Pesticide Applicator Certification Series

Toxicity of Pesticides

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Pesticides are designed to control pests. They all are toxic to some level, otherwise they would not kill pests. They can also be toxic to non-target organisms such as plants, animals or humans. Exposure to a sufficient amount of almost any pesticide can affect a person—either through illness, eye exposure or skin sensitivity.

Since even fairly low risk pesticides can irritate the skin, eyes, nose or mouth, it is essential to understand pesticide toxicity in order to follow safe use practices and eliminate exposure.

How Pesticides Enter the Body

Before a pesticide can harm you, it must be taken into the body. Pesticides can enter the body orally (through the mouth and digestive system), dermally (through the skin), or by inhalation (through the nose and respiratory system).

Oral Exposure

Oral exposure may occur because of an accident, but is more likely to occur as the result of carelessness, such as blowing out a plugged nozzle; smoking or eating without washing your hands after using a pesticide; or eating food that has been recently sprayed with a pesticide. The seriousness of the exposure depends upon the oral toxicity of the material and the amount swallowed.

Dermal Exposure

Dermal or skin exposure accounts for about 90% of all pesticide exposure users receive from nonfumigant pesticides. It may occur any time a pesticide is mixed, applied, or handled, and it is often undetected. Dry materials-dusts, wettable powders, and granules as well as liquid pesticides can be absorbed through the skin. The seriousness of dermal exposure depends upon (1) the dermal toxicity of the pesticide, (2) rate of absorption through the skin, (3) the size of the skin area contaminated, (4) the length of time the material is in contact with the skin, and (5) the amount of pesticide on the skin.

Rates of absorption through the skin are different for different parts of the body (Figure 1). Using absorption through the forearm (1.0) as the standard, absorption is more than 11 times faster in the lower groin area. Absorption in the genital area is rapid enough to approximate the effect of injecting the pesticide directly into the bloodstream.

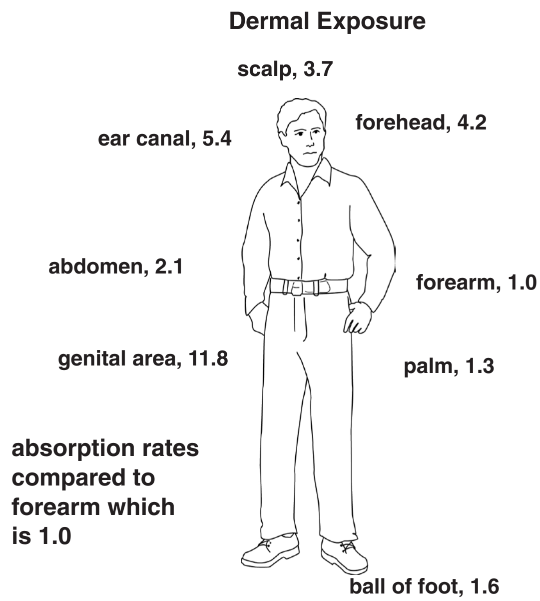

Figure 1. Comparative rates of dermal absorption for different parts of the body.

Absorption continues to take place on the affected skin area as long as the pesticide is in contact with the skin. The seriousness of the exposure is increased if the contaminated area is larger or if the material remains on the skin for a period of time.

Inhalation Exposure

Inhalation exposure results from breathing in pesticide vapors, dust, or spray particles. Like oral and dermal exposure, inhalation exposure is more serious with some pesticides than with others, particularly fumigant pesticides.

Inhalation exposure can occur from the applicator smoking, breathing smoke from burning containers, breathing fumes from pesticides while applying them without protective equipment, and inhaling fumes while mixing and pouring pesticides.

Toxicity

Toxicity refers to the ability of a poison to produce adverse effects. These adverse effects may range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death. Most toxic effects are reversible and do not cause permanent damage if prompt medical treatment is sought. However, some poisons cause irreversible (permanent) damage. Poisons work by altering normal body functions, consequently toxicity can occur in as many ways as there are body functions.

All new pesticides are tested to establish the type of toxicity and dose necessary to produce a measurable toxic reaction. In order to compare the results of toxicity tests done in different laboratories, there are strict testing procedures. Toxicity testing is expensive, intensive, and involves many phases. Humans, obviously, cannot be used as test animals, so toxicity testing is done with animals. Since different species of animals respond differently to chemicals, a new chemical is generally tested in mice, rats, rabbits, and dogs. The results of toxicity tests in these animals are used to assess the toxicity of new chemicals to humans.

