinclorac	Phenoxy + benzoic acid + quinaline carboxylic acid	4 + 4 + 4
QuickSilver	carfentrazone	Triazolinone	14
Raptor	imazamox	Imidazolinone	2
Realm Q	rimsulfuron + mesotrione	Sulfonylurea + triketone	2 + 27
Reflex	fomesafen	Diphenylether	14
Reglone	diquat	Bipyridilium	22
Remedy	triclopyr	pyridinecarboxylic acid	4
Resolve	rimsulfuron	Sulfonylurea	2
Resource	flumiclorac-pentyl	N-phenylphthalimide	14
Revolver	foramsulfuron	Sulfonylurea	2
Reward	diquat	Bipyridylium	22
Ro-Neet	cycloate	Thiocarbamate	8
Ronstar	oxadiazon	Oxadiazole	14
Roundup	glyphosate	glycine	9
Sandea	halosulfuron	Sulfonylurea	2
Scepter	imazaquin	Imidazolinone	2
Sedgehammer	halosulfuron	Sulfonylurea	2
Select/Select Max	clethodim	Cyclohexanedione	1
Sethoxydim G- and E-Pro	sethoxydim	Cyclohexanedione	1
Sencor	metribuzin	Triazinone	5
Sequence	glyphosate + s-metolachlor	Glycine + chloroacetamide	9 + 15
Sharpen	saflufenacil	pyrimidinedione	14
Simazine	simazine	Triazine	5
Sim-Trol	simazine	Triazine	5
Sinbar	terbacil	Uracil	5
Sonalan	ethalfluralin	Dinitroaniline	3
Sonic	sulfentrazone + cloransulam	Triazolinone + triazolopyrimidine	14 + 2
Solicam	norflurazone	Pyridazinone	12
Spartan	sulfentrazone	Triazolinone	14
Spartan Advance	sulfentrazone + glyphosate	Triazolinone + glycine	14 + 9
Spartan Charge	sulfentrazone + carfentrazone	Triazolinone + triazolinone	14 + 14
Spike	tebuthiuron	Urea	7
Spin-Aid	phenmedipham	Phenylcarbamate	5
Spotlight	fluroxypyr	pyridinecarboxylic acid	4
Squadron	imazaquin + pendimethalin	Imidazolinone + dinitroaniline	2 + 3
Stalwart, Stalwart C	metolachlor	Chloroacetamide	15
Stalwart Xtra	metolachlor + atrazine	Chloroacetamide + triazine	15 + 5

HERBICIDE BRAND NAMES, ACTIVE INGREDIENTS, CHEMICAL FAMILIES, AND MODES OF ACTION (continued)

Brand Names	Active Ingredient(s)	Chemical Family	Mode of Action[1]
Staple	pyrithiobac	Pyrimidinyl(thio)benzoate	2
Starfighter	ozadiazon	oxadiazole	14
Status	dicamba + diflufenzopyr	Benzoic acid + semicarbazone	4 + 19
Steadfast	nicosulfuron + rimsulfuron	Sulfonylurea + sulfonylurea	2 + 2
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine	Sulfonylurea + sulfonylurea + triazine	2 + 2 + 5
Stealth	pendimethalin	Dinitroaniline	3
Sterling	dicamba	Benzoic acid	4
Stinger	clopyralid	Pyridine carboxylic acid	4
Storm	acifluorfen + bentazon	Diphenylether + benzothiadiazinone	14 + 6
Stout	nicosulfuron + thifensulfuron	Sulfonylurea + sulfonylurea	2 + 2
Strategy	ethalfluralin + clomazone	Dinitroaniline + isoxazolidinone	3 + 13
Strongarm	diclosulam	Triazolopyrimidine	2
Suprend	prometryn + trifloxysulfuron	Triazine + sulfonylurea	5 + 2
Surflan	oryzalin	Dinitroaniline	3
Surge	2,4-D + dicamba + MCPP + sulfentrazone	Phenoxy + benzoic acid + phenoxy + triazolinone	4 + 4 + 4 = 14
Surmount	picloram + fluroxypyr	pyridinecarboxylic acid	4
Sutan+	Butylate	Thiocarbamate	8
Surpass	acetochlor	Chloroacetamide	15
Synchrony XP	chlorimuron + thifensulfuron	Sulfonylurea + sulfonylurea	2 + 2
Targa	quizalofop	Aryloxyphenoxy-propionate	1
Tenacity	mesotrione	triketone	27
TopNotch	acetochlor	Chloroacetamide	15
Tower	dimethenamid	chloracetamide	15
Transline	clopyralid	pyridinecarboxylic acid	4
TranXit	rimsulfuron	Sulfonylurea	2
Treflan	trifluralin	Dinitroaniline	3
Triangle	atrazine + metolachlor	Triazine + chloroacetamide	5 + 15
Trifluralin	trifluralin	Dinitroaniline	3
Trigger	clethodim	Cyclohexanedione	1
Trilin	trifluralin	Dinitroaniline	3
Trust	trifluralin	Dinitroaniline	3
Tupersan	siduron	Urea	7
Turflon Ester	triclopyr	pyridinecarboxylic acid	4
Ultra Blazer	acifluorfen	Diphenylether	14
Valor	flumioxazin	N-phenylphthalimide	14
Valor XLT	flumioxazin + chlorimuron	N-phenylphthalimide + sulfonylurea	14 + 2
Vanquish	dicamba	Benzoic acid	4
Velocity	Bispyribac-sodium	pyrimidunyloxybenzoic	2
Velpar	Hexazinone	Triazinone	5
Vision	dicamba	Benzoic acid	4
Volley	acetochlor	Chloroacetamide	15
Volley ATZ	acetochlor + atrazine	Chloroacetamide + triazine	15 + 5
Volunteer	clethodim	Cyclohexanedione	1
Weedmaster	2,4-D + dicamba	Phenoxy-carboxylic acid + benzoic acid	4 + 4
Warrant	acetochlor	chloroacetamide	15
Yukon	halosulfuron + dicamba	Sulfonylurea + benzoic acid	2 + 4
Zidua	pyroxasulfone	Isoxazoline	15
2,4-D (numerous brands)	2,4-D	Phenoxy-carboxylic acid	4
2,4-DB (numerous brands)	2,4-DB	Phenoxy-carboxylic acid	4

[1]Modes of Action

1	ACCase inhibition
2	ALS or AHAS inhibition
3	Inhibit Microtubule Structure and Function
4	Synthetic auxin
5	Photosystem II inhibition (different binding site than Groups 6 and 7)
6	Photosystem II inhibition (different binding site than Groups 5 and 7)
7	Photosystem II inhibition (different binding site than Groups 5 and 6)
8	Fatty Acid and Lipid Biosynthesis Inhibitors
9	ESP synthase inhibition
10	Glutamine synthase inhibition
11	Carotenoid Biosynthesis Inhibitors
12	Carotenoid Biosynthesis Inhibitors
13	Carotenoid Biosynthesis Inhibitors
14	PPO inhibition
15	Inhibit Very Long Chain Fatty Acid (VLCFA) Synthesis
16	Fatty Acid and Lipid Biosynthesis Inhibitors
17	Potential Nucleic Acid Inhibitors or Non-Descript Mode of Action
18	Dihydropteroate Synthetase Inhibitors
19	Auxin transport inhibition
20	Cellulose Inhibitors
21	Cellulose Inhibitors
22	Photosystem I Inhibitors
23	Inhibit Cell Division and Microtubule Organization and Polymerization
24	Oxidative Phosphorylation Uncouplers
25	Potential Nucleic Acid Inhibitors or Non-Descript Mode of Action
26	Potential Nucleic Acid Inhibitors or Non-Descript Mode of Action
27	Carotenoid Biosynthesis Inhibitors
28	Cellulose Inhibitors or Potential Nucleic Acid Inhibitors or Non-Descript Mode of Action

Note: This table was originally prepared by Dr. Alan York, North Carolina State University and was updated by Drs. Eric Prostko, Stanley Culpepper, Tim Murphy, and Patrick McCullough, The University of Georgia, October 2011.

PESTICIDE LEGISLATION AND REGULATIONS

Paul Smith, Extension Entomologist

Introduction

The production, transportation, distribution, sale, use, application and storage of pesticides and disposal in Georgia are regulated primarily under two Federal and two Georgia laws. The Federal laws are the Federal Insecticide, Fungicide, and Rodenticide Act and the Food Quality Protection Act. The Georgia laws are the Georgia Pesticide Use and Application Act of 1976 and the Georgia Pesticide Control Act of 1976. FIFRA as amended is administered by the Administrator of the Environmental Protection Agency (EPA). The two Georgia laws are administered by the Commissioner of Agriculture through the Pesticides Division of the Georgia Department of Agriculture.

Many features of the two Georgia laws are necessary to comply with FIFRA and FQPA as amended and requirements laid down by EPA. Without this compliance, the Georgia Department of Agriculture would not be authorized to perform certain valuable functions that benefit the pesticide industry, the pesticide user and consumers. Because of this close compliance, most of the discussion will be aimed at FIFRA as amended and the manner in which it is administered by EPA.

Use Inconsistent with Label Is Unlawful

Pesticides that are shipped, distributed or sold in this country must be registered with EPA and bear the proper label. In Georgia they must also be registered with the Pesticides Division of the Georgia Department of Agriculture. Section 12 (a) (2) (G) of the amended FIFRA makes it unlawful to "use any registered pesticide in a manner inconsistent with its labeling." Section 6 (2) (c) of the Georgia Pesticide Control Act of 1976 makes it unlawful "For any person to use or cause to be used any pesticide in a manner inconsistent with its labeling ..." This and certain implications within FIFRA make it unlawful to make any recommendation for a pesticide use that is not on the label.

Section 12 (a)(2)(G) refers to the particular product that the pesticide user is applying and not merely to the active ingredient or the type of formulation. Even though two products utilize the same active ingredient in a similar formulation, it is unlawful to use a particular brand for a use that is not included on the label. For example, Roundup(TM) and Rodeo(TM) utilize the same active ingredient in a similar formulation, but it is unlawful to use Roundup(TM) to control aquatic weeds as this use is not included on the label.

Most of the troubles with Section 12 (a) (2) (G) have been caused by the manner in which it has been interpreted by EPA. EPA insisted on defining "inconsistent" to mean "failure to be precisely the same." When Congress amended FIFRA by passing the Federal Pesticide Act of 1978, it recognized the need to qualify Section 12 (a) (2) (G) by enacting certain exemptions. You may now deviate from the label directions in the following ways.

You may

1) Apply a pesticide at any dosage, concentration or frequency less than that specified on the labeling.
2) Apply a pesticide against any pest not specified on the labeling if the crop, animal or site is listed and if the labeling does not prohibit such a use.
3) Use any application method not prohibited by the labeling, e.g., aerial application.
4) Mix a pesticide with fertilizer if not prohibited by the labeling.
5) Use a pesticide differently from the label conformance with FIFRA Sections 5 (Experimental Use Permits), 18 (Emergency Exemptions for Governmental Agencies), and 24 (Special Local Needs Registration).

According to EPA's earlier interpretation of FIFRA Section 12 (a) 1 (B) employees of pesticide companies or anyone involved in the distribution or sale of a pesticide could not legally utilize the above exemptions when making recommendations. This restriction was removed by a 1981 FIFRA Enforcement Policy Statement from EPA.

Restricted Use Pesticides (RUP)

All restricted use pesticides will be clearly identified. The words 'Restricted Use Pesticide' will appear at the top of the pesticide label. To use RUP, you or your supervisor must be licensed by the Georgia Department of Agriculture. You can find out how to acquire an applicators license in the next section of this handbook.

If you need a list of all restricted use pesticides, visit the following EPA web site. You will also find recent updates to the RUP list.
www.epa.gov/opprd001/rup/

FIFRA requires that each pesticide product be classified for general use or restricted use at the time of registration or reregistration. It was originally required that all pesticides be reregistered and classified by October 21, 1976. Congress delayed the deadline until October 21, 1977, largely because EPA needed more time. Because of the difficulties encountered in reregistering pesticides, it is now planned that pesticides will be classified prior to reregistration. It is unlawful to advertise a restricted use pesticide without indicating that it is for restricted use. In Georgia restricted use pesticide dealers must be licensed by the state.

No pesticide product bearing a restricted use on its label can be shipped by the registrant or producer after the 120th day nor distributed or sold after the 270th day following the effective date of its classification without appropriate restricted use labeling.

Certification and Licensing

What do I need to start a pesticide applicator's business?
You will need a pesticide applicator's license, a pesticide contractor's license, and you must register power application equipment with the Georgia Department of Agriculture. If you wish to start a business to control structural pests (e.g., termites, roaches), you should contact the Georgia Department of Agriculture at (800) 282-5852 to request an application packet. You must have a four-year degree in entomology (or a related field) or two years of experience.

Who needs a pesticide applicator's license?
If you want to purchase or use a restricted-use pesticide (RUP), you or your supervisor must have a pesticide applicator's license from the Georgia Department of Agriculture.

Any business that operates as a pesticide contractor must have at least one employee with a commercial pesticide applicator's license.

What is the difference between a private license and a commercial license?
With a private license, you or the people that you supervise may use RUP to produce agricultural commodities on your property or the property of your employer. You may only apply RUP to someone else's property if you are not paid for your service. An agricultural commodity includes any plant, plant part, animal, or animal product produced primarily for sale (including general use pesticides).

A commercial license allows you to apply pesticide to the property of others for money. If you are a pesticide contractor (see below), at least one employee must have a commercial pesticide license to apply any pesticide for a fee. If you use an RUP but do not qualify for a private license, you must have a commercial license.

Do all of my employees have to have a pesticide license?
No. Only the supervisor is required to have a license. Keep in mind that the license-holder is responsible for the actions of everyone that he or she supervises.

How do I get a pesticide license?
To get a private license, contact your local extension office. You will have to complete a training exercise. Unless you produce a commodity, you do not qualify for a private license.

To get a commercial license, you will have to visit a local technical college and take the test on their computers. You must pay $45 (nonrefundable) to take the test. If you pass the test (minimum passing score - '70'), you will have to pay an additional $90 license fee. For details about testing sites in your area and how to receive training materials, contact your local Extension office or visit http:/ /agr.georgia.gov - click on Divisions and Plant Industry.

How do I order the study guides?
Visit www.ent.uga/pesticide.htm

Are there any materials available to help me study for the pesticide test?
Ask your local county agent for "Commercial Pesticide Review of General Standards and Category 24, Ornamental and Turf". The videotape is a review of the two tests. You may borrow the tape from the Extension office. An on-line review quiz of General Standards is also available at http://www.ianr.unl.edu/ianr/pat/patc1qu.htm. Review sessions may be periodically scheduled by your county Extension agent to help you study for the exam. Check with you agent for availability.

Will I have to take the test every year?
You will only have to retake the tests if you allow your license to expire. Private applicators must receive three hours of recertification credit in five years; you must either complete recertification 90 days before your license expires or repeat the certification exercise. Commercial applicators must have six or more hours of recertification in five years, depending on the specific category or categories they have; you must complete your recertification 90 days before your license expires or retake the tests. Check the Georgia Department of Agriculture web site for recertification opportunities www.kellysolutions.com/ga/.

How can I find how many recertification hours I have?
Check the Georgia Department of Agriculture web site http://www.kellysolutions.com/ga/.

Is my pesticide license valid in other states?
Georgia has reciprocal agreements with Alabama, Florida, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. If you have a private pesticide applicator's license from Georgia, you may use RUP in any of these other states. If you have a commercial license from any of the cooperating states, you can obtain a reciprocal license from the others without taking their certification tests. Contact the Department of Agriculture for the state in which you are interested.