Toxicity tests are based on two premises. The first premise is that information about toxicity in animals can be used to predict toxicity in humans. Years of experience have shown that toxicity data obtained from a single species may be inaccurate. The second premise is that by exposing animals to large doses of a chemical for short periods of time, we can assess human toxicity due to exposure to small doses for long periods of time.

Toxicity is usually divided into 2 types, acute or chronic, based on the number of exposures to a poison and the time it takes for toxic symptoms to develop. Acute toxicity is due to short-term exposure and happens within a relatively short period of time, whereas chronic exposure is due to repeated or long-term exposure and happens over a longer period (Table 1).

Table 1. Types of Toxicity

Type	Number of Exposures	Time to Develop Symptoms
Acute	usually 1	immediate (minutes to hours)
Chronic	more than a few	one week to years

Acute Toxicity

The acute toxicity of a chemical refers to its ability to do systemic damage as a result of a one-time exposure to relatively large amounts of chemical. A pesticide with a high acute toxicity may be deadly when a very small amount is absorbed. The signal words on the label (Table 2) are based on the acute toxicity of the pesticide. Acute toxicity may be measured as acute oral (through the mouth), acute dermal (through the skin), and acute inhalation (through the lungs).

Acute Toxicity Measure

The commonly used term to describe acute toxicity is LD50. LD means Lethal Dose (deadly amount) and the subscript 50 means that the dose was acutely lethal for 50 percent of the animals to whom the chemical was administered under controlled laboratory conditions. The test animals are given specific amounts of the chemical in either one oral dose or by a single injection, and are then observed for 14 days.

Since LD50 values are measured from zero up, the lower the LD50 the more acutely toxic the pesticide. Therefore, a pesticide with an oral LD50 of 500 would be much less toxic than a pesticide with an LD50 of 5. LD50 values are expressed as milligrams per kilogram (mg/kg), which means milligrams of chemical per kilogram of body weight of the animal. Milligram (mg) and kilogram (kg) are metric units of weight similar to ounce and ton. Milligrams per kilogram is the same as parts per million. For example, if the oral LD50 of the insecticide is 4, it would require a dose of 4 parts of the insecticide for every million parts of body weight to be lethal to at least half of the test animals.

To determine the ounces of actual pesticide that would be lethal to one of every two 187-pound men or other warm blooded animals, multiply the factor .003 times the LD50 value for the pesticide. For example, the oral LD50 value for malathion is 1,200 mg/kg; thus, if a group of men each weigh-

Table 2. Acute Toxicity Measures and Warnings

		Categories of Acute Toxicity			
		LD50	LD50	LC50	
Categories	**Signal Word Required on the Label**	**Oral mg/kg**	**Dermal mg/kg**	**Inhalation mg/l**	**Probable Oral Lethal Dose For 150 lb person**
I Highly Toxic	DANGER POISON-skull and crossbones	0-50	0-200	0-0.05	A few drops to a teaspoonful
II Moderately Toxic	WARNING	50+ to 500	200+ to 2,000	0.05+ to 0.5	Over one teaspoonful to one ounce
III Slightly Toxic	CAUTION	500+ to 5,000	2,000- to 5,000	0.5 to 2.0	Over one ounce to one pint or one pound
IV Relatively Non-Toxic	CAUTION	5,000+	>5,000	….	Over one pint to one pound

ing 187 pounds ate 3.6 ounces (1,200 x 0.003) of technical malathion per man, we might expect half of them to die. The dermal LD50 value of malathion is approximately 4,000 mg/kg, or 12 ounces, for a 187-pound man. Since toxicities depend on body weight, it would take only one-third of this amount to be lethal to a 60-pound child and about five times as much to kill a 900 pound animal.

For standards of comparison, the oral LD50 value of table salt is 3,320 mg/kg, while for aspirin it is 1,200 mg/kg or 3.6 ounces per 187-pound man, the equivalent of malathion.

LD50 values are generally expressed on the basis of active ingredient. If a commercial material is only 50 percent active ingredient, it would take 2 parts of the material to make 1 part of the active ingredient. In some cases, chemicals mixed with the active ingredient for formulating a pesticide may cause the toxicity to differ from that of the active ingredient alone.