Who needs a pesticide contractor's license?
Any company or individual that applies pesticides for a fee must have a pesticide contractor's license. Contact the Georgia Department of Agriculture (404-656-4958). There is no test, but, you must pay an annual fee of $55.00 and demonstrate proof of financial responsibility. You must have at least one certified commercial applicator employed full-time, even if you do not use RUP.

What do aerial applicators need?
The business must have a pesticide contractor's license. All pilots must meet all FAA and Georgia aeronautical requirements and have a commercial pesticide applicator license.

Additionally, Mississippi and Georgia have a reciprocal agreement concerning aerial application, which includes plant agriculture, aquatic, forestry, and right-of-way.

Where can I get more information?
1) Your local extension office (go to the following web address to find your agent http://www.caes.uga.edu/extension/statewide.cfm)
2) Georgia Department of Agriculture (800-282-5852)
3) U.Ga. Pesticide Coordinator (Paul Smith, 706-542-2264 or pfsmith@uga.edu)
4) www.ent.uga.edu/pesticide.htm

Pesticide Registration

How can I register a pesticide?
A registrant must submit information to the U.S. Environmental Protection Agency to show that there will be no unreasonable adverse effects to human health or the environment if the pesticide is used according to label directions.

Registrants do NOT have to prove that a pesticide will be effective. Pesticide users should consult reliable sources before using any pesticide. The Georgia Pest Management Handbook and the U.Ga. extension service are your best sources for pest management information.

If you want to register a pesticide, visit www.epa.gov/pesticides/regulating/registering for complete information.

HELP! There is no pesticide registered to control my pest problem!
Any producer may find his or herself facing a pest problem for which there are no registered pesticides. These situations are likely to become more common as FQPA is implemented. However, there are some programs that can help. For an emergency, you can apply for a Section 18 (emergency exemption). A more permanent solution may be possible through the IR-4 Program.

Emergency exemptions. The EPA will allow emergency exemptions (Section 18) to use unregistered pesticide under special circumstances. You will need to work with the Extension Service and the Georgia Department of Agriculture to obtain an emergency exemption. Visit www.epa.gov/opprd001/section18 or contact Paul Smith 706-542-2264 - pfsmith@uga.edu.

Minor use registrations (IR-4). Minor crops and minor uses will undoubtedly suffer the greatest impacts from FQPA. This USDA program can help you replace critical minor-use pesticides. Visit www.IR-4.rutgers.edu for details or contact Stanley Culpepper at 229-386-3328 - stanley@uga.edu.

Waste Disposal

The EPD permits landfill disposal of certain concentrated pesticides as long as they are absorbed and bagged. Under EPD guidelines, up to 2.2 pounds of an acutely hazardous pesticide may be taken to a sanitary landfill; liquid formulations must first be absorbed by kitty litter or similar materials and contained in plastic bags. Up to one gallon liquid of a toxic pesticide may be taken to a sanitary landfill per visit. If you have more than one gallon but less than 220 pounds (about 25 gallons), you may take it to a sanitary landfill, but not in a liquid form. It must be absorbed and bagged as described above. If in one month you generate more than 220 pounds of toxic pesticide waste or more than 2.2 pounds of acutely hazardous pesticide waste, you must contract EPD for special instructions. Remember, local landfills have the right to refuse any pesticide, no matter how it is presented. The best method to dispose of mixed pesticides or rinse water is to apply it on the crop or site for which it is labeled.

Triple-rinsed (or equivalent), used containers can be disposed of in permitted sanitary landfills without an ID number or further regulation. Regulated waste includes improperly prepared containers, excess pesticides and pesticide dilutions, rinse water, etc., which contain a listed chemical and cannot be properly used. Pesticides or pesticide ingredients among the listed chemicals are:

Acutely Hazardous Chemicals: Aldicarb (Temik); Aldrin; Antu; Avitrol; Calcium Cyanide; Carbon disulfide; Cpd 1080 (Sodium fluoracetate); Cpd 1081 (Fluoroacetamide); Dieldrin; Dimethoate (Cygon); Dinitro Weed Killers; Dinoseb (DNBP); Di-Syston (Disulfoton); Endothal; Endrin; Famphur (Warbex); Heptachlor; Hexa-ethyl tetraphosphate (HETP); Methyl Parathion; Methomyl (Lannate, Nudrin); Nicotine and salts (Blackleaf 40); Parathion; Phenyl mercuric Acetate (PMA); Phorate (Thimet); Phostoxin (Hydrogen phosphide); Strychnine and salts; Sulfotepp (Bladafume); Tetraethyl Pyrophosphate (TEPP); Toxaphene; Warfarin; Zinc Phosphide.

Toxic Chemicals: Acetonitrile; Acrylonitrile; Amitrole; Cacodylic Acid (Phytar); Carbon Tetrachloride; Chlorobenzilate (Acaraben); Chlordane; Chloroform; Creosote; Cresylic Acid; Cyclohexane; Cyclohexanone; 2,4-D Salts and Esters; DDD; DDT; Diallate (Avadex); 1,2-Dibromo-3-Chloropropane (Nemagon, Fumazone); Dibutyl Phthalate; O-dichlorobenzene; 1,3-Dichloropropene (Telone); Dimethyl Phthalate; Ethylene Dibromide (EDB); Ethyl ether; Ethylene Dichloride (EDC); Ethylene Oxide; Formaldehyde; Hexachlorophene (Nabac); Kepone; Lindane; Malefic Hydrazide (MH-3 0); M EK (Methyl Ethyl Ketone); Methanol (Wood Alcohol); Methoxychlor; Methyl Bromide; MIBK (Methyl Isobutyl Ketone); Mirex; Napthalene (Moth Balls); Paradichlorobenzene (Moth Crystals); Paraldehyde; Pentachlorophenol; Pentachloronitrobenzene (PCNB); Perchloroethylene; Phenol (Carbolic Acid); Phenol, 2,4 ,5, Trichloro (Dowicide 2); Phenol, 2,4,6 Trichloro (Dowicide 25); Propyzamide (Kerb); Silvex; 2, 4,5-T; Thiram; Toluene; Xylene.

For current information on compliance, location of permitted sanitary landfills and technical assistance contact Georgia Environmental Protection Division; Hazardous Waste Management Program; (404) 656-2833. In emergencies call the EPD Response Team at (800) 241-4113 (continuous service). Both EPD and the Georgia Department of Agriculture Pesticides Division (800-282-5852) must be notified of fires, spills, etc. that might endanger the public or the environment.

OSHA and the Hazard Communications Standard

The purpose of this Standard (by Act of Congress in 1987) was to provide employers and employees with information regarding hazardous chemicals, including certain pesticides. The basic document involved with this information procedure is the Material Safety Data Sheets or MSDS.

Basic manufacturers and importers are required by OSHA to provide the immediate customer a single MSDS with each shipment of hazardous chemical. Dealers and formulators are supposed to have lists of what chemicals are considered hazardous. Employers who use such hazardous chemicals must keep the MSDS on file available to workers, and the employer must teach all workers to read the sheets as part of the safety training program. Visit www.osha.gov.

Pesticide Record Keeping Requirements (RUP, WPS, and pesticide contractors)

Records of applications of Restricted Use Pesticides (RUP) must be kept for two years from the date of application. The pesticide label will identify an RUP on the front panel. The information should be recorded within 14 days of application. We recommend that you maintain all pesticide use records on computer disks indefinitely. Records of proper pesticide use will protect you if you face legal action concerning pesticide liability.

All applicators must record the following information for federal RUPs:
- the month, day, and year of the application
- the pesticide brand or product name
- the EPA registration number
- the crop, commodity, stored product, or site treated
- the total amount of RUP applied
- size of the area treated
- name and certification number of the certified applicator
- location of the application

The law provides four options for recording the location:
- identify the county, range, township, and section
- maps or written description
- a map and numbering system as used by Natural Resources Conservation Service or Consolidated Farm Service Agency
- a legal property description

There is no required form. There is no reporting requirement. Instead, records must be submitted if requested by:
- USDA
- Georgia Department of Agriculture
- licensed health care professionals who require the information to treat a person who may have been exposed to the RUP for which the record is maintained. In this case, the applicator may submit the record "information" rather than the record itself.