Acute inhalation toxicity is measured by LC50. LC means lethal concentration. Concentration is used instead of dose because the amount of pesticide inhaled from the air is being measured. LC50 values are measured in milligrams per liter. Liters are metric units of volume similar to a quart. The lower LC50 value, the more poisonous the pesticide.

Chronic Toxicity

Chronic Toxicity refers to harmful effects produced by long-term, low-level exposure to chemicals. Less is known about the chronic toxicity of pesticides than is known about their acute toxicity, not because it is of less importance, but because chronic toxicity is much more complex and subtle in how it presents itself. Increased emphasis is being given to the chronic toxicity of pesticides by the U.S. Environmental Protection Agency (EPA). In the past, more emphasis was placed on acute toxicity rather than chronic. While situations resulting in acute exposure (a single large exposure) do occur, they are nearly always the result of an accident or careless handling. On the other hand, persons may be routinely exposed to small amounts of pesticides while mixing, loading, and applying pesticides or by working in fields after pesticides have been applied.

Chronic Toxicity Measures

There is not a standard measure like the LD50 for chronic toxicity. How chronic toxicity of chemicals is studied depends upon the adverse effect being studied. The major chronic adverse effects include:

Carcinogenesis (oncogenesis)

These terms mean the production of tumors. The terms tumor, cancer, neoplasm are all used to mean an uncontrolled progressive growth of cells. In medical terminology, a cancer is considered a malignant (potentially lethal) neoplasm. Carcinogenic or oncogenic substances are substances that can cause the production of tumors. Examples are asbestos and cigarette smoke.

Teratogenesis

Teratogenesis is the production of birth defects. A teratogen is anything that is capable of producing changes in the structure or function of the offspring when the embryo or fetus is exposed before birth. An example of a chemical teratogenis is the drug thalidomide that caused birth defects in children when their mothers used it during their pregnancy. Measles virus infection during pregnancy also has teratogenic effects.

Mutagenesis

Mutagenesis is the production of changes in genetic structure. A mutagen is a substance that causes a genetic change. Many mutagenic substances are oncogenic meaning they also produce tumors. Many oncogenic substances are also mutagens.

Reproductive toxicity

Some chemicals have effects on the fertility or reproductive rates of animals.

Chronic Toxicity Testing

Chronic toxicity testing is both lengthy and expensive. EPA and regulatory agencies in other countries require an extensive battery of tests to identify and evaluate the chronic effects of pesticides. These studies, which may last up to two years, utilize several species of animals to evaluate toxicity from multiple or continuous long-term exposure.

Label Identification of Acute and Chronic Toxicity

To alert pesticide users to the acute toxicity of a pesticide, a signal word must appear on the label. Four different categorie are used (Table 2). Signal words are used to tell the user whether the chemical is highly toxic, moderately toxic, slightly toxic, or relatively non-toxic. If the pesticide meets all of Category IV toxicity levels, that pesticide is not required to have a signal word on the label. These label warnings are based for the most part on the chemical's acute toxicity. For example, the acute oral and acute dermal toxicity of a pesticide may be in the slightly toxic category. But if the acute inhalation toxicity is in the highly toxic category, the pesticide label will have the signal words for a highly toxic pesticide. The degree of eye or skin irrigation caused by the pesticide also influences the signal word.

There is no comparable set of signal words like those used for acute toxicity to alert pesticide users to chronic toxicity problems with pesticides. Instead a statement identifying the specific chronic toxicity problems will be used on the label. Such a statement might read "This product contains (name of chemical) which has been determined to cause tumors or birth defects in laboratory animals." Associated with chronic toxicity warning statements will be label directions to wear certain kinds of protective clothing when handling or working with the pesticide to minimize or eliminate exposure to the pesticide.

It is important to read the label to look for signal words identifying the product's acute toxicity and for statements identifying any chronic toxicity problem. A pesticide may be low in acute toxicity (signal word caution), but it may have a label statement identifying potential chronic toxicity.

Safety Factors

In feeding studies, the pesticide being investigated is incorporated into the daily diet and fed to animals from a very young to a very old age. These as well as the reproductive effects studies are designed to arrive at a No-Observable-Effect-Level (NOEL); that is, a level in the total diet that causes no effect in treated animals when compared to untreated animals maintained under identical conditions. This NOEL is expressed on a mg/kg of body weight/day basis. An Acceptable Daily Intake (ADI) is usually established at 1/100 of the NOEL, in order to add an additional margin of safety. The ADL is the amount of chemical that can be consumed daily for a lifetime without ill effects.

Extensive residue trials are conducted to determine levels of the pesticide that will remain in or on growing crops after treatment with the pesticide. These trials lead to the establishment of a tolerance for residues of the chemical on food commodities. A tolerance is the maximum allowable amount of the pesticide permitted in or on a specific food commodity at harvest. Use directions for a pesticide are written to assure that residues in food commodities are below the tolerance. The tolerance is set low enough to ensure that even if someone ate only food items with residues of a given pesticide at the tolerance limit, there would still be a safety factor of at least 100 when compared to a level causing no observable effects in laboratory animals. This is, of course, a worst-case situation since all crops on which the pesticide is registered for use would not be treated with the chemical, and in most cases residue levels would be well below the tolerance due to preharvest intervals being longer than the minimum period stated on the label. Further reduction of residues may occur in storage, or due to washing, trimming, and processing.

Dose Response

Ironically, the extensive amount of data developed about a pesticide is often used against it by conveniently ignoring the dose response. For example, some acute studies, which are designed to include dosage levels high enough to produce deaths, are cited as proof of the chemical's dangers. Chronic effects seen at very high doses in lifetime feeding studies are misinterpreted and considered as proof that no exposure to the chemical should be allowed. Major improvements in analytical chemistry permit detection of chemicals at levels of parts per billion (ppb) or even parts per trillion (ppt). People are constantly hearing that they are being exposed to toxic chemicals in their foods and beverages and that exposure levels are so many parts per billion or parts per trillion, with no comprehension of the real meaning of these numbers. Most stories on pesticides reported by the media completely neglect the issue of dose-response, the key principle of toxicology. The concentration of a chemical in any substance is meaningless unless it is related to the toxicity of the chemical and the potential for exposure and absorption. Chemicals of low toxicity such as table salt or ethyl alcohol can be fatal if consumed in large amounts. Conversely a highly toxic material may pose no hazard when exposure is minimal.

Monitoring for Residues

Monitoring foods for pesticide residues is carried out by the Food and Drug Administration. Crops containing residues over the official tolerance established by the EPA must be destroyed. The threat of crop destruction with resultant financial loss is a strong incentive for farmers to observe use instructions on pesticide labels and thus ensures that residues will be below established tolerances. Crops grown for export are often checked for residues by foreign residue laboratories to assure that the local tolerance limits are not exceeded. Lastly, market basket surveys (analyses of food items from grocery stores) have confirmed the low exposure of the general public to pesticides in foods.

Hazard

Hazard is a function of the toxicity of a pesticide and the potential for exposure to it. We do not have control of the toxicity of a pesticide since toxicity is a given characteristic of a particular pesticide; however, we can have control over our exposure to pesticides. This is done by following several safety practices including the use of protective clothing and equipment.

All pesticides are hazardous if misused, no matter what their toxicity. All pesticides can be handled safely by using safety practices that minimize or eliminate your exposure to them.

Federal laws regulating pesticides have placed the burden of proving safety of pesticide usage on the manufacturer. Hazard evaluation studies are generally done by scientific laboratories maintained by the manufacturer or through outside contract laboratories. Few products are subjected to such extensive and vigorous testing as pesticides, prior to being marketed. Many promising pesticide products are not marketed because they to not pass the extensive toxicology testing. Older pesticide products that were registered before the current toxicology testing standards were established are being reevaluated under current standards. Precautions and other safety information found on the product's label are based on information from these tests. By reading and following the directions on the label, the user can minimize or eliminate hazards due to use of the pesticide to him or herself and others.

Toxicity Tables

Complete information is not available on the toxicity of all pesticides. The following tables give the acute oral and, when available, the acute dermal toxicity for some common insecticides, fungicides and nematicides, and herbicides. These tables do not identify any chronic toxicity effects. Pesticide chemicals with identified chronic toxicities will have label statements identifying the specific chronic effect and practices to use when using the pesticide.