There are special guidelines for recording a spot treatment application. A spot treatment is defined as treating an area during one 24-hour period that is less than one-tenth of an acre. Greenhouse and nursery applications are NOT spot treatments. When making a spot treatment of an RUP, applicators must record:
- pesticide brand or product name
- EPA registration number
- total amount applied
- the location designated as "spot treatment" (e.g., 'plot adjacent to spray shed')
- date of application

The law provides for penalties for failure to keep RUP records. For the first violation, the penalty is not to exceed $500. For subsequent violations, penalties will not be less than $1000, unless it is determined that a good-faith effort had been made to comply.

The Worker Protection Standard requires you to record the following information concerning applications of ALL pesticides, RUP and general use.
- location and description of treated area
- product name, EPA registration number, and active ingredient(s)
- time and date of application
- restricted entry interval (REI)

WPS requires that you keep this information for 30 days after the REI expires. However, WPS have been requested as evidence of proper pesticide use long after the 30 day mandate. We recommend that you maintain records on computer disks indefinitely.

Georgia regulations require that all pesticide contractors keep records of ALL pesticide applications, RUP and general use. Record the following information.

the date and time of the application
the pesticide brand or product name
the EPA registration number
the crop, commodity, stored product, or site treated
the total amount of pesticide applied
size of the area treated
name of the applicator
location of the applicator
rate of pesticide application
target pest
application equipment
method of pesticide disposal
accidents/pesticide spills and corrective actions

For more information about recordkeeping visit, www.ams.usda.gov/science/sdpr.htm

PESTICIDE RATE AND DOSAGE CALCULATIONS

Paul Smith, Extension Entomologist

How to Calculate Pesticide Dilutions and Dosages for Large Areas

Pesticides for use in sprays are generally available as wettable or soluble powders and as liquid concentrates. These must be diluted, usually with water, before use. Other diluents, such as deodorized kerosene, may be used for special applications.

The precise amount of water applied to an acre (or other given area) is immaterial as long as it falls within a recommended range, delivers the recommended amount of pesticide, provides adequate coverage, and does not result in excessive runoff or drift . If you know the area (acres, sq. ft., etc.) or units (trees, cows, etc.) covered by a given amount of spray you can determine the dosage or rate of active ingredient each receives by adding the proper quantity of pesticide to that amount of water. Dusts and granules are applied without dilution by the user. Therefore the amount applied per acre or unit is much more critical because you have no other way of controlling the dosage or rate of active ingredient.

The amount of active ingredient in liquid concentrates is expressed in pounds per gallon. In granules, dusts, wettable or soluble powders, and other solids it is nearly always expressed as percent by weight. Application rates are usually expressed as amount of pesticide product but sometimes they may be expressed as pounds of active ingredient or actual toxicant. Actual toxicant and active ingredient are practically synonymous.

1. To find the pounds of wettable powder (WP), dust (D) or granules (G) per acre to obtain the desired pounds of active ingredient (a.i.) per acre:

$$\textit{lbs. of WP, D or G per acre} = \frac{\textit{lbs. a.i. desired x 100}}{\textit{\% a.i. in WP, D, or G}}$$

2. To find the pints of liquid concentrate per acre to obtain the desired pounds of active ingredient (a.i.) per acre: pints of liq.

$$\textit{conc. per acre} = \frac{\textit{lbs. a.i. desired x 8*}}{\textit{lbs. a.i. per gallon of liq. conc.}}$$

*If you want the answer in gallons, quarts, or fluid ounces substitute l, 4, or l28 respectively for 8.

3. To find the amount of wettable powder (WP) or liquid concentrate to use in a given amount of spray:

   amt. of WP or liq conc. = no. of acres treated with amount of spray X desired amount of WP or liq. conc. per acre*

   *Trees, animal, etc. can be substituted for acres.

4. To find the pounds of wettable powder needed to obtain a desired percentage of active ingredient in water:

$$\textit{lbs. of WP} = \frac{\textit{gals. of spray desired x \% a.i. desired x 8.3**}}{\textit{\% a.i. in WP}}$$

5. To find the gallons of liquid concentrate needed to obtain a desired percentage of active ingredient in water:

$$\textit{gal. of liq. conc.} = \frac{\textit{gals. of spray desired x \% a.i. desired x 8.3**}}{\textit{lbs. a.i. per gal. of liq. conc. x 100}}$$

**One gallon of water weighs approximately 8.3 pounds. If another diluent is used the weight per gallon of the other diluent should be substituted for 8.3.

PESTICIDE RATE AND DOSAGE CALCULATIONS (continued)

Pesticide Conversion Table for Large Areas

LIQUID FORMULATIONS
Amount of Commercial Product to Add to Spray Tank for Each Acre Treated

FORMULATION LBS./GAL. ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1	1.1	1.5	2	2.5	3	4	6	9
1.5	10 oz	17 oz	26 oz	34 oz	43 oz	51 oz	64 oz	85 oz	96 oz	128 oz	171 oz	213 oz	256 oz	341 oz	512 oz	768 oz
2	8 oz	13 oz	19 oz	26 oz	32 oz	38 oz	48 oz	64 oz	72 oz	96 oz	128 oz	160 oz	192 oz	256 oz	384 oz	576 oz
3	5 oz	9 oz	13 oz	17 oz	21 oz	26 oz	32 oz	43 oz	48 oz	64 oz	85 oz	107 oz	128 oz	171 oz	256 oz	384 oz
4	4 oz	6 oz	10 oz	13 oz	16 oz	19 oz	24 oz	32 oz	36 oz	48 oz	64 oz	80 oz	96 oz	128 oz	192 oz	288 oz
6	2.6 oz	4.3 oz	6.4 oz	9 oz	11 oz	13 oz	16 oz	21 oz	24 oz	32 oz	43 oz	53 oz	64 oz	85 oz	128 oz	192 oz
6.7	2.3 oz	3.8 oz	5.7 oz	7.6 oz	9.6 oz	11.5 oz	14.3 oz	19.1 oz	21 oz	29 oz	38 oz	48 oz	57 oz	76 oz	115 oz	172 oz
7	2.2 oz	3.7 oz	5.5 oz	7.3 oz	9.1 oz	11 oz	13.7 oz	18 oz	20 oz	27 oz	37 oz	46 oz	55 oz	73 oz	110 oz	165 oz
8	2 oz	3.2 oz	4.8 oz	6.4 oz	8 oz	9.6 oz	12 oz	16 oz	18 oz	24 oz	32 oz	40 oz	48 oz	64 oz	96 oz	144 oz

WETTABLE POWDER FORMULATIONS
Pounds of Commercial Product to Add to Spray Tank for Each Acre Treated

% ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.															
	0.2	0.3	0.4	0.5	0.6	0.8	0.8	1	2	2	3	3	4	4	5	8	10
50	0.4	0.6	0.8	1	1.2	1.5	1.6	2	2	3	4	5	6	8	10	16	20
75	0.3	0.4	0.5	0.7	0.8	1	1.1	1.3	2	2	3	3	4	5.3	6.6	10.7	13.33
80	0.3	0.4	0.5	0.6	0.8	0.9	1	1.2	2	2	3	3	4	5	6.2	10	12.5

GRANULES AND DUSTS
Pounds of Commercial Product to Apply Per Acre

% ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.					
	1	2	3	4	5	10
2.5	40	80	120	160	200	400
5	20	40	60	80	100	200
10	10	20	30	40	50	100
15	6.6	13.3	20	26.6	33.3	66.6
20	5	10	15	20	25	50

PESTICIDE RATE AND DOSAGE CALCULATIONS (continued)

Converting Large Volume Recommendations to Small Volumes or Areas

Frequently, pesticide recommendations are given only for large volume applications, i.e. amount per l00 gallons or per acre, but only a small amount is needed. Conversion of liquids to smaller quantities is relatively easy and precise because suitable equipment such as measuring spoons are readily available. Scales sensitive enough to handle small quantities of solid materials are not widely available and it is often more practical to use volumetric measures. Various conversion tables have been prepared on the premise that there are 200 to 300 teaspoons (roughly 2 to 3 pints) per pound of solid pesticide product. These tables are grossly inaccurate because of the wide variation in bulk density among solid pesticide formulations. For instance, a pint of almost any insecticide wettable powder will weigh much less than a pint of fungicide that has a high metal content. Greater accuracy can be obtained if one first determines the weight of a given volume of the solid material and then calculates the volumetric measure. This will usually provide acceptable accuracy but it is still not as accurate as actually weighing a solid formulation. When coupled with a little simple arithmetic the following formulas will enable you to convert large volume recommendations to smaller quantities.

1. To find the amount of liquid concentrate per gallon when label recommendations are given in pints per 100 gallons:
   teaspoons/gallon = recommended pints per 100 gallons x 1*
   or
   teaspoons/gallon = recommended pints per l00 gallons x 0.96
   or
   milliliters/gallon = recommended pints per 100 gallons x 4.73*

2. To find the amount of wettable powder (WP) or other solid formulation per gallon when label recommendations are given as pounds per 100 gallons:
   teaspoons/gallon = recommended lbs./ 100 gals. x cupfuls in 1 lb. of formulation x 0.053*
   or
   teaspoons/gallon = recommended lbs./100 gals. x Tbs. in 1 ounce of formulation x 0.53*
   or
   grams/gallon = recommended lbs./100 gals x 4.54*

3. To find the amount of liquid concentrate to apply per 1,000 square feet when lab el recommendations are given as pints per acre:
   teaspoons/1,000 sq. ft. = recommended pints/acre x 2.20*
   or
   milliliters/1,000 sq. ft. = recommended pints/acre x 10.9*

4. To find the amount of dust (D), granules (G) or wettable powder (WP) to apply per 1,000 square feet when label recommendations are given as pounds per acre:
   lbs./1,000 sq. ft. = recommended lbs./acre x 0.023*
   or
   Tbs/1,000 sq. ft. = recommended lbs./acre x cupfuls in 1 lb. of formulation x 0.37*
   or
   Tbs/1,000 sq . ft. = recommended lbs./ac re x Tbs. in 1 lb. of formulation x 0.023*
   or
   grams/1,000 sq. ft. = recommended lbs./acre x 10.4*

*These values have been rounded off to facilitate calculations.

Conversion Tables for Small Areas

LIQUID FORMULATIONS[1]
Amount of Commercial Product to Add to Spray Tank to Treat l0 00 Sq. Ft.

FORMULATION LBS./GAL. ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.							
	0.25	0.5	1	2	4	8	10	12
0.5	3 Tbs[1] (43.4)3	3 oz[2] (86.8)	6 oz (173.7)	11 oz 1 Tbs (347.4)				
1	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	5 oz 1 Tbs (173.7)				
2	2 tsp (10.8)	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	5 oz 1 Tbs (173.7)	11 oz 1 Tbs (342.4)		
4	1 tsp (5.4)	2 tsp (10.8)	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	6 oz (173.7)	7 oz 2 tsp (217.1)	8 oz 4 tsp (260.6)

[1] approximate values
[2] refers to level measure
[3] figure in parentheses refers to milliliters

CALIBRATION METHOD FOR HYDRAULIC BOOM AND BAND SPRAYERS, AND OTHER LIQUID APPLICATORS

Paul E. Sumner, Extension Engineer

The procedure below is based on spraying 1/128 of an acre per nozzle or row spacing and collecting the spray that would be released during the time it takes to spray the area. Because there are 128 ounces of liquid in 1 gallon, this convenient relationship result in ounces of liquid caught being directly equal to the application rate in gallons per acre.

Calibrate with clean water when applying toxic pesticides mixed with large volumes of water. Check uniformity of nozzle output across the boom. Collect from each for a known time period. Each nozzle should be within 10 percent of the average output. Replace with new nozzles if necessary. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be applied.

Exercise extreme care and use protective equipment when active ingredient is involved.

Step 1. Determine type of application to be made and select appropriate procedure from Table 1. Example - Herbicide Broadcast - Procedure A.

Table 1. Corresponding procedures for different spray applications.

Type of Application	Procedure	Coverage Basis
	Herbicide, Insecticide, Nematicide, Fungicide, or Liquid Fertilizer	
Broadcast	A	Broadcast (gal/ acre)
Band	B	Broadcast (gal/acre of band)
Row (See note)	C (Use this procedure when rates are given for row treatment)	

Note: Determine and use average row spacing for modified row patterns. Use width of area covered per row as row spacing in skip row patterns.

Step 2. Using procedure A, B, or C below as selected in Step 1, determine appropriate calibration distance from Table 2.

(A) Broadcast Application: Outlets or nozzles must be evenly spaced. Measure outlet (nozzle, etc.) spacing. Find this spacing in left column of Table 2 and read the corresponding calibration distance. Example - for a 19” spacing the distance would be 214.9 feet.

(B) Band Application: Measure band width. Find this band width in the left column of Table 2 and read the corresponding calibration distance. Example - for a 12” band, the distance would be 340.3.

(C) Row Application: Measure row spacing for evenly spaced rows. Find this row spacing in the left column of Table 2 and read the corresponding calibration distance from the column on the right. Example - for a 38” row spacing, the distance would be 107 .5 feet. (See note above for modified and skip rows.)

CAUTION: AGRICULTURAL CHEMICALS CAN BE DANGEROUS. IMPROPER SELECTION OR USE CAN SERIOUSLY INJURE PERSONS, ANIMALS, PLANTS, SOIL, OR OTHER PROPERTY. BE SAFE: SELECT THE RIGHT CHEMICAL FOR THE JOB. HANDLE IT WITH CARE. FOLLOW THE INSTRUCTIONS ON THE CONTAINER LABEL AND INSTRUCTIONS FROM THE EQUIPMENT MANUFACTURER.

Step 3. Measure and mark calibration distance in a typical portion of the field to be sprayed.

Step 4. With all attachments in operation (harrows, planters, etc.) and traveling at the desired operating speed, determine the number of seconds it takes to travel calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

Step 5. With sprayer sitting still and operating at same throttle setting or engine R.P.M. as used in Step 4, adjust pressure to the desired setting. Machine must be operated at same pressure used for calibration.

Step 6. For procedure (A) Step 2, broadcast application, collect spray from one nozzle or outlet for the number of seconds required to travel the calibration distance.

For procedure (B) Step 2, band application, collect spray from all nozzles or out lets used on one band width for the number of second s required to travel the calibration distance.

For procedure (C) Step 2, row application, collect spray from all outlets (nozzles, etc.) used for one row for the number of seconds required to travel the calibration distance.

Table 2. Calibration distances with corresponding widths.

Row Spacing, Outlet Spacing or Band Width (Whichever Applies) (Inches)	
48**	85.1
46	88.8
44	92.8
42	97.2
40	102.1
38	107.5
36	113.4
32	127.6
30	136.1
24	170.2
20	204.2
19	214.9
18	226.9
14	291.7
12	340.3
10	408.4
8	510.5

To determine distance for spacing or band width not listed, divide the spacing or band width expressed in feet into 340.3. Example: for a 13" band the calibration distance would be 340 divided by 13/12 = 314.1.

** To increase calibration accuracy for a wide nozzle spacing, multiply calibration distance by a factor (for example, 2); then, divide the fluid amount collected by the same factor for GPA. For narrow nozzle spacings with long calibration distances, divide calibration distance by a factor (for example, 4); then, multiply the fluid amount collected by the same factor for GPA.