Some of the preceeding material was adapted from Pesticide Toxicities, Leaflet 21062, Division of Agricultural Sciences, University of California; The Dose Makes the Poison by Alice Ottoboni, PhD, Vincente Books; and the Farm Chemical Handbook, Meister Publishing Company.

Insecticides

Common Name	Trade Name	Acute Oral LD50	Acute Dermal LD50
abamectin	Avid, Ascend, Zephyr	650	>2,000
acephate	Orthene, Payload	980	>10,250
acetamiprid	Intruder	866	>2,000
aldicarb	Temik	1	20
allethrin	(many)	480	11,200
amtraz	Mitac, others	800	>200
azadirachtin	Aza-Direct, Ecozin, others	>5,000	>2,000
Bacillus thuringiensis	Deliver, Dipel, Javelin, others	>5,000	>2,000
beta-cyfluthrin	Cylence Ultr	960	>2,000
bifenazate	Acramite	>5,000	>2,000
bifenthrin	Capture, Talstar, Onyx	375	>2,000
boric acid	Roach Prufe	3,5000	>10,000
uprofezin	Applaud, Courier, Talas	>5,000	>2,000
Carbaryl	Sevin	246-283	4,000
chlorfenapyr	Phantom, Pylon	560	>2,000
chlorpyrifos	Lorsban, Dursban, Durap	96-270	2,000
chlorpyrifos-methyl	Reldan	1,000-3,70	>3,700
clofentezine	Apollo, Ovation	>5,000	>2,400
clothianidin	Arena, Celero, Poncho	4,000	5,000
coumaphos	Co-Ral	140	860
cyfluthrin	Baythroid, Tempo, others	826	.>2,000
cypermethrin	Ammo, others	250	>2,000
cyprodinil	Vanguard	>2,000	>2,000
cyromazzine	Citation, Larvadex, Triga Syngenta	3,387	3,100
DDT	–	113	2,510
deltamethrin	Decis, DeltaGard, Susper	129	2,000
diazinon	Diazinon, Spectracide	300-400	3,600
dichlorvos	DDVP, Vapona	80	105-107
dictotophos	Bidrin	17-22	224
dienochlor	Pentac	3,160	>3,160
diflubenzuron	Dimilin, Adept	>4,640	>10,000
dimethoate	Dimethoate, Cygon	235	400
dinotefuran	Safari	2,804	>2,000
disulfoton	Di-Syston	4	10
d-Phenothrin	Summithrin	>10,000	>10,000
emamectin benzoate	Denim, Proclaim	2,950	>2,000
endosulfan	Thiodan, Phaser	160	359
esfenvalerate	Asana	458	>2,000
famphur	Warbex, Famophos	40	1,460
fenbutatin-oxide	Vendix	2,631	>2,000
fenoxycarb	Logic, reclude	16,800	>2,000
fenpropathrin	Tame, Danitol	71-164	>2,000
fenoyroximate	Akari, Fujimite	7,193	>4,000
fenthion	Spont-On, Tiguvon	250	1,000
fenvalerate	Belmark, Tribute	451	>5,000
fiponil	Termifor	>5,000	>2,000
flumetsulam	Python Magnum	>5,000	2,000
fluvalinate	Mavrik, Yardex	261-282	20,000
gamma-Cyhalothrin	Proaxis	79	632
halofenozide	Mach 2	>5,000	>2,000
hydromethylnon	Combat,Amdro	1,131	>2,000
hydroprene	Gen Trol	>34,000	5,100
imidacloprid	Admire, Marahion, Premise	450	>5,000
indoxacarb	Avaunt Steward	1,867	>5,000
isazofos	Triumph	40-60	>3,100
isofenphos	Amaze	20	162
kinoprene	Enstar	4,950	9,000
lambda-cyhalothrin	Demand	79	632
lindane	Lindane, others	200	2,000
malathion	Cythion, Malathion	2,800	4,100
metaldehyde	Deadline	283	>5,000
methidathion	Supracide	25-44	1,546
methomyl	Lannate	17	5,000
methoprene	Altosid, Precor, others	>34,000	>3,000
methoxfendozide	Intrepid	>5,000	>2,000
methyl bromide	(many)	214	–
naled	Dibrom, Trumpet	376	1,100
neem oil	Triact	4,200	2,000
nicotine	(many	55	–
oxamyl	Vydate	37	2,960
oxydemeton-methyl	Meta-Systox-R	48-61	112-162
parathion-methyl	Methyl Parathion	25	25
permethrin	Ambush, Astro, others	2,215`	>2,000
phorate	Thimet, GX-118	4	6
phosmet	Imidan, Prolate	147-316	>4,640
phosphoric acid	Foray	1,530	2,740
piperonyl butoxide	(many)	>7,500	–
pirimiphos methyl	Actellic, Dominator, others	>2,000	>4,592
potassium salts	M-Pede	>5,000	>2,000
profenofos	Cura Cron	358	277
propargite	Omite, Comite	4,029	2,940