Step 7. Measure the amount of liquid collected in fluid ounces. The number of ounces collected is the gallons per acre rate on the coverage bas is indicated in Table 1. For example, if you collect 18 ounces, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc. to obtain recommended rate. If speed is adjusted, start at Step 4 and recalibrate. If pressure or nozzles are changed, start at Step 5 and recalibrate.

Step 8. To determine amount of pesticide to put into a sprayer or applicator tank, divide the total number of gallons of mixture to be made (tank capacity for a full tank) by the gallons per acre rate from Step 7 and use recommended amount of pesticide for this number of acres.

Band Application

Use the recommended **broadcast** pesticide rates to make tank mixtures for band applications when calibrating with procedure (B) of this method. The number of gallons/acre determined in Step 7 is the gallons that will be applied to each acre of actually treated band.

To determine the gallons of spray mixture required to make a band application on a field, the number of acres that will be in the actually treated band must be determined. When all treated bands are the same width and all untreated bands are the same width, which is usually the case, the acres in the actually treated band can be calculated by placing the width of the treated band over the sum of the widths of the treated band and the untreated band, and multiplying this fraction times the number of acres in the field. Example - How many acres will actually be treated in a 30 acre field if a 12" band of chemical is applied over the drill of rows spaced 36" apart. The treated band width is 12". The untreated band width is (36" - 12") = 24". Acres actually treated will be 12" divided by (12" + 24") times 30 acres equals 10 acres. The amount of mixture required will be 10 times the number of gallons per acre from Step 7. The amount of chemic al required will be 10 times the recommended broadcast rat e for one acre.

Check rate recommendations carefully as to type of application, broadcast, band or row, and type of material specified, formulated product, active ingredient, etc.

Calculating Formulation Requirements For Active Ingredient Rates.

To determine amount of liquid pesticide required for a rate given in pounds of active ingredient per acre, divide recommended rate by pounds active ingredient per gallon stated on label. Example - Pesticide lab el states 4 lbs. active ingredient per gallon and recommends 1/2 pound active ingredient per acre. Amount of pesticide required: 1/ 2 lb. /A divided by 4 lb./gal. = 1/8 gal./ A.

To determine amount of wettable powder required for a rate given in pounds active ingredient per acre, divide recommended rate by percent active ingredient stated on label. Example - Pesticide label states powder is 50% active ingredient. Two pounds of active ingredient is recommended per acre. Amount of pesticide powder required: 2 lbs. AI/A divided b y 0.5 AI/lb. = 4 lbs./A.

CALIBRATION METHOD FOR BOOMLESS BROADCAST SPRAYERS

Paul E. Sumner, Extension Engineer

All sprayers should be calibrated often to ensure that pesticide is being applied at the correct rate. Most broadcast applications are made with a boom arrangement where the nozzle tips are spaced evenly along the boom. However, in some situations this may be impossible or undesirable, so a cluster nozzle or a single nozzle with a wide spray pattern may be used.

Calibrate with clean water when applying toxic pesticides mixed with large volumes of water. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be app lied. Exercise extreme care and use protective equipment when active ingredient is involved.

The following instructions outline a simple method to calibrate a boomless broadcast sprayer.

Step 1. Determine spray width. The spray width is the distance between successive passes through a field. This is usually given in the manufacturers' literature for a specific nozzle. If you are unable to find this in the catalogs, use 80 to 85 percent of the wetted spray width.

Step 2. Using the spray width in Step 1, determine the calibration distance from Table 1.

Step 3. Measure and mark calibration distance on typical terrain to be sprayed.

Step 4. With all attachment s in operation and traveling at the desired operating speed, determine the number of seconds it takes to travel the calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

Step 5. With sprayer sitting still and operating at same throttle setting or engine R.P.M. as used in Step 4, adjust pressure to the desired setting. Machine must be operated at same pressure used for calibration.

Step 6. Collect spray from all nozzles or outlets for the number of seconds required to travel the calibration distance.

Table 1. Calibration distances with corresponding widths.

Swath Width (feet)	Calibration Distance (feet)
40	85.1
38	89.5
36	94.5
32	106.3
30	113.4
28	121.5
24	141.8
20	170.2
18	189
16	212.7
12	283.6
10	340.3
8	425

To determine distance for swath width not listed, divide the swath width expressed in feet into 340.3 and multiply by 10. Example: for 13 feet swath the calibration distance would be 340.3 divided by 13 multiplied by 10 = 261.8.

Step 7. Measure the amount of liquid collected in fluid ounces.

Step 8. Divide t he total number of fluid ounces by 10 to obtain gallons per acre applied. For example, if you collect 180 ounces, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc. to obtain recommended rate. If speed is adjusted, start at Step 3 and recalibrate. If pressure or nozzles are changed, start at Step 5 and recalibrate.

Step 9. To determine amount of pesticide to put into a sprayer or applicator tank, divide the total number of gallons of mixture to be made (tank capacity for a full tank) by the gallons per acre rate from Step 8 and use recommended amount of pesticide for this number of acres.

CAUTION: AGRICULTURAL CHEM ICALS CAN BE DANGERO US. IMPROPER SELECTION OR USE CAN SERIOUSLY INJURE PERSON S, ANIMALS, PLANTS, SOIL, OR OTHER PROPERTY. BE SAFE: SELECT THE RIGHT CHEMICAL FOR THE JOB. HANDLE IT WITH CARE. FOLLOW THE INSTRUCTIONS ON THE CONTAINER LABEL AND INSTRUCTIONS FROM THE EQUIPMENT MANUFACTURER.

CALIBRATION METHOD FOR GRANULAR APPLICATIONS

Paul E. Sumner, Extension Engineer

Applicators used in granular applications should be calibrated to insure uniformity and accuracy of the application. A more accurate and uniform application can reduce the quantity of an active ingredient required for a given degree of control, which benefits the environment as well as the producer.

Several factors influence the amount of granular material applied to a given area. Granular material is usually metered with an adjustable orifice. The amount of material that flows through the orifice per revolution relies on orifice opening size and may rely on rotor speed. A wide variation in product characteristics, such as size, density, and shape, requires that a calibration be made for every chemical applied. Also changes in climatic conditions, such as temperature and humidity, can result in a different flow rate.

CAUTION: Calibration is done using the chemical to be applied. Protective equipment, such as rubber gloves, etc. should be used to avoid contact with the chemicals to be applied.

Granular application is usually done in combination with another operation, such as planting or cultivating. The applicator may be ground driven or driven with a small electric motor. The following procedure will give the pounds (total weight) of material applied per acre broadcast or row basis as indicated. A weight scale incremented in ounces is required for this procedure.

Step 1. Determine type of application to be made and select appropriate procedure from Table 1. Example - Broadcast - Procedure A.

Table 1. Corresponding procedures for different spray applications.

Type of Application	Procedure	Coverage Basis (Volume of Application)
Broadcast	A	Broadcast (lbs /acre)
Band	B	Broadcast (lbs/acre of band)
Row (See note)	C (Use this procedure when rates are given for row treatment)	

Note: Determine and use average row spacing for modified row patterns. Use width of area covered per row as row spacing in skip row patterns for broadcast rates

Step 2. Using procedure A, B, or C below as selected in Step 1, determine appropriate calibration distance from Table 2.

(A) Broadcast Application: Outlets must be evenly spaced. Measure outlet spacing. Find this spacing in left column of Table 2 and read the corresponding calibration distance. Example - for a 19" spacing the distance would be 214.9 feet.

(B) Band Application: Measure band width. Find this band width in the left column of Table 2 and read the corresponding calibration distance. Example - for a 12" band, the distance would be 340.3.

(C) Row Application: Measure row spacing for evenly spaced rows. Find this row spacing in the left column of Table 2 and read the corresponding calibration distance from the column on the right. Example - for a 38" row spacing, the distance would be 107.5 feet.