Insecticides (continued)

Common Name	Trade Name	Acute Oral LD50	Acute Dermal LD50
propetamphos	Catalyst	119	2,825
propoxur	Baygon, others	>500	>5,000
pymetrozine	Fulfill	>5,000	>2,000
pyrethrin	(many)	1,500	>1,800
pyridaben	Nexter, Sanmite	820-1,350	>2,000
pyriproxyfen	Distance	>5,000	>2,000
rotenone	(many)	350	940
ryania speciosa plant extract	Ryania	1,200	–
spinosad	Spin Tor	5,000	5,000
spiromesifen	Oberon	>2,000	>2,000
sulfur	Microthiol, Thiodex	>2,000	2,000
sulfotepp	Bladafum	10	65
tebufenozide	Confirm	>5,000	>5,000
tebupirimphos	Aztec	132	>2,000
teneogis	/tempo	7,102	>2,000
terbufos	Counter	29-34	900-1,425
tetrachlorvinphos	Rabon, Gardona	4,000-5,000	>2,500
tetramethrin	Duracid	>5,000	–
thiamethoxam	actara, Cruiser, others	>5,000	>2,000
thiodicarb	Larvin	166	>2,000
tralomethrin	(many)	1,250	>2,000
triclorfon	Dylox, Neguvon	250	>2,100
zeta-cypermethrin	Fury, Mustang	>2,000	>4,000

Rodenticides

Common Name	*Trade Name*	*Major Producer*	*Acute Oral LD50*
alpha-chlorohydrin	Epibloc	Gametrics	159
brodifacoum	Talon, Havoc	Syngenta	50
bromadiolone	Maki, Contrac	Bell Labs, Lipha Tech	1
chlorophacinone	Rozol	Lipha Tech	21
cholecalciferol	Quintox	Bell Labs	42.5
diphacinone	Ramik	Hacco	2
warfarin	Warfarin	many	3

Herbicides

Common Name	Trade Name	Acute Oral LD50	Acute Dermal LD50
acetochlor	Harness Plus	2,953	3,667
acifluorfen	Blaer	1,540	>3,680
alachlor	Lasso	930-1,,350	–
aminopyralid	Milestone	>5,000	>5,000
asulam	Asulox	>5,000	>2,000
atrazine	AAtrex, others	1,780	–
benefin	Balan	>10,000	–
bensulide	Betasan, Prefar, Bensumec	271-1,1470	–
bentazon	Basagran	2,063	
bromocil	Hyvar-X, Urox	5,200	–
bromoxynil	Buctril, Bronate	260	>2,000
butylate	Sutan	3,500-5,431	>4,640
chlorimuron	Classic	>4,000	>2,000
chloroxuron	Tenoran	3,700	>10,000
chlorsulfuron	Glean	3,053	>2,000
cinmethylin	Argold, Cinch	3,610	>2,921
clethodim	Select	3,610	>2,921
clopyralid	Reclaim, Transline	>5,000	>2,000
cloransulam-methyl	First Rate	2,000	–
coper sulfate	Basicop	472	–
cyanazine	Bladex	288	>2,000
cycloate	Ro-Neet	2,000-4,100	–
DCPA	Dacthal	>5,000	>2,000
dicamba	Banvel	1,707	>2,000
2,4-D	(many)	699	–
2,4-DB	Butoxone, Butyrac	700	–
dichlobenil	Casoron	>3,160	1,350
diclofop-methyl	Hoelon	512	>5,000
diethatyl ethyl	Antor	2,300	–
dimethenamid	Frontier	2,400	>2,00
dimethipin	Harvade	1,180	8,000
dinitramine	Cobex	3,00	6,800
diquat	Diquat, Reglone	215-235	>400