CAUTION: AGRICULTURAL CHEMICALS CAN BE DANGEROUS. IMPROPER SELECTION OR USE CAN SERIOUSLY INJURE PERSONS, ANIMALS, PLANTS, SOIL, OR OTHER PROPERTY. BE SAFE: SELECT THE RIGHT CHEMICAL FOR THE JOB. HANDLE IT WITH CARE. FOLLOW THE INSTRUCTIONS ON THE CONTAINER LABEL AND INSTRUCTIONS FROM THE EQUIPMENT MANUFACTURER.

Step 3. Measure and mark calibration distance in a typical portion of the field to be applied.

Step 4. With all attachments in operation (harrows, planters, etc.) and traveling at the desired operating speed, determine the number of seconds it takes to travel calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

Step 5. **Multiply the number seconds required to travel calibration distance by 8**. This is the number of seconds to collect.

Step 6. With applicator sitting still and operating at same speed as used in Step 4, adjust gate openings to desired setting. Check uniformity of outlets across the swath or rows. Collect from each outlet for a known time period. Each outlet should be within 5 percent of the average outlet output.

Table 2. Calibration distances with corresponding widths.

Row Spacing, Outlet Spacing or Band Width (Whichever Applies) (Inches)	Calibration Distance (feet)
48*	85.1
46	88.8
44	92.8
42	97.2
40	102.1
38	107.5
36	113.4
32	127.6
30	136.1
24	170.2
20	204.2
19	214.9
18	226.9
14	391.7
12	340.3
10	408.4
8	510.5

To determine distance for spacing or band width not listed, divide the spacing or band width expressed in feet into 340.3. Example: for a 13" band the calibration distance would be 340 divided by 13/12 = 314.1.

* To increase calibration accuracy for a wide outlet spacing, multiply calibration distance by a factor (for example, 2); then, divide Step 8 material collected by the same factor for pounds per acre. For narrow spacings with long calibration distances, divide calibration distance by a factor (for example, 4); then, multiply Step 8 by the same factor for pounds per acre. Keep in mind that application accuracy will decrease when factoring narrow outlet or band spacings.

Step 7.**For procedure (A), Step 2, broadcast application, collect from one outlet for the number of seconds indicated in Step 5. For procedure (B), Step 2, band application, collect from all outlets used on one band width for the number of seconds indicated in Step 5. For procedure (C), Step 2, row application, collect from all outlets used for one row for the number of seconds indicated in Step 5.
**** For ground driven equipment, multiply the calibration distance by 8 and collect from each outlet while traveling the calibration distance.**

Step 8. Weigh the amount of material collected in ounces. The number of ounces collected is the pounds per acre rate on the coverage basis indicated in Table 1. For example, if you collect 18 ounces using procedure (A) or (B), the applicator will apply 18 pounds per acre on a broadcast coverage basis. Adjust applicator speed, gate opening, etc. to obtain recommended rate.

Step 9. Applicators should be checked for proper calibration every 4-8 hours of use. Simply repeat steps 7 and 8. If there is a difference of more than 5 percent of original calibration, check the system.

Band Application

To determine the pounds of material required to make a band application on a field, the number of acres that will be in the actual treated band must be determined. When all treated bands are the same width and all untreated bands are the same width, which is usually the case, the acres in the actual treated band can be calculated by placing the width of the treated band over the sum of the widths of the treated band and the untreated band, and multiplying this fraction times the number of acres in the field. Example - How many acres will actually be treated in a 30 acre field if a 12" band of chemical is applied over the drill of rows spaced 36" a part. The treated band width is 12 inches. The untreated band width is (36" - 12") = 24". Acres actually treated will be 12 inches divided by (12" + 24 ") times 30 acres equals 10 acres. The amount of material required for the 30 acre field will be 10 times the number of pounds per acre from Step 8.

Check rate recommendations carefully as to type of application, broadcast, band or row, and type of material specified, formulated product, active ingredient, etc.

CALIBRATION OF BACKPACK SPRAYERS 1000 Ft² Method

Paul E. Sumner, Extension Engineer

Backpack sprayers are often used to treat ornamental or small areas of turf. Herbicide recommendations are based amount per acre and amount per 100 0 ft^2. Regardless of the type of sprayer used to apply herbicides, the speed, pressure and nozzle height must be kept constant for accurate application. The backpack sprayer may require some modification so that it is better suited for application. A pressure gauge mounted on the tank side of the shutoff valve will allow continuous monitoring of the tank pressure, which must remain uniform. Optimum pressure control can be achieved by inserting a pressure regulator between the pressure gauge and nozzle. To prevent dripping after the shutoff valve is closed, use a quick, positive pressure shutoff valve or a strainer with a check valve. Nozzle clogging, a problem associated with the use of wettable powders (as well as DF and WDG formulations) can be reduced by inserting a 50 mesh in-line strainer and keeping the solution constantly agitated. The following is a procedure of 1000 ft^2.

Step 1. Measure the length and width of the test area to be sprayed. Then calculate the area to be covered.

Test Area is: length _____ ft X width _____ ft = _____ ft^2

Step 2. Fill sprayer with water and spray the test area. Record the amount of water to refill the sprayer.

Volume (ounces) per test area _____

Step 3. Find the label rate of material to be applied per 1000 ft^2 .

Rate _____ per 1000 ft^2

Step 4.

$$\frac{\textit{1000 ft}^2 \textit{ x Volume (ounces) per test area}}{\textit{Test Area (ft}^2\textit{)}} = \textit{Volume (ounces) per 1000 ft}^2$$

Step 5. Calculate the area covered per tank as follows:

$$\frac{\textit{Tank volume (ounces) x 1000 ft}^2}{\textit{Volume per 1000 ft}^2} = \textit{Area covered per tank (ft}^2\textit{)}$$

Step 6. Calculate amount of material to add to tank.

$$\frac{\textit{Area per tank (ft}^2\textit{) x Label rate per 1000 ft}^2}{\textit{1000}} = \textit{Amount to add (rate units)}$$

Solutions derived from the above may need to be converted to a smaller unit in order to accurately measure the pesticide accurately. The following conversion will help simplify this problem.

Conversions:

Volume		Weight	
gallon x 128	= fluid ounces (fl oz)	pounds x 16	= weight ounces (wt oz)
pints x 16	= fluid ounces (fl oz)	wt. ounces x 28.35	= grams (g)
fl oz x 29.57	= milliliters (ml)	grams x 1000	= milligrams (mg)
gallon x 4	= quarts (qts)		
quarts x 2	= pints (pts)		
fl oz x 2	= Tablespoons (tbs)		
tsp x 3	= Tablespoons (tbs)		
tsp x 5	= milliliters (ml)		

CALIBRATING TURFGRASS SPRAYERS (Gallons per 1000 ft^2)

Paul E. Sumner, Extension Engineer

Low-pressure boom sprayers are used frequently for applying chemicals on large areas such as golf courses and recreational areas. Application rates for turf are normally given in gallons per 1000 sq ft. Calibrating a boom sprayer is not as difficult as it sounds. Calibrate your sprayer often to compensate for nozzle wear, pump wear and speed changes.

Calibrate with clean water. Check uniformity of nozzle output across the boom. Collect from each for a known time period. Each nozzle should be within 10 percent of the average output. Replace with new nozzles if necessary. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be applied. Exercise extreme care and use protective equipment when active ingredient is involved..

Step 1. Determine the Effective Swath Width (W) per Nozzle
For boom spraying, the effective spray width of each nozzle (W) is equal to the distance in inches between two nozzles.