Herbicides (continued)

disodium methanearsonate	DSMA, Ansar, Dconate	1,585-2,267	3,150-4,204
dithiopyr	Dimension	>5,000	>5,000
diuron	Karmex	3,40	2,000
endothall	Aquthol, Endothal, Hydrothol	51	–
EPTC	Eptam, Eradicane	1,630	–
ethalfluralin	Sonalan	>10,000	–
ethephon	Prep, Super Boll	4,229	–
ethofumesate	Prograss	6,400	>1,400
etofenprox	Primo	>42,880	>2,140
fenac	Fenatrol	1,780	>3,160
fenoxaprop-ethyl	Acclaim, Bugle, Excel	2,565	>2,000
fenoxarop-p-ethyl	Silverado	3,040	>2,000
fluazifop-butyl	Fusilade	2,712	>2,420
fluazifop+fenoxaprop	Fusion	2,000	2,000
flumetsulam	Broadstrike, Python	>5,00	>2,000
fluometuron	Cotoran	8,900	>10,000
fluridone	Sonar	>10,000	–
fosamine ammonium	Kernite	>5,000	–
fomesafen	Reflex	1,858	–
fumiclorac-penyl ester	Rsource	>2,500	>5,620
glufosinate	Finally, Ignite	2,000	1,620
glyphosate	Rodeo, Roundup	5,000	>5,000
glyphosate trimesium	Touchdown	750	>2,000
halosulfuron	Manage, Permit	1,287	>5,000
haloxyfop-methyl	Verdict	2,179	3,536
hexazinone	Velpar	1,690	5,278
imazameth	Cadre	>5,000	>5,000
imazamethabenz	Assert	>5,000	>2,000
imazapyr	Arsenal	>5,000	>2,148
imazaquin	Scepter	5,000	2,000
imazethapyr	Pursuit	>5,000	>2,000
imazethapyr +dicamba	Resolve	>5,000	>2,000
isoxaben	Gallery	>10,000	–
isoxaflutole	Balance	>5,000	>2,000
lactofen	Cobra	59,600	2,000
linuron	Lorox	4,000	–
MCPA	(many)	1,160	>4,000
mecoprop	MCPP	1,166	>4,000
mefluidide	Embark	>4,000	>4,000
mepiquat chloride	Pix	464	–
methazole	Probe	2,501	>12,500
metolachlor	Dual	2,780	>10,000
metribuzin	Contrast, Lexone, Sencor	1,100-2,300	>20,000
monosodium methanearsonate	MSMA	700	–
napropamide	Devinol	>500	–
naptalam	Alanap	8,200	–
nicosulfuron	Accent	>5,000	>2,000
norflurazon	Solicam, Zorial	>8,000	>20,000
oryzalin	Surflan	>10,000	–
oxadiazon	Ronstar	>5,000	>2,000
oxyfluorfen	Goal	>5,000	>10,000
paraquat	Grmoxone, Cyclone	150	–
pendimethalin	Prowl	3,956	2,200
phenmediphanm	Spin-Aid	>8,000	>4,000
picloram	Tordon, Grazon	8,200	4,000
primisulfuron	Beacon	>5,050	>2,010
prodiamine	Barricade	>5,000	>2,000
profluralin	Tolban	1,808	>10,000
prometon	Pramitol	2,980	>2,000
prometryn	Caprol	5,235	>3,100
pronamide	Kerb	8,350	3,160
propachlor	Ramrod	500-1,700	–
prosulfuron	Peak	4,360	>2,020
pyrazon	Pyramin	3,030	2,500
pyridate	Tough, Lentagran	2,000	3,400
pyrithiobac-sodium	Staple	4,000	>2,000
quinclorac	Paramount	4,120	>2,000
quizalofop	Assure	1,210	–
saflufenacil	Integrity, Optill, Sharpen	>5,000	>5,000
sethoxydim	Poast	2,676-3,125	–
siduron	Tupersan	>7,500	–
simazine	Princep	>5,000	>3,100
sodium chlorate	Defol	4,950	500
sulfosate	Touchdown	750	>200
sulfosulfuron	Maverick	>5,000	>5,000
tebuthiuron	Graslan, Spike	644	–
terbacil	Sinbar	5,000-7,500	–
thifensulfuron-methyl	Pinnacle	>5,000	–
tralkoxydim	Achieve	934-1,324	–
triallate	Far-go, Avadex	395	>2,000
triasulfuron	Amber	>5,000	>2,000
tribenuron methyl	Express	>5,000	>2,000
triclopyr	Remedy, Turflon, others	2,140	–
tridiphane	Tandem	1,743	3,536
triflurlin	Treflan	>10,000	–
vernolate	Vernam	1,800-1,900	10,000