Step 2: Determine Travel Speed (MPH)
To determine the travel speed, measure a known distance. Use fence posts or flags to identify this distance. A distance over 200 feet and a tank at least half full are recommended. Travel the distance determined at your normal spraying speed and record the elapsed time in seconds. Repeat this step and take the average of the two measurements. Use the following equation to determine the travel speed in miles per hour:

$$\textit{Travel Speed (MPH)} = \frac{\textit{Distance (feet) x 0.68}}{\textit{Time (seconds)}}$$

(0.68 is a constant to convert feet/second t o miles/hour)

Step 3. Determine Nozzle Flow Rate (GPM)
With the sprayer parked, operate the sprayer at the same pressure level and catch the output from each nozzle in a measuring jar for one minute (or collect output for half a minute and then double the ounces collected) to determine the nozzle flow rate in ounces per minute (OPM) Then, convert the final average output in OPM to gallons per minute (GPM) using the following equation:

$$\textit{GPM = OPM/128 (1 Gallon = 128 ounces)}$$

Step 4. Determine the Actual Application Rate in Gallons per Gal/1000 sq ft
Use the following equation to determine the gallons per acre application rate:

$$\textit{Gallons per 1000 ft}^2 = \frac{\textit{136 x gpm (per nozzle)}}{\textit{MPH x W}}$$

GPM: average nozzle flow rate in gallons per minute
MPH: travel speed in miles per hour
W: distance between two nozzles in inches
136 a constant to convert units to gallons/1000 ft^2

Step 5. Calculate the area covered per tank as follows:

$$\frac{\textit{Tank Volume (gallons) x 1000}}{\textit{Application Rate (gallons per 1000 ft}^2\textit{)}} = \textit{Area covered per tank (ft}^2\textit{)}$$

Step 6. Calculate amount of material to add to tank.

$$\frac{\textit{Area covered per tank (ft}^2\textit{) x Material rater per 1000 ft}^2}{\textit{1000}} = \textit{Amount to add (rate units)}$$

HAND SPRAYER CALIBRATION FOR ORNAMENTAL AND TURF

Paul E. Sumner, Extension Engineer

Hand sprayers are often used to treat ornamental or small areas of turf. The directions on many ornamental pesticide product labels say to "spray until foliage is wet" or perhaps "spray until runoff." Unfortunately, these directions are subject to each applicator's interpretation of what "wet" or "runoff" is.

Recommendations are based on amount per 100 gallons. This is the dilution ratio for the chemical applied. Use the following to convert 100 gallon rate to bed area rate.

1. Measure the length and width of the area to be sprayed. Then calculated the area to be covered.

Bed Area is: length _____ X width _____ = _____ ft^2

2. Fill sprayer with water and spray the area. Record the amount of water to refill the sprayer.
   Gallons per bed area _____

3. Obtain the rate of material to be applied per 100 gallons.
   Rate _____

4. $$\frac{\textit{Rate x Gallons per bed area}}{\textit{100}} = \textit{Amount per bed area}$$

5. Calculate the total amount of material to be used for the application (total bed area) as follows:

$$\frac{\textit{Amount per bed area x Area to be sprayed}}{\textit{Bed area } (ft^2)} = \textit{Amount of material}$$

6. Total solution to prepare is:

$$\frac{\textit{Gallons per bed area x Area to be sprayed } (ft^2)}{\textit{Bed area } (ft^2)} = \textit{Total Solution}$$

Solutions derived from the above may need to be converted to a smaller unit in order to accurately measure the pesticide. Refer to the conversion section to help simplify this problem.

Conversions:

Volume		Weight	
gallon x 128	= fluid ounces (fl oz)	pounds x 16	= weight ounces (wt oz)
pints x 16	= fluid ounces (fl oz)	wt. ounces x 28.35	= grams (g)
fl oz x 29.57	= milliliters (ml)	grams x 1000	= milligrams (mg)
gallon x 4	= quarts (qts)		
quarts x 2	= pints (pts)		
fl oz x 2	= Tablespoons (tbs)		
tsp x 3	= Tablespoons (tbs)		
tsp x 5	= milliliters (ml)		

AIRBLAST SPRAYER CALIBRATION — ORCHARD AND VINEYARD

Paul E. Sumner, Extension Engineer

Calibration is the process of measuring and adjusting the gallons per acre of spray actually applied. Sprayers need to be calibrated to meet the coverage needs of the orchards to be sprayed and to facilitate precise dosing of each material. A sprayer should be set up to apply a gallon per acre rate at a desired speed and pressure. In-orchard calibration frequently indicates a need for adjustments to achieve the target gallons per acre.

Speed of travel of a sprayer is a vital factor in obtaining the number of gallons of spray per acre desired. Change in gallons per acre (GPA) applied is inversely proportional to the change in speed. If speed is doubled, the gallons per acre will be halved. Thus, if nozzles have been installed and pressure set to provide a gallon per acre rate at a certain speed, the sprayer should apply the GPA rate at that speed.

To determine the travel speed, measure a known distance. Use fence posts or flags to identify this distance. A distance over 100 feet and a tank at least half full are recommended. Travel the distance determined at your normal spraying speed and record the elapsed time in seconds. Repeat this step and take the average of the two measurements. Use the following equation to determine the travel speed in miles per hour:

$$\textit{Travel Speed (MPH)} = \frac{\textit{Distance (feet) x 0.68}}{\textit{Time (seconds)}}$$

(0.68 is a constant to convert feet/second to miles/hour)

Calculating Gallons per Minute (GPM) Output
The gallons per minute output required for a sprayer traveling along both sides of each row spraying from one side for a desired gallon per acre rate can be calculated with the following equation:

$$\textit{GPM Required} = \frac{\textit{GPA (required) x MPH (determined) x Row Spacing (feet}}{\textit{990 (spraying one side)}}$$

(If one pass is made between rows spraying from both sides of the sprayer, use 495 as constant.) GPA = Gallons per Acre
MPH = Miles per Hour

To check actual GPM output:

1. Fill sprayer with water. Note the level of fill. If a material with considerably different flow characteristics than water is to be sprayed fill the sprayer with this material.

2. Operate the sprayer at the pressure that will be used during application for a measured length of time. A time period of several minutes will increase accuracy over a time period of 1 minute. A suggested time is 5 - 10 minutes.

3. Measure the gallons of liquid required to refill sprayer to the same level it was prior to the timed spray trial with the sprayer in the same position as when it was filled initially. The actual GPM can be calculated as follows:

$$\textit{GPM (actual)} = \frac{\textit{Gallons to refill sprayer tank}}{\textit{minutes of spray time}}$$

4. Calculate the GPA being app lied spraying from one side on both sides of row by the sprayer.

$$\textit{GPA (actual)} = \frac{\textit{GPM (actual) x 990 (spraying one side)}}{\textit{MPH x Row Spacing (feet)}}$$

If the actual GPA is slightly different from the required GPA, the actual GPA can be increased or decreased by increasing or decreasing spray pressure on sprayer models that have provisions for adjusting pressure. Only small output changes should be made by adjusting pressure. Major changes in output should be done by changing nozzles or ground speed.

Nozzle Setup
Nozzle arrangement and air guide or director vane settings should place most of the spray in the top half of the plants, where most of the foliage and fruit are located. Air blast sprayers are typically set up to apply 2/3 to 3/4 of the spray to the top half, and 1/3 to 1/4 to the bottom half (Figure 3). This targeted spraying is accomplished by placing more or larger nozzles on manifolds in the area that supplies spray to the upper half of trees and setting the air directors on the fan outlet to direct the air stream accordingly. Plant growth and target pest habits should be considered in determining the setup for specific applications.

ATTENTION! PESTICIDE PRECAUTIONS

1. Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful and illegal to do otherwise.

2. Store all pesticides in original containers with labels intact and behind locked doors. "KEEP PESTICIDES OUT OF THE REACH OF CHILDREN."

3. Use pesticides correct label dosages and intervals to avoid illegal residues or injury to plants and animals.

4. Apply pesticides carefully to avoid drift or contamination of non-target areas.

5. Surplus pesticides and containers should be disposed of in accordance with label instructions so that contamination of water and other hazards will not result.

6. Follow directions on the pesticide label regarding restrictions as required by State and Federal Laws and Regulations.

7. Avoid any action that may threaten an Endangered Species or its habitat. Your county extension agent can inform you of Endangered Species in your area, help you identify them, and through the Fish and Wildlife Service Field Office identify actions that may threaten Endangered Species or their habit.

Index

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

V

W