Fungicides and Nematicides

Common Name	Trade Name	Acute Oral LD50	Acute Dermal LD50
aldicarb	Tmik	1	20
anilazine	Dyrene	>5,000	>5,000
azoxystrobin	Abound, Heritage, uadris	>500	>4,000
Bacillus subilis	Kodiak	–	–
bordeaux mixture	Bordelesa	100	1,000
captan	Captan, Orthocide	9,000	–
carboxin	Vitavax	3,820	>8,000
chloroneb	Trraneb, Nu-Flow D	>5,000	>5,000
chorothilonil	Daconil, Bravo, Thalonil	>10,000	>10,000
copper comple	Phyton 27	4,500	–
copper hydroxie	Kocide	1,000	–
copper salts of fatty & rosin acids	TENNCOP	10,000	–
copper sulfate	TOP CCOP, others	472	–
cymoxanil	Curzate	1,100	>3,000
dicloran, DCNA	Botran	>5,000	–
difenoconazole	Dividend	1,453	2,010
dimethomorph	Acrobat	3,900	>2,000
dinocap	Karathane	980	9,400
dodemorph	Milban	4,180	>4,000
dodine	Cyprex	1,000	>1,500
duosan	Duosan	10,200	8,000
1,3-dichlorpropene	DD,Telone	224	333
ethoprop	Mocap	62	2
etradiazol, ETMT	Terrazole, Koban, Truban	1,077	1,366
fenamiphos	Nemacur	3	200
fenarimol	Rubigan	2,500	4,500
fenbuconazole	Indar	>2,000	>5,000
ferbam	Ferbam, Carbamate	>17,000	–
fludioxonil	Maxim, Medallion	>5,000	>2,000
flutolanil	Moncut, Prostar	10,000	>5,000
fosetyl-AL	Aliette	5,800	>2,000
gliocladium virens	Soil Gard	–	–
imazalil	Fecundal, Flo-Pro, Nu-Zone	227-343	4,200-4,880
iprodione	Chipco 26019, Rovral	>4,400	>2,000
mancozeb	Manzate 200, Fore, Penncozeb	11,200	>15,000
maneb	Maneb 80, Manex	7,990	>5,000
maneb+lindane	DB-Green	–	–
mefenoxam	Subdue Maxx	2,084	>2,020
metalaxyl	Ridomil, Subdue	669	>3,100
metam-sodium	Vapam	1,891	>3,074
myclobutanil	Eagle, Nova	1,600	>5,000
oxamyl	Vydate, Oxamyl	5	2,960
oxycarboxin	Plantvax	2,000	>16,000
paclobutraol	Protect	5,346	>1,000
piperalin	Pipron	2,500	–
propamocarb	Banol, Previcur-N	2,000-8,5000	>3,000
propiconazole	Tilt, Alamo, others	1,517	>4,000
quintazene, PCNB	Terraclor, Defend	1,700-5,000	2,000-4,000
sovran	Cygnus	>5,000	>2,000
streptomycin sulfate	Agri-strep	9,000	–
sulfur	That F, Kocide F, Kumulus	17,000	–
TCMTB	Busan	1,590	–
tebuconazole	Elite, Folicur	3,766-3,710	>2,011
terbufos	Counter	29-34	900-1,425
thiophanate-methyl	Fungo, Topsin M, Domain	7,500	–
thiabendazole	Mertect 340-F	3,100	–
thiram	Thiram	1,000	>5,000
triadimenol	Baytan 30	700	>5,000
trifloxystrobin	Flint	>4,000	>2,000
triflumizole	Terraguard	1,057	>5,000
triforine	Funginex	>16,000	>10,000
triphenyltin hydroxide	DuTer, Super Tin	156	1,600
ziram	Ziram	1,400	>6,000

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